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STAPLE CROPS STORAGE HANDBOOK

August 2011

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ACKNOWLEDGEMENTS

The handbook is produced to meet the Market Linkages Initiative's (MLI) support of the Alliance for Commodity Trade in East and Southern Africa (ACTESA) in establishing learning alliances which are platforms to share lessons learned and best practices. ACTESA's main goal is to increase regional integration and improved competitiveness of staple food across the Common Market for East and Southern Africa (COMESA) region, leading to broad-based growth and decreased food insecurity.

This handbook is the result of tremendous amount of work by numerous people and organizations.

Special thanks go to Cephas Taruvinga, upon whose previous work and training courses the initial backbone of this handbook was constructed.

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Finally, special thanks go to John Leary who led the editing process that brought this handbook to fruition.

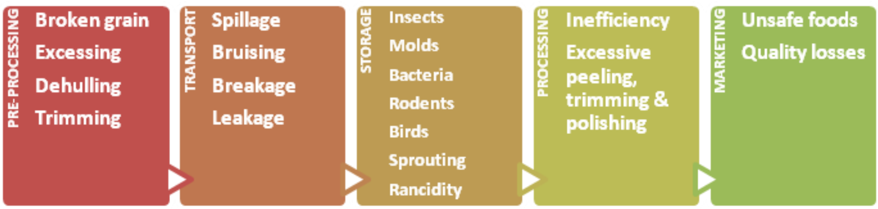
The authors' views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

INTRODUCTION

The Market Linkages Initiative (MLI) is funded by the USAID's Famine Prevention Fund with activities supporting the project goal to promote growth in food staples and food security by integrating smallholder staple food producers into national and regional markets.

MLI seeks to strengthen market systems and institutions that increase the commercial integration of smallholder staple commodities into national and regional markets. MLI works in the East Africa region and Malawi to collect and share lessons and best practices from all market linkage endeavors for replication throughout the region.

Storage is but one part of the post-harvest system through which food grain passes on its way from the field to the consumer. The system has been likened to a pipeline in which there are many leaks through which food can be lost, as seen below. Losses, shown below in the pipeline below (post harvest system) are finite and, unlike crop losses, they cannot be offset by further plant growth.



As storage is part of a system, the losses which occur at this stage will be affected by conditions prevailing in the pre-storage stages (harvesting, threshing and drying). Similarly, post-storage losses may be affected by storage conditions.

There have been many attempts to define the term "loss" and much confusion has arisen since "loss" has frequently been used synonymously with "damage".

- Loss is a measurable decrease of the foodstuff, which may be qualitative or quantitative.

- Damage generally refers to superficial evidence of deterioration, e.g. broken grains, which may later result in loss.

The importance of damage to the consumer will depend upon his status. A subsistence farmer often has no alternative but to consume a certain amount of damaged grain in his diet. In this case the loss, expressed as a simple weight loss, will be quite small. On the other hand a more affluent farmer may be in a position to exercise selection of the grain he consumes. In this case the loss in quality of food grain, i.e. that which is rejected, may be quite high.

Having collated the different practices, the MLI project will work with partners throughout the region to promote wider understanding and implementation of best practices in crop storage. The USAID MLI project will bring implementing partners together to continue to identify the most successful storage training practices to ensure as many farmers as possible can learn from the best training USAID and others can provide.

This handbook begins with the first three sections on grain quality. Then, beginning in section four, it covers storage structures and warehouse management. Though the target audience for this handbook is new store managers of large scale storage facilities, the first section does include traditional and small-scale storage. Sections 6-8 cover the milestones in the process of packing, receiving, stacking and record keeping as grain is delivered and stored. Once the grain is in the storage facility, this handbook covers losses, pests and controls in the final three sections.

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SECTION 1 | QUALITY IN FOOD GRAINS

Fresh grains are living organisms and accordingly contain organic compounds such as carbohydrates, proteins, oils and vitamins, in addition to minerals and water. Each type of food grain possesses its own characteristics, and understanding these characteristics enables us to identify and attach use and monetary value to the grain. Consumers and industrial users want to eat, grow or process grain of a certain quality, so understanding these characteristics also helps us to devise means of handling, storing and processing the grain to our best advantage.

These characteristics can be grouped into two broad categories: intrinsic and acquired characteristics.

INTRINSIC CHARACTERISTICS

Intrinsic characteristics are possessed by the whole-unblemished, fresh grain. They are inherent and natural to the grain variety and are developed after the grain has matured, ripened and harvested.

Shape – size – structure – natural color – flavor – smell
These characteristics determine the type description of grain, whereby it can be identified and checked for purity. Variations in these intrinsic characteristics enable us to distinguish varieties of the same type of grain. Examples: yellow dent maize and white flint maize, or long grain and short grain rice.

Hardness – flowability – angle of repose – bulk density – thermo conductivity – equilibrium moisture content
These physical characteristics have to be taken into account when designing grain handling equipment, storage management and quality analysis systems.

SUSCEPTIBILITY TO INFESTATION

Different types or varieties of grain can also be characterized by differences in their relative susceptibility to insect infestation or infection by microorganisms. This characteristic is important in controlling the movement of grain through the supply chain. Those types or varieties which are least resistant to pest attack should either be moved quickly through the system or given greater protection from infestation

ACQUIRED CHARACTERISTICS

Acquired characteristics are induced by outside elements which cause either positive or negative changes on the grain kernel. After production and harvesting - and through the supply and processing stages - grain undergoes changes caused by external elements which force it to alter and acquire new characteristics.

In the majority of cases, acquired characteristics are detrimental to the overall quality of the grain concerned. As a result any assessment of the utilitarian or monetary value of the grain must take into account acquired characteristics. Acquired characteristics are mostly in the following forms: foreign matter, moisture content, physical damage, pest damage, contaminants and undeveloped grain.

FOREIGN MATTER

At several stages in the supply chain, grain is liable to acquire foreign matter. Foreign matter is any matter mixed with the grain which does not resemble the type description of the grain concerned. The following are general categories of foreign matter which can be found in grain.

- Seed coats, parts of stem, pods, leaves

- Other crop seeds and weed seeds;
- Animals – alive or dead (whole or fragmented), such as insects, mites, rodents and birds-and animals excretions;
- Earth, sand, dusts stones, metal, glass etc

The presence of foreign matter can have far reaching effect on the overall quality of grain.

- Organic foreign matter is food for many storage pests and micro organisms and can be a source of cross infestation.
- Foreign matter shortens the storage life of the grain through the translocation of heat or moisture generated by the infested condition of foreign matter.
- The presence of foreign matter also affects the bulk density, flowability, angle of repose and other physical characteristics of the grain.
- Foreign matter also can damage handling equipment and storage structures unless the physical facilities and handling systems are designed to allow for it.
- Stones and other hard foreign matter have to be removed to avoid damaging equipment and affecting the quality of the commodity itself.

ABNORMAL MOISTURE CONTENT

When grain is harvested it generally has moisture levels higher than required for storing, therefore it is dried to acquire a moisture level suitable for storage. If the moisture content of the grain is below or above that which might be expected under ambient climatic conditions and is outside the limits prescribed by a standard, the grain may be said to have acquired abnormal moisture content. Abnormal moisture content may occur if the grain has been excessively dried or if it has been exposed to rain, condensation or if water has been added deliberately in order to increase the weight of the grain.

Abnormally high moisture content can be the cause of several problems.

- If the grain needs to be dried further after purchase it can be a direct cause of loss of weight. This is the principal factor responsible for what traders call shrinkage, the cost of which is passed on to consumers or farmers.

- High moisture content encourages infestation by insects and microorganisms if the grain is stored under poorly ventilated conditions.
- It allows the grain to metabolize more rapidly than is desirable, resulting in unwanted chemical changes in the grain or germination and premature aging. This also leads to increase in temperature leading to heat damage and even self destruction of the grain.

Grain with abnormally low moisture, particularly paddy rice, pulse and certain oilseeds, become very brittle such that it is liable to split, crack or break easily. This is undesirable if whole grain is preferred by the consumer and processors. However, grain with low moisture content is unlikely to become badly infested by insect pests and the risk of micro-biological infection is low. Therefore abnormally low moisture content often presents fewer problems than abnormally high moisture content.

PHYSICAL DAMAGE

Physical damage (breaking, splitting or cracking) of the grain renders it more prone to infestation by insects and microorganisms than when it is undamaged. Exposure of the internal parts of the grain to air also induces changes in the composition of the grain. While the consequences of physical damage may be confined for a while to the grains affected, the effects often spread to adjacent whole grains and eventually to the whole stock of grain.

PEST DAMAGE

Pest damage will occur if the grain is susceptible to infestation and is not protected from such damage. Insects cause damage to grain either by chewing it from the outside or boring holes inside the grain. Rodents will also chew grain usually starting at the embryo end. Molds and bacteria will spread into and through grains and may cause unhealthy discoloration and lesions which may be the only manifestations of infection indicating the grain was dried poorly.

HEAT DAMAGE

Grain may also become discolored as a result of heat damage caused by over-exposure to the sun or excessive artificial drying or association of the grain with "hot spots" in bulk grain. Weather damage - usually indicated by fading of the natural of the grain and replacement of it by a dull gray-black appearance - is the consequence of prolonged exposure to rain, snow or frost.

CONTAMINANTS

Contaminants are different than foreign matter. They cannot be readily removed from grain. Examples include soluble excretions (of pests and animals), oil, paint, and pesticides. Pathogenic microorganisms spread by rodents and some insect species and toxins produced by certain molds may also be classified as contaminants of grain.

AGEING

For as long as grain is alive it is subject to the natural process of ageing during which time the physical characteristics and composition of the grain changes. The rate at which ageing takes place varies according to the type or variety of grain, but ageing may also be influenced by environmental conditions and acquired characteristics. Reduction of germination potential is probably the most obvious consequence of ageing, but other characteristics of the grain such as milling quality may also be affected by aging. The age of the grain is thus an important factor to take into account when assessing the overall quality of grain.

UNDEVELOPED GRAIN

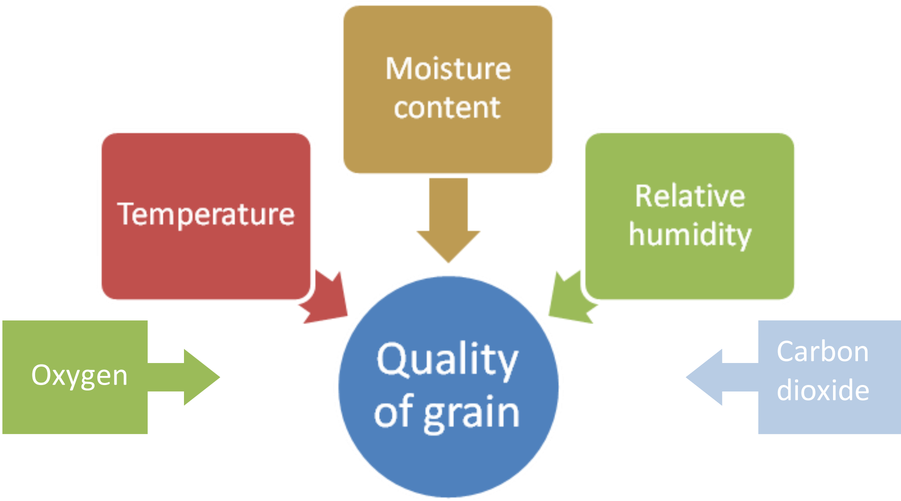
Undeveloped grain is grain which died during the early stages of development. It usually appears thin and paper like. It should not be confused with small but otherwise well-developed grains, such as the "tip" and "butt" grains of the maize. Shriveled or wrinkled grain is grain having an abnormally convoluted seed coat. This condition is usually the result of the grain having been harvested and dried before it has reached maturity.

Notes

SECTION 2 | PHYSICAL FACTORS THAT AFFECT GRAIN IN STORAGE

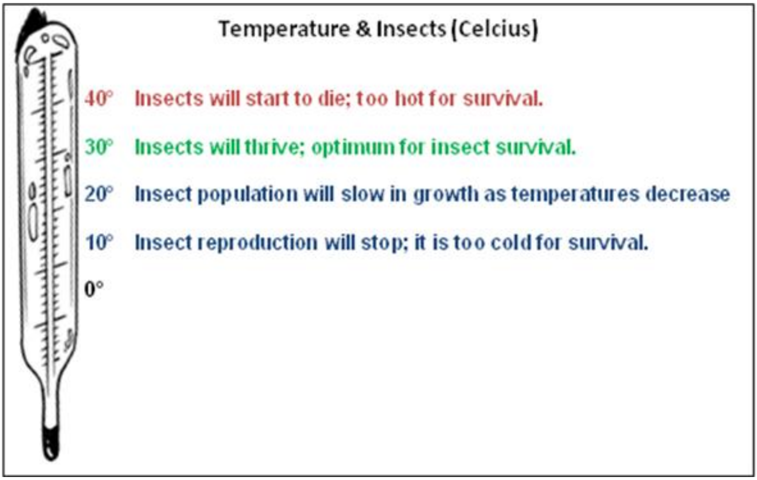
The principal physical factors that affect grain in storage are temperature, moisture content and relative humidity. Other factors are oxygen and carbon dioxide. The concentration of atmospheric gases around stored products is of particular interest only in hermetic storage where infestation will decrease the concentration of oxygen with corresponding increase of carbon dioxide.

The five factors have an effect on the micro-environment under which grain is stored, thus it is important that these factors are well understood and managed by the person in charge of storage. In this guide we will only deal with the effect of temperature, moisture content and relative humidity.



TEMPERATURE

Temperature is the measure of how cold or hot a material is. It is a kind of "heat density". It is determined using various types of thermometers, and usually given in degrees Celsius (C). Generally, most of a large bulk of stored food will remain at a temperature close to the ambient air (shade) value. Storage pests like all living organisms have a specific temperature range which they thrive at. Generally speaking, the optimum temperature for most insects is around 30° C; temperatures of 40° C or higher will sooner or later kill off all insect species. The lower the temperature, the longer the creature will take to develop. In practice, reproduction ceases below 20°C. Below 10°C, insects become dormant and they cannot survive below zero temperatures.



MOISTURE CONTENT

Moisture content is described as the quantity of water which is bound in the grain kernels expressed as a percentage by weight of the sample. Grain moisture content is expressed as a percentage of moisture based on wet weight (wet basis) or dry matter (dry basis). Wet basis moisture content is generally used. Dry basis is used primarily in research and for wheat. The moisture content of dry grain ranges from 6% to 15% depending on the type of grain. Moisture content determines whether or not mold growth will occur. Moisture content is also important because a commodity can change in overall weight due to loss or gain of moisture and most commercial transactions are made on weight basis.

RELATIVE HUMIDITY

Relative humidity is the percentage of the amount of water vapor in air (air between the grains). It is defined as the ratio of the water vapor pressure of a sample of air to the saturation water vapor pressure point at the same temperature expressed as a percentage. Since the saturation vapor pressure increases as temperature rises, it means the actual quantity of water per kilogram of air for a given relative humidity is greater at higher temperatures. Equilibrium relative humidity of stored grain at a given temperature represents the relative humidity of the air in equilibrium with the moisture content of the grain, that is, when there are steady state conditions with no net exchange of water between air and grain.

Susceptibility of grain to deterioration is directly related to the level of relative humidity and moisture content. In storage relative humidity is seldom measured, instead moisture content is measured. There are two reasons for this, first commodities are bought and sold by weight and the most convenient way of checking how weight gain or loss has occurred due to moisture transfer during storage is by measuring moisture content and making appropriate calculations. Second instruments for measuring relative humidity (hygrometers) are often very expensive and fragile and require frequent very careful calibration by skilled personnel. On the other hand moisture meters are reasonably cheap and robust and seldom drift out of calibration unless they are damaged. Also although it is possible to measure relative humidity the actual process is considered inconvenient because relative humidity changes rapidly due to minor disturbances. However relative humidity instruments do not have to be calibrated to suit a particular grain.

EFFECTS OF PHYSICAL FACTORS ON STORED GRAINS

All foodstuffs even when they are not subjected to infestation by insects and molds, may suffer changes in texture, color, flavor or nutritive value resulting from the effects of temperature and relative humidity during prolonged storage. These changes do not necessarily render the food unfit for human consumption, but they may make it less palatable and sometimes unacceptable to the consumer. Weight changes also are caused by changes in moisture content. Grain stored at higher moisture content will lose weight over time. Grains are generally bought and sold by weight, thus measuring weight and moisture content before and after storage allows us to account for gains or losses due to moisture transfer.

Temperature, moisture content and relative humidity influence insect and mold development, which causes deterioration and loss of grain in storage. At temperatures around 30 degrees and relative humidity of 70% or moisture content of 14%, storage pests thrive.

Keeping the three factors below safe levels controls insects and mold development in storage. This means that the lower the temperature, relative humidity and moisture content, the lower the risk of grain infestation.

INTERACTION OF TEMPERATURE AND MOISTURE CONTENT

A rise in temperature will cause the grain to lose moisture to the air thereby increasing the relative humidity. A drop in temperature will cause the relative humidity in the air to turn to water (dew) which settles on the grain. As some of the dew settles on the grain and gets re-absorbed it causes changes in texture and color, flavor and nutritive value. When temperature rises again, water remaining outside of the grain causes the formation of molds and pests. These temperature changes can happen in a short period within the day as the position of the sun changes.

GRAIN IS A GOOD INSULATOR

Heat loss at the edges of a grain mass during cooler periods occurs at a faster rate than the well-insulated inner grain. This results in temperature gradients in undisturbed and un-aerated stacks, with the interior maintaining warmer temperatures. Insects will often move toward the warmer middle regions of a grain mass (Flinn et al., 1992).

MOISTURE MIGRATION

The temperature gradients in grain mass cause an internal airflow. Colder air has a higher density than warm air and will tend to fall down and displace the warm air causing an air current that circulates in loops from the colder outer regions to the warmer inner core. The cold air gradually warms and rises and as it is forced out it takes up humid air. The humid air then starts to cool as it reaches the surface and its capacity to hold moisture reduces depositing the water on the surface areas. This process of moving humid air and depositing water at the surface is referred to as moisture migration. Where a peak or ridge forms at the top of the bulk grain this may have the effect of channeling the humid air to the top. The peak acts like a chimney channeling warm air and this leads to an accumulation of moisture on the top forming initial conditions suitable for mold and pest development. On stacks this is remedied by opening the tarpaulins and aerating and drying the surface during the day.

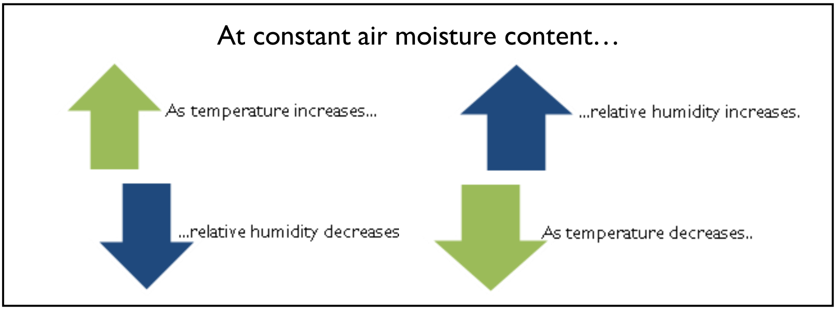
RESPIRATION

Grain is a living organism and it respires – this is why it germinates into a plant. The lower the level of moisture the less active the grain and the less it respires. Respiration emits moisture albeit in small amounts per grain, however large masses of grain all add to the amount of moisture moving within the grain mass. Biological factors such as insects and molds also respire and can add to the moisture being released and migrating through the stack. Additionally insects generate heat and where the insects accumulate the heat generated causes additional warm humid air to move to cooler parts. The problem can continue to worsen if not identified and dealt with at an early stage.

INTERACTION OF TEMPERATURE AND RELATIVE HUMIDITY

If you put grain in a container and change its temperature, it will cause a corresponding change in relative humidity. In cereals, a 10 degree rise will cause an increase of about 3% in relative humidity. Conversely a decrease in temperature of 10 degrees will induce a decrease of about 3% in relative humidity of the air in the container.

Relative humidity is 100% when the air holds as much moisture as it can. This can result in dew or rain if there are temperature changes. Warm air can hold more moisture than cool air. If the amount of moisture in the air remains the same but the temperature changes, then the relative humidity also changes in the opposite way to temperature changes.



A typical example where it is important to consider the effect of likely temperature and relative humidity changes to a body of grain in storage is when the grain is shipped from a temperate country with cool temperatures to a hot tropical country.

For food grains to store well it is best to lower both the relative humidity and temperature. This is achieved by ventilation that is allowing or forcing dry air into the store.

INTERACTION OF MOISTURE CONTENT AND RELATIVE HUMIDITY

All stored grains and their products are hygroscopic, that is, they lose moisture to dry air and gain moisture from humid air until there is no moisture movement (an equilibrium is reached). If the relative humidity of the air is high the grain will absorb moisture. If the relative humidity of the air is low the grain will give off its moisture to the air.

These changes take place very slowly until a new equilibrium moisture content of the grain is reached together with a corresponding equilibrium relative humidity of the surrounding air.

At a moisture content of 14%, most grains have a relative humidity around 70%. For storage pests to thrive other things being equal, the ideal relative humidity has to between 40 and 80%.

In temperate cool regions moisture contents hire than 14% are considered safe for storage while in tropical humid regions storing grain at above 14% is considered unsafe. If grain with a moisture content of 15% is shipped from a temperate country to a tropical country, as the shipment approaches and enters the tropics the grain temperature rises and starts to lose moisture content leading to a rise in the relative humidity The increase in temperature and the rise in relative humidity create suitable conditions for pests and mold development. If this grain is not used immediately on arrival and kept in storage, deterioration will continue leading to total spoliation which cannot be reversed. Even within the country where grain is harvested in winter at high moisture content and stored through summer. The same effect as moving grain from a cool region to a hot region happens leading to rapid deterioration in quality due to mold and insect development. Grain which is going to be stored or moved from cooler temperatures to hot temperature must be dried to below safe moisture levels of the destination country otherwise the grain must be used immediately on arrival.

SAFE MOISTURE CONTENT OF STORED GRAINS

Every type of grain has a safe moisture content level; this is the level of moisture content at which equilibrium relative humidity will not cause the development of insects or molds. At this level or below it insects and molds find it difficult to develop and multiply. The moisture content of grain plays a vital role in the development of agents of deterioration. It is difficult for insects to establish themselves below 9% moisture content, but between 10 and 20% they proliferate. Above 17%, they may start to be replaced by molds.

Safe moisture content levels of stored food grains in bags for Malawi	
Wheat	12.5
Maize	12.5
Sorghum	12.5
Millet/Rapoko	12.5
Beans/Soya bean	11.0
Unshelled groundnuts	9
Shelled groundnuts	7
Sunflower	9.5

Above the safe moisture levels the following infestation will start to occur:

1. Infestation by insects
2. Infestation by fungi
3. Infestation by bacteria

Although the safe moisture content levels for storage could be as indicated above, the industry allows commodities to be traded at levels 2% or more above the safe storage moisture levels. For instance in South Africa, Malawi and Zimbabwe, grain is traded at moisture content levels of 14%. This has erroneously given the impression that it is also safe to store grain at 14%. In considering the safe moisture level you have to take into consideration factors like climatic conditions, storage systems and storage practices. In the tropics the recommended moisture levels is 12.5% for bagged maize and 13.5% for bulk maize. Grain can be stored at slightly higher moisture content in silos because it can be moved from one bin to another to allow for good aeration unlike bagged grain which cannot be moved easily when placed on stacks.

SECTION 3 | CLASSIFICATION OF GRAINS

This section covers the standards, processes and tools involved in classifying grains. It covers how to grade the grain and it provides examples of standards used to determine grades. This section also explains how to take a sample for grading purposes, and it reviews the common tools used to sample and analyze grain.

QUALITY PERCEPTIONS

Different consumers or consumer groups, while intending to use a commodity for essentially the same purpose, e.g. human food, they may have different concepts of what constitutes maximum or minimum acceptable quality. In each case it is the relative importance attached to the different qualities of the commodity which determines its acceptability. One consumer may regard a variation in a particular quality as a defect, while another may not attach importance to it or even regard it as a desirable feature. Traders have to be aware of such differences in "customer appeal" particularly if they deal with a variety of consumers and especially if they are involved in international markets.

In relatively unsophisticated marketing situations the quality of produce is determined on an entirely subjective basis. That is to say both the seller and the buyer depend upon those qualities, which can be judged by sight, smell or touch. Occasionally non- quantitative weight assessment (a commodity may 'feel' light) or sound (quality assessed by tapping or shaking) may be used. If the vendor's stock of produce is of variable quality, such that it does not appeal to certain sectors of the market, they may either reduce the unit price or sort the produce into various categories to be sold at different prices. This course of action will depend on what is practical and economical. This approach is a rudimentary form of grading which is subjective.

FAIR AVERAGE QUALITY

The selling and buying of produce on a Fair Average Quality (FAQ) basis as practiced by many national and international marketing agencies is also essentially subjective. Normally representatives of both the seller and potential buyers take samples from different parts of the available stock of produce offered for sale (which may be scattered on farms or in warehouses throughout the producing area) and submit them under seal to independent assessors (public analysts or the like) for appraisal. After examining the samples by sight, smell, taste and (perhaps) touch, the assessors will select those samples which they consider representative of the samples, mix them together and reduce the lot to a single reference sample which is declared to represent the Fair Average Quality of the sellers' stock. Parts of this sample may be used for certain objective tests, such as determination of percentage moisture content, oil content, free fatty acid content, and bulk density. The main part of the reference sample is retained by an independent agency such as SGS (a commodity inspection company) for a specified period, during which any transaction involving the produce should be completed.

If there is a dispute over quality the independent agency can be referred to for arbitration and the reference sample may be used as evidence. It is important to appreciate that the results of the FAQ assessment relate only to the crop, which has been sampled and for the period agreed upon between the sellers and buyers. If consecutive FAQ samples from the same crop, or from the same growing area in consecutive years, or samples of the same commodity grown concurrently in different areas are compared objectively, significant differences in quality may be revealed. Thus FAQ has a loose definition, and can only be applied when fairly wide variations in quality can be tolerated and agreed upon.

The main advantage of FAQ is that it enables producers to dispose of most of their crop with the minimum amount of trouble and expense. At the same time, the buyer can expect to gain by paying only a moderate price for the crop, although he does run the risk of having to bear the cost of additional processing if quality is in some way short of optimal.

In sophisticated markets objective testing of qualities or factors affecting quality has been developed to such an extent that subjective assessment has been substantially superseded. That is to say 'expert opinion' has given way to the identification and quantitative measurement or description of each quality or factor of interest to the consumer. The assessment of taste and smell, particularly as far as beverage crops (e.g. cocoa and coffee) are concerned, remains the exception to this general observation – but even organoleptic tests may involve scoring methods which are essentially objective in nature.

QUALITY STANDARDS SCHEDULES

A Quality Standards Schedule helps define grades. The schedule lists a set of parameters that should be objectively tested, and it provides a minimum and maximum range of values for each parameter. The minimum and maximum values should not be exceeded for each quality or factor without penalty. Within the set of minimum and maximum values are intermediate values which define the grades within the range. See the EAC maize grading schedule on page 30 as an example.

Quality Standards Schedule is important for the following reasons:

- To ensure that the sector has operational systems and standards thereby reducing variations in quality in the industry
- To have the same basis for negotiations and reducing disputes between buyers and sellers
- Providing a positive basis for relating price differentials to quality and ensure that buyers get value for their money
- For the government to protect the health of its citizens and animals.
- To facilitate stock evaluation in storage
- To comply with government legislation

Different consumer groups may have different concepts of what constitutes optimum or minimum acceptable quality for a particular commodity. Such differences can lead to the establishment of several Quality Standards Schedules, which vary in fundamental details even within the same country. An industry or country which uses different quality standard schedules runs the risk of creating confusion in the commodity sector.

At national level, such a situation can be resolved by establishing a common Quality Standards Schedule, in addition to or in replacement of existing schedules. A solution of this nature is less readily achieved at international level. Differences among national standards can be quite fundamental, and it is fitting that they should remain so if there are sound reasons.

National Quality Standards may be drawn up by a ministry of agriculture, food, or trade. A quasi-government organization such as an Institute of Food Technology or a National Standards Board may serve the same function. At the international level, both the International Organization for Standards (which represents the interests of national standards boards, institutes and ministries) and the United Nations Codex Alimentarius Commission (established under the FAO/WHO Food Standards Program) are striving to attain uniformity.

COMMON GRADING FACTORS

When classifying grain there are grain characteristics which have to be analyzed and quantified. The following is a list of common grading characteristics, their descriptions and how they are determined. It is important for a grader and storage practitioner to understand them since they also form part of the basis of grain handling and storage management activities.

i. Moisture Content - The amount of moisture contained in grain expressed as a percentage of the weight of the grain. (see page 8)
ii. Foreign Matter - These are substances that are not the actual commodity, this can include straw, husks, stones, pieces of cob, dust, and other rubbish. Foreign matter can also be referred to as extraneous matter.
iii. Trash - Any vegetable matter other than grain which will not pass through a grading sieve.
iv. Defective grain - Grain that is discolored by heat, fermentation, germinated, weather-damaged, visibly infected with fungus or virus, immature or insect damaged grain.

v. Discolored - Grains which is markedly discolored by weathering or by heating caused by fermentation but does not include other colored varieties

vi. Insect damaged grain - Grain which has been attacked and damaged by any insect or animal pest

vii. Diseased - Grain visibly infected with fungus or other agents

viii. Chipped grain - Grain which has been chipped or cracked.

ix. Broken grain - Grain and pieces of grain which will pass with thorough shaking through the grading sieve

x. Germinated grain - Sprouted grain in which the process of germination is visible within the embryo

xi. Shriveled grain- Grain which is shriveled over its entire surface and the embryo area.

xii. Stained grain - Grain which is stained by soil or any foreign agent but does not include discolored grain

xiii. Other colored grain- Grain of a color or partly colored grain present in grain other than the grain being analyzed.

xiv. Undeveloped grain - Grain which is thin and papery in appearance which is small and wrinkled

xv. Stones - Any mineral material which will not readily disintegrate or dissolve in water.

xvi. Contaminant – Foreign substances or chemicals in the grain. This mainly includes soluble elements which cannot be removed like excretions of pests and other animal and plant material, pesticides, oils, pathogenic organisms, toxins from fungal infections.

xvii. Test density/weight - Is a measure of grain bulk density, it is an indicator of general grain quality. Kg/hectoliter is used to measure the test weight.

GRADING EQUIPMENT

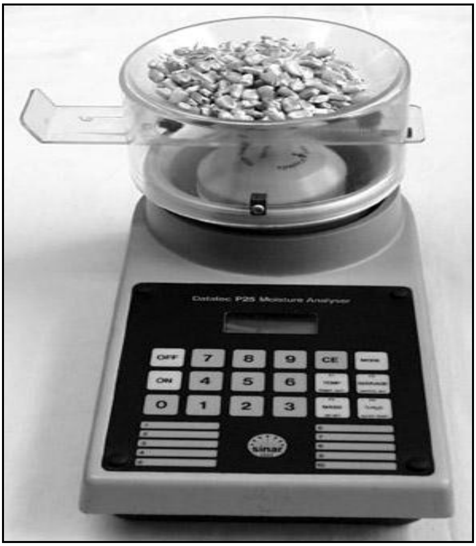
The classification of grains is done using specialized equipment. With the advent of computers advanced electronic equipment is now available for measuring the characteristics of grain. In most developing countries, conventional methods of grading and equipment are still in use.
The following section describes the commonly used grading equipment for grains.

MOISTURE METERS

Although there are other laboratory methods of measuring moisture content, moisture meters are commonly used to determine the moisture content in grain. Most moisture meters are portable, simple and quick to use.
There are two types of moisture meters: **resistance meters** and **capacitance meters**. Both types work by measuring the electrical characteristics of grain which vary due to the amount of moisture content in the grain. The electrical characteristics also vary due to the degree of grain compaction and temperature of the grain. The difference between a resistance and a capacitance moisture meter is that a resistance meter measures the resistance (conductivity) of grain and a capacitance meter measures the dielectric constant of the grain.

Good moisture meters must compensate for different temperatures between the grain and the meter (however it is advisable to allow the moisture meter to adjust to the ambient temperature by leaving it for 30 minutes where testing is going to occur). Resistance moisture meters require a ground sample and test the internal as well as the external levels and are therefore said to be more accurate. As result they are suitable for testing grain coming off a drying floor or machine.

Resistance moisture meter



Capacitance moisture meter

METER-RELATED TERMINOLOGY

Repeatability	This is the ability of a meter to give the same reading when the same sample is tested several times. Capacitance meters, due to packing variations in the grain compartment may not produce repeat and reliable results as resistance meters, which normally use a more homogeneous ground or compressed sample.
Ambient effect	This refers to temperature correction. As meter readings vary with temperature, a correction is required. Modern meters include this correction in the indicated moisture content.
Calibration of moisture meters	Before using a meter it is important to ensure that it is calibrated to measure the moisture content of the commodities to be tested. A calibration check should be done at least once a year.

Moisture meters measure the electrical property that is related to the moisture content. The relationship between the electrical property and moisture content varies, depending on the type, variety and condition of the grain being measured. In many cases therefore it is necessary to calibrate the relationship between electrical reading on the meter and the actual moisture content. To achieve this, a set of samples of the grain are conditioned to a range of moisture content which are measured accurately by the oven method (accurate to +/- 0.1% moisture content). The moisture content and the corresponding electrical readings are plotted on a graph. (For further reading on this refer to Moisture Meter Calibration: A practical guide, N.R.I, M.C Gough)

In classifying commodities, the moisture content does not determine the grade but is only used to reject or accept the commodity into storage. When the moisture content has been determined, reference should be made to the grading schedule to determine if the reading is below or above the acceptance standards. The level of moisture content can also be used to make weight adjustment when calculating the net weight of the commodity. The East African Community (EAC) moisture acceptance level is 13.5% for maize; above that the consignment is rejected.

RIFFLE DIVIDER

The purpose of a riffle divider is to divide a sample into three similar samples from a larger sample. The riffle divider is the simplest of sample dividers recommended by the International Standards Organization. It comprises a funnel arrangement and three sample boxes, each identical in size. The rectangular-mouthed funnels are arranged side-by-side so that alternate funnels lead to opposite sides. The funnel assembly is fitted inside a box which is open at the bottom. It is so designed that the funnel assembly box sits on any two sample boxes whilst the third is used to pour a sample through the hopper. Splitting of samples is accomplished by pouring a sample into the hopper from which it is divided by riffles into two equal parts by a series of chutes and discharged into two pans.

SAMPLING SPEAR (ALSO KNOWN AS SAMPLING PROBE OR GRAIN SPEAR)

A sampling spear is a hollow metal tube sharp at one end used to extract grain samples from a bag. The sampling probe/spear has holes along one side to allow in grain when inserted into a bag. The probe is pushed into the bag with holes facing down and when the probe is inside the bag it is turned half circle so that the holes face upwards. As the probe is turned this allows grain in the middle of the bag to enter into the probe through the holes. The probe is then pulled bringing out grain from across the bag.

SIEVES

These are handheld sieves used for screening grain on the basis of size. A sieve for each grain type has a specific perforation size. Usually every sieve type has a tray at the bottom to hold material passing through the sieve.

TEST WEIGHT APPARATUS

This a special instrument for measuring the test weight of grain, commonly for wheat. Grain for testing is placed in the hopper. When the gate is opened, grain drops into the kettle, fills it and flows over the sides. The grader strikes off the top of the kettle with a leveling stick and weighs it giving the measurement in kg/hectoliter. Some advanced moisture meters determine the test density automatically when analyzing moisture content.

SAMPLING

Sampling is an activity which is critical in the grading process and it is important that its purpose and process is well understood. Sampling is described as the process of selecting units from a population of interest so that in studying the sample one may fairly generalize the results back to the population from which they were selected. The following are three reasons for sampling commodities:

1. Bagged or bulk commodities are not always uniform in quality even if they are in a condition which satisfies consumers. Various reasons can cause grain not to be consistent within a consignment, this can be due to the fact that the grain is harvested from different parts of a field, or that it has been damaged or affected by other agents like heat, moistures and the grain/bag is mixed together. In such a case the only certain way of getting information about the commodity is to examine the whole consignment. However, such an exercise is only practical if the

consignment is small. Where the consignment is large, extracting a sample and analyzing it is the only option.

2. Traders in grains do not always have the opportunity to see the commodities before agreeing to purchase them because the cost in terms of time and money spent travelling is high or contracting a local representative to inspect the grain can be inhibitive. It is simpler and cheaper to ask the seller to submit a sample and include clauses in the purchase agreement which protect the buyer in the event the actual consignment differs from the approved sample.

3. Some of the methods used to examine or analyze commodities damage or destroy the packaging of the grain. Sometimes the packaging might be rigid such that total examination of the contents is not possible. In these cases sampling is an appropriate option.

PRINCIPLES OF SAMPLING

Sampling is a scientific process which has specific steps and principles which must be followed. The following are key ones.

1. *The consignment should be divided into primary units of equal size or status, any or all of which may be sampled. In the case of bagged grain individual bags can be regarded as primary sampling units.* For bulk grain, the primary units may be expressed in terms of weight if the commodity is being moved or volume when the commodity is static in a truck or bin.

2. *All primary units should have an equal opportunity of being sampled.* This is possible during the construction or breaking of a stack, the loading of trucks or when bulk grain is being moved. It is not possible to get a representative sample if the grain is stacked or in a bin. Where it is not possible to get a representative sample as in a stack, samples should be taken from accessible primary units as far as is possible in accordance with other principles of representative

sampling and this should be stated in the documents accompanying the sample.

3. *The method of selecting primary units for sampling should permit a sufficient number to be selected so as to be representative of the consignment and be free from bias.* In the case of bulk commodities which are being moved, at least one primary sample can be taken from each primary unit. In the case of bags a statistical scheme for selecting a proportion of the primary units must be used. The international Standards Organization (ISO) has the following recommendations of units to be sampled in batches of different sizes.

How to determine the number of units to be sampled from batches of different sizes

Number in batch	Number to be sampled
Up to 10	Every unit
11 to 100	10 drawn at random
More than 100	The square root of the total number of units drawn at random according to a suitable scheme

Once the required number of primary sampling units has been determined, the actual units must be selected, ideally at random.

4. *Primary samples should be extracted from primary units in such a manner and of such a size, as to be representative of the consignment.* Standards established by government will usually stipulate what the measuring standard is. Some sampling equipment and methods are more efficient than others in obtaining representative samples. If the sampling method is not established by the government then you must choose a method that is efficient and that ensures you get a

sample that represents the entire consignment; avoid disproportionately representing the consignment with a small sample.

TERMINOLOGY

Primary samples are the initial samples obtained from the primary unit. If samples are taken to determine the extent or distribution of insects the samples should be packed and kept separate. However, primary samples for determination of quality are usually mixed together to form the *bulk sample*. This may be subdivided or reduced to the required number of *submitted, final lot or laboratory samples*. In the laboratory the submitted sample may be further divided or reduced to one or more *working samples*. Sometimes duplicate samples may be set aside as *file reference samples* which may be analyzed at a later date if there is dispute over the first set of results. Samples which are kept for later analysis should be placed in air tight containers.

SAMPLE SIZE

Primary samples for free-flowing commodities (cereal grains, pulses, etc.) should not be less than 1 kg. For commodities that are not free-flowing (e.g. small packs) the primary sample should not be less than one item (e.g. one small packet of flour) if each item weighs more than 1kg. *Submitted or final lot samples* should never be less than 1 kg.

It is important to note that whilst the principles of representative sampling can be used in establishing a basic sampling scheme for a wide range of commodities there are occasions when more specialized schemes are needed, for example when samples are required for mycotoxin analysis. It may be necessary to increase both the number and size of the primary and submitted samples.

GRADING PROCEDURES

The following section describes how to grade maize based on the East African Community Trade Quality standards. For one to be proficient in grading one needs to work through this with a trained and experienced grader. Grading schedules are not the same for all countries, so it is important that the correct schedule is used. More schedules for other grains for other specific countries can be found in Appendix 4.

MAIZE GRADING PROCEDURES

GRADING PROCEDURES

1. Obtain a representative sample of not less than 1 kg
2. Check for infestation and record accordingly.
3. Mix and quarter
4. **Moisture level -** Use 100 grams to test for moisture.
5. Take 500 grams from the original sample and mix and quarter to obtain a working sample of 200 grams
6. Transfer the working sample to a No. 6 sieve and thoroughly sieve the grain by shaking making sure that the material which falls through the sieve is captured.
7. **Broken grain -** remove by hand any broken grains and grain fragments add the material which passed through the sieve in stage 7 and record the weight.
8. **Pest damaged grain -** remove any pest damaged grains and record the weight
9. **Rotten, diseased, and discolored grains -** remove by hand any rotten, diseased and discolored grains and record the weight
10. **Colored grains** - remove by hand any other colored grains and record the weight
11. **Foreign matter** - remove by hand any foreign matter and record the weight
12. Determine the percentage of broken, pest damaged, rotten etc, foreign matter and classify

Counting, Result Reporting and Interpretation

Different characteristics of grain are determined as a percentage. The national grades or the trader will stipulate what is acceptable. For instance 3% pest damaged grains. Where a more thorough analysis is required like resolving quality disputes, a working sample for each parameter should be obtained from the main representative of 500 grams and analyzed.

EAC TRADE QUALITY STANDARDS FOR GRADE 1 AND 2 MAIZE (KENYA, TANZANIA AND UGANDA)		
Purity Attribute	Maximum percentage or quantity by weight	
	Grade 1	Grade 2
Foreign matter (max %)	0.5%	1%
Broken maize (max %)	2%	4%
Pest damaged maize (max %)	1%	3%
Rotten and diseased maize (max %)	2%	4%
Discolored maize (max %)	0.5%	1%
Moisture content (max %)	13.5%	13.5%
Aflatoxin level (ppb)	< 10 ppb	< 10 ppb

Source: East African Community; A Guide for Maize Traders on Regulatory Requirements for Imports and Exports of Maize in The East African Community 2005/2006

TESTING FOR AFLOTOXIN

Molds are spread by spores which often cannot be seen by the human eye. They are in the soil, on plants, in the air, left on old bags, or in poor storage spaces. When these spores fall onto moist grains, under warm, humid conditions, they start growing. As these fungi grow, they release poisons called mycotoxins. There are over 500 types of mycotoxins, but the most important in maize are produced by *Aspergillus, Fusarium*, and *Pencillium* species. These fungi species occur naturally in the soil throughout specific latitudinal zones which include Eastern, Western, Central and Southern Africa.

The most dangerous mycotlotoxin, aflatoxin – which can cause death or long-term health problems in both humans and animals – cannot be seen by the human eye, and only special tests will show its presence. Important control mechanisms include post harvest handling, storage and biological control technologies which work to prevent the production of mycotoxins.

Biological control technologies to eliminate harmful mycotoxins in the soil are being developed in the region. Once aflatoxin is produced on or in the grain it is not destroyed by cooking or heating the grain. The only way to prevent these fungi/molds from growing and spreading is to dry the grain quickly at harvest to moisture levels of less than 13.5% and to keep the grain in clean bags, in dry conditions and off the ground of the storage space. There are a number of different ways of testing for aflatoxin ranging from the simple kits which give simple yes/no answers to full analysis which provides the exact amount present and identifies the different types of aflatoxin (and other mycotoxins). The advantages of kit testing are that it is quick to use, does not require a full laboratory with trained lab staff and is relatively inexpensive. Aflatoxins have been found in all grains; however they are more prevalent in grains such as maize and ground nuts.

Testing for aflatoxin *Courtesy of Iowa State University (2009)*

There are two primary types of 'kit' screening tests available: commercial test kits and black light tests. The black light (ultraviolet light) test is a visual inspection for the presence of a greenish gold fluorescence under light at a wavelength of 365 nm (nanometers). This generally needs to be done in dark conditions. The greenish gold fluorescence looks like a firefly glow. More than four glowing particles per 5-pound sample (before grinding) indicate a likelihood of a +20 ppb (parts per billion) level of aflatoxins. However, remember that this test is an initial screening for the presence of aflatoxin and the results should be verified by laboratory analysis. If there are less than four glowing particles per 5 lb sample, this does not guarantee that the sample is free of aflatoxins.

Commercial test kits with immunoassay or ELISA techniques are available for on-site tests for aflatoxin. Protocols developed by CYMMIT and ICRISAT testing using the ELISA procedure can be found on the following web site: http://programs.ifpri.org/afla/afla.asp. Immunoassay analysis is based on the detection of specific proteins found in aflatoxins using antibodies to identify these proteins. The tests are very specific for aflatoxin, but they require operator training and practice to be accurate. Some tests determine only the presence or absence of aflatoxin; others can quantify, within a range, the amount of aflatoxin present. If a lot of maize is rejected based on the results of an immunoassay test kit, the results also should be confirmed by laboratory analysis. The entire sample should be ground before removing a subsample for the test kit.

1. ENVIRONMENTS THAT ENCOURAGE AFLATOXIN DEVELOPMENT

For these fungi and molds to grow, they require the following environment:

- Moisture content of 14-30% in grains
- Temperature range of 10-40 degrees C.
- Relative humidity above 70%
- Unclean environment
- Prolonged rains after crop has matured preventing harvest
- Periods of drought stress while the plant has been growing

2. KEY STEPS THAT PREVENT AFLATOXIN

1. To avoid the growth of the fungi and molds which produce mycotoxins, dry your grain quickly at harvest and very well before storage, and keep it in a dry and clean and well ventilated storage area.
2. Avoid insect and rodent damage which can open up the grain by offering easy access to grain by fungus and mold.
3. Avoid contact of the grain with the soil.
4. Do not add water to the grain to add weight before the sale.
5. Handle the grain carefully when harvesting and moving.
6. Store grains in clean sacs on pallets.
7. Ensure sacks are in good condition, are full and well closed so grain does not fall out and it is more difficult for rodents to get in.
8. Ensure that no grain is left on the ground in the store.

FINAL GRADING REPORT

Having made all the tests and analysis and recorded them on the commodity receipt, the grader should note whether the commodity meets a grade the warehouse is storing and signs the receipt accordingly. If the grader has to reject the commodity, the grader then issues a rejection certificate.

SECTION 4 | STORAGE STRUCTURES AND SYSTEMS

For our purpose we will divide storage structures and systems into two, traditional methods and modern methods. Traditional methods vary from storing on the floor to storing in the crib; modern methods vary from the small drum and bags to the complex silo.

Modern systems can be categorized as farm level or centralized storage. Farm level storage is designed to meet the needs of the household and market grain at a local level, while the second level is designed to meet the needs of commercial and food security needs of large populations.

The storage arrangements and methods currently in use in many societies are the result of age-old experience and tradition and have become perfectly suited to local conditions. Each type of grain storage arrangement must undergo continued improvements in order to give commodities the greatest protection against pests and adverse environment.

TRADITIONAL METHODS

More than three-quarters of the agricultural output of African smallholder farmers is kept at village level for local use and stored using traditional methods. Storage at the household level offers several advantages:

- It stores food close to the majority consumer
- It gives farmers easy access to their assets and facilitates sale transactions
- It does away with transport and handling costs and eliminates losses which occur at this level
- It serves as a source of information regarding the supply of grain on the market which informs production decisions. If the household storage is still full when farming preparations are underway, this might signal that there is still an oversupply of the type of grain on the market. An informed farmer may reduce his acreage from the over supplied grain to another crop.

The type of foodstuff and the size of the crop to be stored determine the design and capacity of these facilities. Farmers store their crops either outside, suspended or on platforms, or in granaries, or even inside their homes.

AERIAL STORAGE

Unshelled maize cobs and other unthreshed cereals are suspended in bunches or sheaves, using rope or plant material, under eaves, from the branches of trees or the top poles driven into the ground. The grain dries in the air and the sun until it is needed by the farmer for consumption or marketing. The disadvantage is that the grain is exposed to the environment and pests

STORAGE ON THE GROUND

This is for temporary storage, following on immediately from harvesting and lasting only a few days, either because the farmer had not had time to bring in what he has harvested or because he wants to let it dry in this manner for a while when there is no prospect of rain. Storage on the ground is not efficient and not good in tropical areas because of the high incidence of damp. If a farmer uses this method the grain should be placed on a tarpaulin.

PLATFORMS

A platform consists essentially of a number of relatively straight poles laid horizontally on a series of upright posts. If the platform is constructed inside a building, it may be raised just 35 - 40 cm above ground level to facilitate cleaning and inspection. Platforms in the open may be raised at least 1 meter above ground. Platforms are usually rectangular in shape, but circular or polygonal platforms are common in some countries. Grain is stored on platforms in heaps, in woven baskets or in bags. In humid countries fires may be lit under elevated platforms, to dry the produce and deter insects or other pests. Instead of being horizontal and flat, the platform may be conical in shape; conical platforms are pointed at the bottom and are up to 3 meters in diameter. Such platforms facilitate drying because of their funnel shape. At the top they consist of a frame of horizontal poles which is square, circular or polygonal in shape, against which the timbers which form the cone rest. These timbers meet at the bottom on a wide central supporting post.

CRIBS

A distinct improvement on platforms, a crib has ventilated sides made of bamboo grass stalks or even wire netting. It should face such a way that the prevailing winds blow perpendicular to the length.

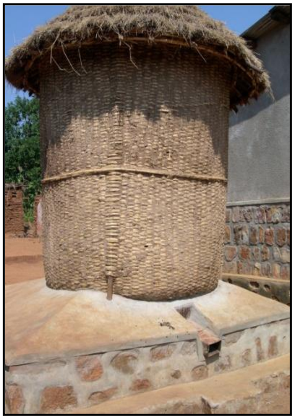
In humid countries where grain cannot be dried adequately prior to storage and needs to be kept well aerated during the storage period, traditional granaries (cribs) are usually constructed entirely out of plant materials. This includes timber, reeds and bamboo which provide good ventilation. Storage cribs made of wood and chicken-wire have been introduced by NGOs. These worked well in Rwanda and rural parts of Uganda but were rejected by farmers in Kenya because the sides made of chicken wire made the contents visible and were easy to steal from. One fault with the pictured crib is that the design does not include rat entry prevention measures.


Grain crib in Rwanda

DWELLINGS

Unthreshed cereals are commonly stored under the roof of dwellings, hanging from the roof timbers or spread out on a grid above the fire, the heat and smoke ensuring that the insects are deterred. These grain reserves are intended for day to day consumption because they are within easy reach and safe from theft and pests.

BANCO GRANARIES



These granaries are made of clay which is sometimes mixed with fragmented plant materials (grass, twigs). In some cases the clay comes from termite mounds. They may also be constructed with clay bricks. They are insulated from the ground by means of wooden poles, clay pedestals or large stones. They maybe either circular or rectangular in shape; in the latter case the inside may be partitioned off into separate compartments. In Senegal banco granaries 3 m by 1.50 m are found with a central corridor leading to slatted trays 80cm above the ground. The paddy sheaves stored in them are dried by means of a fire which is kept burning in the corridor. In some regions, these granaries are covered with a straw roof or built completely of mud. Some are more or less round with the tip pointing downwards and resting on stones. These “banco” granaries are common in Chad, Mali, Mauritania and Niger and are a cheap means of storage well suited to the dry climate of these countries. While some are quite small, others have a capacity of up to 5 tons. Because they can be hermetically sealed, insects are unable to penetrate and find it difficult to develop once inside because of reduced oxygen.

Banco granaries in Kirehe, Rwanda.

The complete lack of ventilation means moisture content of the grain must not exceed 10% and the humidity must be less than 70%. These granaries are not resistant to persistent or heavy rainfall and care must be taken to seal up promptly the cracks which easily form with this type of material.

DESIGNING MODERN STORAGE STRUCTURES

Modern structures should be designed such that they meet certain basic requirements with regards to location, accessibility and use. The following is a basic guide on the requirements of modern storage structures and systems.

BASIC REQUIREMENTS AND RECOMMENDATIONS FOR STORAGE STRUCTURES

1. **Store site**
   - Easily accessible throughout the year.
   - Sited above flood plains and should not be liable to flooding and the area must have good water drainage.
   - Sufficient space to maneuver delivery or collection vehicles
2. **Floors**
   - Above ground level with sufficient elevation to allow drainage
   - Crack-free reinforced concrete
   - Vapor proof barrier under the floor and up to the walls to prevent dampness rising in the walls from the ground
3. **Walls**
   - Inside surface must be plastered with cement/sand and mortar (essential for cleaning and pest control)
   - Outside surface must be plastered with cement, lime and sand (helps in keeping the store cool and easy to clean)
   - Have windows or openings for ventilation designed not to allow birds or rats to enter
   - Have at least two doors wide enough to allow loading in and out.
   - Painting the bins and or walls white (both inside and outside) can reduce the heat absorption by the walls and this can lower temperatures by up to 5 degrees and makes observing insect infestation easier.
4. **Roof**
   - Must not have any holes of leaks

- Must be designed to shed water quickly without leaking
- Must keep out pest like rodents, birds, insects, dust and heat
- Roof overhang at eaves level should be sufficient to shed rain-water clear of walls and help to keep the walls cool
- Gutters and draining pipes are not always necessary they get blocked and allow rodent entry in not properly managed

5. **Doors**
    - All doors must be secure and rodent proof
    - Doors must be large enough to allow for loading in and out and positioned for better inventory management and supplementary ventilation
6. **Ventilation**
    - Necessary for the reduction of humidity which encourages pest development. Large doors can provide sufficient, controllable ventilation in the absence of eaves-level ventilation in stores that are regularly opened daily when full.
7. **Pest Proof**

    Complete exclusion of pests is difficult but all possible points must be screened with expanded metal mesh with holes not exceeding 6 mm. Windows should also be screened if they are less than 1 meter from the ground since rodents can jump this height.

    - Granaries and drying platforms should be erected on large stones or platforms (which must be at least 80 cm high)
    - They should be reinforced with conical rat guards made of 0.50 mm thick steel plate, 25cm in diameter
    - Buildings must be protected by ensuring that all the means of access close properly and are made of materials that are resistant to attack
    - Rodents must be prevented from climbing along the posts, pipes, cables and rails in contact with the building and guards must be fitted to all these possible means of access
8. **Hygiene**
    - As with any grain warehouse, the interior should be designed and built to facilitate cleaning

ON FARM MODERN STORAGE

On farm storage is designed to handle and store production from the farm and will consists of small to medium structures like drums, cocoons, platforms, farm stores, communal warehouses.

METAL SILOS

Metal silos (including recycled oil drums) have emerged as efficient and low cost storage containers for the storage of cereal grains and pulses. Inaccessible by rodents, efficient against insects, sealed against entry of water, drums make excellent grain containers. However they should be protected from direct sunshine and other sources of heat. To avoid condensation they should be located in shaded and well ventilated places.

Metal silos for grain storage in Mbeere, Kenya (Photo by Guantai S.M)

HERMETIC COCOONS

A relatively new development is the hermetically sealed bag or cocoon of various sizes (1 – 300 metric ton), which appear to offer good possibilities to store grain in a variety of quantities. These cocoons are being used in Kenya with some success. The hermetic bags work on the principal that grains releases carbon dioxide which rapidly replaces the oxygen in the sealed container. Once oxygen is exhausted, the pests die and fungi cannot spread. For these sealed units to work effectively they need to be completely filled quickly and only opened when the entire contents have to be used.

FARM STORES

Smaller stores are built with timber on a raised platform. The supporting poles should have rodent proof fixtures to prevent rodents from climbing or jumping into the store. Larger stores may be constructed using iron sheeting or concrete and should meet the following standards:

- The floor of the inside of the store should be above the level of the ground outside (to prevent dampness and rain entering).
- Ideally there should be damp proofing under the floor and in the walls.
- Ventilation points should be placed in the walls – these should be covered with screens to prevent rats, birds and insects entering.
- The store should have a large well fitting door to allow carrying bags in and out of the store and for allowing good aeration.
- The stores should preferably be built a distance from the residential house so as to avoid fumigants and other storage chemicals filtering into the residential dwellings.

Typical farm store. Note: rat guards on upright poles (Photo by Guantai S.M)

COMMUNAL WAREHOUSES

Where farmers come together in formal groups they often consider establishing communal stores that are managed by a trained store manager. The individual farmers can consolidate their stocks ready for the market by delivering to the communal store. This arrangement may be the better option for small holder farmers who do not have the capital to put up own stores, have limitations of land available for the store or do not know how to store commodity well for extended periods of time.

These stores work extremely well as bulking centers where large traders come and pickup truck loads of commodity (preferably of the same quality) at one time. The advantage to the big buyer is the reduction in the cost of buying through multiple aggregate traders with their multiplied handling costs.

A typical community store (Photo by Guantai S.M)

FLATBED WAREHOUSES

The majority of warehousing in Eastern Africa entails flat bed warehouses in which the commodities are stored in bags on pallets in large stacks. These warehouses range from 2,000 to over 15,000 tons. Essentially they are larger versions of the communal warehouse. Generally they will have more than one set of doors for access. Any ventilation openings under the eaves should be covered with screens that keep out rodents, birds and insects. Often there will be a separate grading room as well as an office for record keeping.

OPEN STACKS

This form of storage has been used successfully in Zimbabwe in the late 80's and early 90's. With proper planning, careful preparation and the right management this form of storage can fill in the gap where there is a huge shortage of storage space. In this form of storage quantities of upwards of 5000 tons can be stored for periods of up to 2 years or more. The other advantages are that the initial investment is very low and local materials can be used in preparing the stacks and the stack can be constructed anywhere, as long as the place is secure and the ground is suitable..
The disadvantages are that it requires good security especially when there is a shortage of grain in the community. It requires trained and experience personnel to construct the stacks and the preservation of quality through pest control. Special bags which are strong and UV protected have to be used and if the grain is to be stored for long periods. The stacks can be constructed with channels to improve ventilation.

GRAIN SILOS

Silos are an efficient method of storing grain; bulk grain takes less space and can be handled mechanically reducing bagging and handling costs. Recycling grain in silos helps through aeration to reduce potential increases in grain temperature. This is essential in silo management. The importance of managing the temperature of grain is further explored in section 2.

There are different types of silos of various sizes for storing grain in bulk. Silos are either constructed from concrete, bricks or sheet metal bolted together. Bolted corrugated steel silo models are becoming popular in most grain producing countries because they are effective and relatively cheap.

The disadvantage of bulk facilities is that in the case of underutilization they cannot be used for other activities.

Farm silos (Photo by Guantai S.M)

SECTION 5 | WAREHOUSE MANAGEMENT

Once grain is received, sampled, weighed, graded and stacked, it is critical for warehouse managers to maintain the quality of the consignment and minimize losses. This short section provides several lists of good management practices.

What are the requirements for effective storage management?

- Good storage site
- Produce in a suitable condition
- Intake orderly and controlled
- Storage period controlled
- Quality maintenance ensured
- Security against theft and loss
- Any loss identifiable and accountable
- End use requirement is satisfied

Warehouse management covers the organization and management of commodities in a warehouse. Most of the technical issues which have to be managed in a warehouse have been covered, such as factors that affect grain in storage, hygiene, stock control and stacking. How these issues are organized plus labor supervision and other administrative issues enables a warehouse operator to run a warehouse more efficiently and try to achieve the following objectives:

- Know the quantity in store at any given time
- Reduce grain loss in storage
- Quickly recognize causal agents of losses
- Control agents of losses.

Although technical issues mentioned above cut across the storage discipline, storage management is divided into the following areas:

- Receiving the commodities into the warehouse
- Stacking and stock organization

- Inspection for deterioration
- Controlling or inhibiting deterioration and loss
- Disposal of commodities
- Labor management

INSPECTION FOR DETERIORATION AND LOSS

Time must be set aside for a really good inspection, preferably at weekly intervals. No more than between 1% and 2% loss in staple grain commodities in store is acceptable. An inspection system to detect deterioration or loss is critical:

- There must be a security system to detect theft. This is achieved by putting in place professional security services and a proper record keeping system and monitoring.
- The sampling and inspection system must detect early water entry, heating, insects and rodents. This is achieved by having the correct equipment, trained staff and monitoring.
- Commodities must be inspected during intake, this provides a base-line to later evaluate and provide a "feeling" of what might or could happen during storage.
- Stocks must be examined frequently and thoroughly. A quick look around is usually a waste of time.

CONTROLLING OR INHIBITING DETERIORATION AND LOSS

- Efficient stacking, stock control, hygiene and inspection are the most important tools in controlling and inhibiting grain losses. The rule should be *a gram of prevention is cheaper than a kilogram of loss*.
- Theft - Know your staff, employ trustworthy Supervisors and Guards. Clearly designated staff must be made responsible and accountable for losses. Staff should have clear areas of operation and should have no need to be in areas they do not work in.
- Water - Check leaking tarpaulins in open storage, drainage of store, and condensation in store, trucks and wagons.
- Insect and rodent damage - Check daily sweepings for rodent droppings, insects feeding, and dust and moth webbing on stack surfaces.
- Inspect floors and walls of store as well as commodities.

DISPOSAL OF COMMODITIES

- This is usually a very lengthy procedure. Ideally it is best to have a separate store bay where deteriorated commodities can be fumigated separately and the sheet left in place. The use of separate "disposal store" is preferable.
- A record of disposed stocks should be kept separately and inspected frequently.

DISPATCH OF COMMODITIES

'First in, first out' (FIFO) should be the rule unless the customer insist on a new crop and is paying a premium. The FIFO rule is easy to apply if different stocks of the same commodity are stacked separately. If shortage of space makes it necessary to stack different stocks of the same commodity more or less continuously, each stock should be on a distinct section of the stack.

All dispatches must be in sound bags, suitable to withstand the journey to the market. Commodities in badly damaged packaging must be re-bagged before release, they should not be issued and transported as excessive spillage and perhaps contamination may occur during transportation.

LABOUR MANAGEMENT

It is the responsibility of the storekeeper to ensure that staff working in the store are adequately informed, trained and supervised, particularly with regard to handling commodities and their own safety. Staff should also be made aware of any pest control treatments that are in use or going on and the potential hazards associated with them.

Staff should be adequately protected by wearing protective clothing for their own safety and that of commodities in storage. The right tools for use by staff should be available. Important items include: brooms, dustpan and brushes, refuse bins, sieves, simple tools and repair materials, a good battery operated torch (for inspection of commodities) and suitable weighing equipment. These items should be part of warehouse tools and should be made available before the buying season starts.

REPORTS

Detailed reports may or may not be called for by other stakeholders, but the storekeeper should maintain accurate reports on stocks and activities in the warehouse. He should be encouraged to make brief and accurate reports whenever he observes any signs of serious stock deterioration, structural faults in the store or labor difficulties. The problem and the action to be taken must be clearly stated.

SO, WHAT DO WE HAVE TO MANAGE?

- Staff — clerks, laborers, drivers
- Customer — purchasing, selling, (public relations)
- Resources — stores, equipment, vehicles
- Commodities — grading, safe handling, losses, storage
- Services — pest control, inspection, security
- Budget — running costs, capital expenditure
- Accounts — purchases, sales, wages
- Policy — procurement, distribution

INSPECTION METHODS

Here again we repeat the mantra:

A gram of prevention is cheaper than a kilogram of loss.

Warehouse inspection involves a detailed examination of the commodities in storage and the warehouse facilities. The examination of the commodities themselves may, or may not, include the taking of samples for analysis. The overall objectives of inspection are to provide information as a basis for management action and future planning and to ensure that deterioration and loss of stored commodities are kept to a minimum.

Inspection and sampling work calls for the exercise of judgment based mainly on experience and a thorough knowledge of the nature and characteristics of the commodities and the conditions under which they are stored. The past treatment of a commodity, the expected storage period and

its future destination or use may influence the methods of inspection and sampling adopted.
The objectives of a particular inspection must be clear. These could be:

- To ensure that grain procured conforms to prescribed standards
- To determine the suitability of a store for long term storage of food grains and recommend essential repairs
- To assess the condition of grain in store and to determine the need for pesticide treatment
- To determine the quality of a consignment of grain and assess its acceptability for human consumption.
- To ensure that personnel are observing statutory safety precautions.

EFFECTIVE INSPECTION

The personnel responsible for inspection must be adequately trained and equipped. They must be able to record their observations accurately and interpret the observations and take necessary action. A thorough knowledge of a particular storage system and the defects that are likely to occur is needed and can only be acquired by experience. Similarly, the characteristic of stored grain must be understood so that any departure from normality can be recognized.

INSPECTION OF TRANSPORT

Though this section focuses on inspection at the warehouse, inspection should also occur of the transportation being used. A carriage vehicle designed to carry commodities is a form of moving storage (storage on wheels) and should therefore be secure, dry, clean, free from pest infestation and able to provide protection against adverse climatic condition. All forms of transport should be inspected to check on these factors before use and rejected if found to be inadequate – after all, poor grain quality resulting from water on the floor of the truck may be blamed on the store rather than the truck.

In most cases the depositor is responsible for the reliability of the trucks sent to collect the grain from the warehouse – however the warehouse supervisor has the right to reject unsuitable vehicles to protect his reputation as a store keeper.

In instances where transport is sub-contracted the appropriate contract terms and conditions will normally specify the responsibilities of the contractor with respect to documentation, security and fitness to carry grain.

INSPECTION OF STORAGE BUILDINGS

The quality of food grains can be adversely affected directly or indirectly by the design and condition or location of the building in which it is stored. Security of stocks from theft or other forms of loss and the health and safety of persons in or near the building may also be affected. It is therefore important that buildings are regularly inspected to ensure that standards are maintained. It is also important to plan improvements and maintenance prior to the harvest periods and plan that the work will be completed prior to harvest and the store being needed.

An inspection of storage buildings will cover the whole site, the external and internal structure and a review of the standard of house-keeping and hygiene. The following questions are important both as a depositor considering using a warehouse in the coming season and the warehouse operator. A warehouse inspection check list can be developed from this:

Warehouse site

- Is the site generally clean and tidy
- Is there a suitable arrangement for the disposal of rubbish?
- Are the roads and access areas in good repair?
- Are the areas adjacent to the warehouse clear of vegetation, refuse, equipment and machinery?
- Is there evidence of rodent activity?
- Is drainage and flood water disposal satisfactory?

Warehouse-external

- Are walls structurally sound?
- Is the roof in good condition?
- Are windows and ventilators in good condition and screened to prevent access by birds and rodents?
- Are doors sound, well-fitting and secure?
- Are there rodent barriers in good condition and in place?

- Are rainwater guttering and drain pipes secure, functioning and screened against birds and rodents?
- Are eaves and guttering free of birds' nesting materials?
- Are service duct entries (water, electricity) screened against birds and rodents?

Warehouse internal

- Are walls structurally sound, clean and as smooth as possible?
- Is the roof inside in good repair?
- Are windows and ventilators in good condition and screened to prevent access by birds and rodents?
- Are doors sound, well-fitting and secure?
- Are rodent barriers in good condition and in place?
- Are internal drainage pipes functional and in good condition?
- Are concrete floors smooth and crack-free?
- Is there any evidence of insect infestation?
- Is the lighting adequate and functioning?
- Is the equipment in working order?
- Have the scale and (if available) weighbridge been recently calibrated?
- Have spare parts (eg batteries for moisture meters) been replenished?

General information

- Are licenses current and will they cover the storage period?
- Are the insurances current and will they cover the storage period?
- Does the warehouse have suitable staff?
- Is there any need of additional staff training?

INSPECTION OF COMMODITIES IN STORE

This involves taking an in depth look at the commodities, the packaging and the stacking arrangements in storage. The basic tools required for inspection comprises a notebook, flashlight, knife, sampling spear, sample bags, labels, sieves and a hand lens. Effective inspection depends upon access to all parts of the store. For stacked commodities there is need for sufficient space around the stack to examine the sides and the top surface. The best time to inspect commodities is when it is being moved into or out of the warehouse because all parts of each lot can be examined. However, routine inspections of commodities in store are needed to detect any early signs of deterioration.

In the tropics, one of the major causes of loss is insect infestation. The description of methods of inspection that follows concentrates upon the detection of insects, but the principles are basically the same for inspections for other forms of qualitative deterioration.

GENERAL INSPECTION FOR INSECTS/PESTS

Storage insects are mostly small, dull-colored and able to hide well. Only when they are present in large numbers or have moved away from the commodity due to physical disturbance are they readily noticeable.
A torch or lamp which provides a powerful beam of light is essential when looking for insects in a dark store. Insects are often induced to move and show themselves when suddenly exposed to bright light, so illumination of the sides of a stack or the spaces between bags will usually reveal insects if they are present. Therefore, if at first no insects are seen, other methods of detection should be tried.

Physical disturbance, such as sweeping likely resting places with the hand or turning the ears of bags may reveal larvae, pupae or adult insects. The stitched overlap of the mouth of the bag should be examined carefully.
The next step should be to move some of the bags on the top layers of the stack as this often reveals free living insects moving in previously completely dark or hidden places. Also if the bags are moved vigorously enough, insects will move out of the bags regardless of light intensity.

During the course of the inspection, supplementary evidence of infestation should be sought. Residual infestations are likely to be found in cracks and crevices in the building structure and in any piles of spillage or sweepings lying around the store. Disturbing suspect materials is usually sufficient to reveal insects, but samples should be sieved if infestation is not obvious.
Other evidence of infestation includes webbing or cast larval skins on the commodity or the walls and floor of the building or unusual levels of 'dust'.

In dimly lit stores, adult insects are likely to be found on floors, walls and superstructures. Moth larvae may be found wandering away from infested produce and settling on corners or crevices to pupate. Anything, which looks like a mass of spiders webbing should be investigated as it may consists of cocooned moth pupae.

Termites (white ants) can be a menace in untreated stores. Their presence is indicated by their earth-covered pathways on floors, walls, dunnage or even the stored commodity itself.

Inspection should also cover identifying rodent activity. This is shown by signs of rat gnawing, droppings, rat tracks and nesting areas. Inspection for rodents should cover adjacent buildings indicating existing and potential access routes.

RECORDING INSECT INFESTATION

A form of shorthand notation is needed to record the results of inspections and the following categories are normally used.

1. Clear (C) - No insects found in the course of a prolonged search
2. Light (L) - Small numbers of insects occurring irregularly
3. Medium (M) - Insects obvious, occurring regularly (sometimes in small aggregations).
4. Heavy (H) - Insects immediately obvious (large numbers crawling over the whole outside of the stack)
5. Very Heavy (VH) - Insects so numerous and active that a rustling sound can be heard inside the stack, carpet of insects or cast skins is often present on the floor round the base or on top of the stack.

In describing the insects found, only general names (e.g. beetles or moths) should be given. If possible, specimens should be collected for identification by a specialist.

SAMPLING INSPECTION FOR INSECTS

Although a general inspection in a warehouse may provide useful information about the nature and distribution of insect infestation, general inspection cannot yield details about the infestation within the commodity itself.

A knowledge of the history of the consignment can help considerably in determining how best to sample for insect infestations. Well-kept stock record cards will provide information when the grain was received into store or when it was fumigated. Having this kind of information can help in determining when live insects entered the store, when cross-infestation happened and the depth of the infestation in the stack.

If the history of the consignment is unknown it may be necessary to conduct a more extensive examination involving the collection of samples from inner parts of the stack or bulk. This is relatively easy in the case of bulk commodities since a spear sampler can be used to draw samples from below the surface. However, sampling deep within a stack of bags involves moving some of the bags. This is satisfactorily achieved only when the stack is completely dismantled. If this is not practical or desirable, a compromise of sampling bags in the top two to three layers has to be accepted.

SIEVING METHODS

Free living insects can be extracted from samples of granular material by using either a bag sieve or hand held sieve. However, in order to obtain maximum extraction of insects it is important that the sieve has a screen of the right specification and that it is properly used. As a general rule, 'fine' sieves for determining foreign matter are also suitable for extracting insects from samples of large grain such as maize. Appropriately fine woven wire screens may be used for separating insects from flour or similar commodities.

The most accurate estimates of free living insect population in granular commodities are obtained by sieving the contents of whole bags. Bag sieves commonly used have a sloping screen about 1m wide and 2 m long under which a tray is fitted to collect the insects and foreign material. The sample is fed directly from the bag onto the top end of the screen or through a hopper and then worked across the screen towards the bottom end where it is guided into a bag.

HYGIENE

The objective of good hygiene is to reduce the use of chemicals in pest control through the reduction of areas where insects are likely to hide and breed. This involves taking care of the building, implementing preventive measures, receiving clean grain and looking after the grain properly in storage and having the right equipment and knowledge to implement the hygiene strategy. Excessive use of chemicals is costly, damages the environment and leaves the grain with a chemical residue. Good hygiene offers many benefits, including that it:

- Keeps the commodity free from dirt and other undesirables
- Prevents the spread of infestation
- Reduces the incidence of chemical residue in stored products
- Reduces the cost of pest control
- Protects the environment from harmful chemicals
- Makes commodities presentable and marketable
- Maximizes the efficacy if insecticidal sprays by reducing dust and dirt which reduces the effectiveness

CONDITION OF BUILDING

The warehouse supervisor should carry out the necessary hygiene checks before the next intake commences preferably when the building is empty. This allows sufficient time to carry out any necessary repairs or make any changes facilitate better storage conditions of the building. If these operations require special finance or expenditure, there will be adequate time to start making the necessary arrangements.

AREAS OF THE BUILDING TO BE CHECKED

Water proofing

- After it rains, are there any leaks in the roof, doors, or windows?
- Are the flow through pipes, guttering and ditches adequate for draining away the water when there is heavy rain? Are the walls or floor allowing damp to rise?

Protection against pests

- Are the anti-rodent guards still in place and in good condition?

- Are there any holes in the floor, walls, doors, windows etc.?
- Have any cracks formed in the floor or walls which can harbor insects?

PREVENTIVE SANITARY MEASURES - CLEANLINESS

- Remove any equipment, utensil or objects which do not have to be housed in the warehouse.
- Thoroughly sweep the floor to remove dust and any rubbish (the latter should immediately be burned)
- Remove spider webs or Lepidoptera silk from the timbers, pillars, walls, doors, windows etc.
- Remove any piles of refuse which could have accumulated nearby.
- Clear the surrounding ground of vegetation and burrows and prune trees that are too close.
- Repaint, if necessary, the walls, doors, windows etc, inside and outside (dark insects are seen more easily on white walls).
- After carrying out any repair works and cleaning shortly before the first deliveries, remove insects from the whole of the inside area (including pallets) by spraying with an insecticide mixture. If some parts of the store are inaccessible, complete the treatment by means of spraying with a fine mist of insecticide mixture
- Clean and remove insects from bags
- Dispose of or repair torn bags
- Fumigate stocks of bags

WAREHOUSE CLEANING REGIME

- Cleaning should be planned and regular.
- Someone should be responsible for sweeping daily.
- Roofs trusses, ceiling and top of walls must be cleaned once a month.
- Crevice in structures where pests might hide should be filled in.
- Clean away debris which may conceal insects or provide food for them.
- Walls and sides of stacks should be cleaned once a week.
- Conveyor systems, rail trucks and handling areas must be cleaned and sprayed with residual insecticide.
- Infested grain deliveries must be fumigated before stacking onto bigger stacks.

SECTION 6 | GRAIN PACKAGING

Adequate packaging can make a major contribution to the reduction of losses and marketing of commodities. This contribution is particularly significant for storage in tropical regions where climatic conditions make food deterioration a great hazard. Properly specified packaging is designed not only to protect the commodities but also to identify, quantify and handle the product.

The main functions of packaging are:

Containment	A quantity of the commodity can be handled and distributed as a unit, which can be measured (weighed) and quantified in terms of number of units.
Protection	The commodity is handled and stored in an acceptable condition before reaching the consumer.
Storage	A bag is a form of storage facility and when properly used as such can reduce losses and improve handling and distribution efficiency.
Distribution	The package facilitates easier transportation, handling and storage.
Provision of information	The type of food stuff, manufacturing batch and date, expiry date, weight, source and destination and method of use can be indicated on the pack.

Packaging material is divided into two types: rigid packaging and flexible packaging.

RIGID PACKAGING

Examples of rigid packaging are wooden boxes, crates and metal containers. These are mainly used for highly perishable commodities because they provide a very good barrier to the external environment which helps to prolong the shelf life of the product. Rigid packaging is not suitable for grains.

FLEXIBLE PACKAGING

This form of packaging is mainly used for commodities with a low water activity like grains. Flexible packaging provides a limited barrier to the environment. It is cheap and easily disposable. The commonly used packaging for grains is a grain bag.

THE GRAIN BAG

The main form of material used for making grain bags is polypropylene and jute, and they are used as woven fibers. Jute is natural fiber and polypropylene is artificial fiber. These two fibers are very flexible and to some extent resistant to tearing and permeability by water or water vapor. Jute was largely used in the past but has since been replaced by polypropylene which is cheaper.

WOVEN POLYPROPYLENE "POLY" BAGS

Polypropylene material provides some resistance to wetting of its contents and does not rot. The poly bag is made from slip-resistant tubular woven material of which polypropylene is a major component (+/-85%). Polypropylene material is liable to lose strength and become brittle through exposure to sunlight. This can be remedied during manufacturing by incorporating an ultraviolet stabilizer which protects the bag from electromagnetic radiation from the sun. If the bag has no UV stabilizer, then it is not suitable for long term storage.

For long term storage, the poly bag is suitable for whole cereal grains except wheat and oilseeds like groundnuts and cashew nuts. Oil seeds and wheat can be stored in poly bags for short periods (3 months). Because the material does not allow air to permeate as easily as jute, heat and moisture build up more easily in the poly bags.

ADVANTAGES AND DISADVANTAGES OF POLY BAGS	
Advantages	**Disadvantages**
1) Slip resistant weave gives the bag its anti-slip properties enabling it to be used on large stacks 2) Easy to sew with machines especially when grain is bagged from bulk storage 3) Not easily attacked by rodents.	1) Restricts air flow more than the jute bag, therefore heat and moisture more easily build up in the bag. For this reason it is not used for large stacks for prolonged periods without building ventilation channels into the stacks. 2) Over time the bag breaks easily due to exposure to the sun unless it has UV protection.

EMPTY BAG WEIGHT

All bags have a weight (tare weight) therefore the gross weight of a filled bag is the weight of the grain plus the empty bag weight. It is advisable to always check the bag weight by weighing about 20 and establish the average weight.

FILLING A 50 KG BAG

The bag must be filled with the correct amount of grain. A fifty kilogram bag should be filled with 50 kg - or close to that - of grain. While farmers who do not have scales must get creative in how they measure 50 kilograms, such as by determining how many 20 liters containers must be filled to measure 50 kg. It is expected that storage facilities have appropriate scales.

TEARING DUE TO OVER FILLING

Grain should be put in clean bags, with no holes. Bags are designed to carry and store a specified weight. If the bag is over filled and carries more than what the bag is designed for, the bag will bulge and tear. This will allow grains to spill out encouraging pests and losses to accumulate over time. Over filled bags also do not stack as well because they do not lie as flat when placed one on top of the next. Therefore stacks become more likely to collapse.

WEIGHING BAGS

Before stitching the bags they must be weighed and an allowance for the bag weight made. This if often done by weighing 20 bags and then getting the average weight.

CALIBRATING SCALES

Weighing scales must be regularly calibrated because use over time causes the scales to become less accurate. The scales should be calibrated before the beginning of the season by a government agency mandated to do so. Warehouse managers should avoid placing a load on a scale larger than what it is made to accommodate, otherwise even slightly exceeding the maximum load of a scale will ruin it.

BAG STITCHING

For hand stitching, bags should be filled to their correct capacity and then the bag mouth should be folded 5 to 10 cm inside to create a “valve” so that grain is not forced out when bags are stacked. The twine should not be tied at both ends so that the stitching can be undone easily by cutting it in the middle and pulling both ends when the bags are being emptied. Thirty two stitches are required for a 90 kg bag. A 50 kg bag should have at least 16 stitches. To close the bags using machines, stitching is made on the hems of the bag. Machine stitching is becoming more popular and can be achieved using hand held equipment.

BAG STANDARDIZATION

Bag standardization is the arrangement where the grain sector agrees to use a specific type of bag. The bag is specific in terms of the fabric strength, quality, volume, dimensions and even the color so that the bag can be easily identified.

The following are the advantages of having a standard bag for the grain sector

1. The bag has a common weight such that the calculation of the weight of the empty bags in a consignment is easily done.
2. Filling the bag without a scale at home is made easier because with experience farmers can gauge the level of grain in the bag that weighs close to 50 / 90 / 100 kg.
3. If standard bags are packed correctly, weighing 10% of a large consignment can give an accurate representative weight of the whole consignment, because the bags have a uniform size.
4. Standard bags lead to improvement in stacking since the bags will be uniform and a well-balanced stack can be constructed.
5. Warehouse operators can reimburse farmers who deliver their grain in them because they also have the confidence of being reimbursed when they sell their commodities
6. Establishing a standard bag creates a viable market for grain bags.
7. The use of standard bag reduces double handling (rebagging) at the warehouse by traders and warehouse operators.
8. Standard bags (such as the 50 kg bag) offer a consistent unit of measure for calculating stocks and dosages for pest control treatments.
9. Using standard bags can be cheaper when supplied in high volume at low cost.

EXAMPLE: BAG SPECIFICATIONS FOR THE ZIMBABWE STANDARD BAG			
Parameters	**Description**	**Specifications**	
		Maximum	Minimum
Style and Make	Length of hem (mm)	17	14
	Length of bottom seam (mm)	33	27
Dimensions	Length of bag (mm)	970	960
	Width of bag (mm)	610	600
	Area yield in grams/m^2	125	120
Weave construction in strands/100 mm	Longitudinal	50	46
	Transverse	50	46
Resistance to signs of failure	Drop tests – all sides	Nil	Nil
Angle of slide	Longitudinal	90	25
	Transverse	90	25
Resistance to probing	Longitudinal	3	
	Transverse	3	

Notes

SECTION 7 | RECEIVING AND STACKING COMMODITIES

The documentation process and activities involved in receiving grain into storage depends on whether grain is in bags or bulk and whether it is being delivered by vehicle, on foot, or on the back of a donkey.

Prioritization of which clients and which commodities to accept depends on the setup of the warehouse. The actual decision on how to prioritize intake is best left to the manager who should be guided by grain handling principles. Here we will address the actual activities involved when grain is being taken in irrespective of its form, demand or mode of transportation.

When grain is being received it will pass through the following stages:

We assume that prior to these activities the depositor has prepared the commodity for storage. In preparing the grain for delivery to the warehouse, the depositor must clean and dry the grain and pack it correctly in the right bag. We also expect that the consignment is not mixed i.e groundnuts and maize bags are clearly separated. Also the consignment is accompanied by a delivery note stating the farmer, address, number of bags and types of crops

AT THE WAREHOUSE GATE

At the gate, the depositor (can be a farmer or trader) passes the delivery note to the security guard who will check the load against the delivery note ensuring the following:

- Is there one grain type in the consignment? If not, different crops must be separated for easier sampling and counting.
- How the bags are packed and sewn is checked and the depositor is asked to correct where necessary.

- The quality of bags used is checked, if there is need for better bags the depositor is supplied with better bags and asked to change them.
- Basic details of the consignment are recorded in the gate book. That is the name of the depositor, number of bags and grain type and delivery note number. The depositor signs the gate book and proceeds to the next stage.

RECEIVING THE COMMODITIES

Before the commodity is accepted into the warehouse it has to be sampled, graded and weighed. If it meets the parameters laid out by the warehouse it will then be received into the warehouse. The sampling and grading is linked to specific commodity grades within a commodity standard; these grades generally are linked to price per grade. The grades and standards are usually used as a measure of acceptance. Standards outline the acceptable limits of:

- Weight per bag
- Moisture content
- Amount of foreign matter, defective and other key parameters
- Purity of sample
- Degree of deterioration

The objective of grading commodities is to ensure like commodity is stored together and can therefore be comingled, it also helps minimize losses by ensuring that the right quality is put into storage and the quantity is known. This means that while the depositor may not receive the bags she deposited into the store, the depositor will receive bags of exactly the same quality as deposited and therefore the same market value. So a judicious process to manage the receiving process must be adhered to and cutting corners should be avoided at all cost.

COLLECTING SAMPLES

The depositor passes the delivery note to the sampler who will further examine the consignment to confirm the type of grain and quantity. At this stage the section about the farmer, number of bags and grain type is completed on the commodity receipt. The sampler will proceed to sample the consignment based on sampling procedures described in the sampling section. Grain from each bag or a proportion of bags is examined as it is being sampled to check for consistency. If there is an obvious quality difference the depositor is advised and the proportion which is unacceptable is rejected. The farmer can either take the bags outside to correct the load so that grain of one type and acceptable quality deposited. Depositors are discouraged to combine grains which greatly differ in quality. A mixed sample is always downgraded, so it is to the advantage of the depositor to clearly separate bags of different quality. During sampling other things to check are stones and very high moisture levels which can be felt or observed as the grain is sampled. The commodity receipt is placed in the sampling container to identify the sample with the relevant commodity receipt and the sample is passed to the grading office.

WEIGHING

If bags are 20 or less all of them are weighed. If they are more than 20 bags and have a consistent shape or standard size, 10% are weighed. If the weight of the bags differs greatly, the depositor is advised to correct and repack if the bags are going to be stacked. If the grain is going to be put into silo, there is no need to correct the bags. The weight of the consignment is recorded as gross weight. Each grain variety is weighed and recorded on a separate commodity receipt. If a weighbridge is available – the truck is weighed full going in and then empty going out. Subtracting the empty truck weight from the full truck weight should give the weight of the loaded. Care should be taken to check that everything on the truck for the first weight is also there for the second weight (tarpaulins, spare tires, driver and turn boy etc.). Otherwise all loose items other than the grain should be removed at the gate before weighing the full truck.

Often weighing will not occur until grading has been done to avoid dealing with a load that will be rejected due to poor quality.

GRADING

In the grading room, the moisture of the grain is determined. If the moisture is above the acceptable level, the grain is either rejected or sent to the drying section. If there is a large supply of grain, it is advisable to reject the grain. Depositors should have their moisture checked before delivery to avoid costly rejections.

If the moisture content is acceptable, the moisture reading is recorded on the commodity receipt. The grain is then graded and the details are recorded on the commodity receipt.

The following sections of the commodity receipt are completed in the grading room (see Commodity Receipt on page 80).

- Gross Mass – The weight of the grain including the bag weight
- Bag Mass – The weight of the bags when empty
- Nett Mass – The grain weight less bag weight (net weight)
- MC % – The moisture content
- Defective – The level of defective grain.
- S.M.K – Sound mature kernels (for ground nuts)
- Test Mass – The test density of the grain (for wheat)
- F.M. – Foreign or extraneous matter
- Remarks – Any other grade determining factors are written here.

STACKING

When grain has been graded and all the appropriate details written on the commodity receipts by the grader, the bags are transported to the warehouse using the same vehicle. The warehouse supervisor will receive the consignment and have the bags placed on the appropriate stack. As the bags are moved from the vehicle onto the stack, each bag is speared and sample checked for consistency. Removing bags from the vehicle onto a stack provides the perfect opportunity to analyze each individual bag. Any bag that does not meet the class stated on the commodity receipt is removed and rejected. This means that the final net mass received is endorsed after completing the transaction at the stacking area or the commodity receipt is returned to the grading office with indication of rejected bags as remarks so that the weight is calculated properly.

Based on the stacking plan and location of the stack for the particular grain and grade the supervisor will endorse the stack number on the commodity receipt and update the stack record sheet accordingly.

STACKING PLAN

A plan to operate the warehouse and to lay out the commodities must be put in place. The plan must be discussed with key staff members like supervisors and stack builders. Space for emergency and normal stacking must be set aside. But remember that in actual constructing stacks, there are no emergency stacks. All stacks must be constructed as if they are permanent stacks. Stacks prepared hurriedly are always the ones that present problems because when not done properly they are prone to infestation and breaking.

The main objective of stacking is to store commodities so that they can be used at a later date, which can be as early as the following week or some months later. Good stacking should ensure that the grain remains as close to its original condition as possible. Also good stacking makes effective use of space and allows for handling efficiency and operational convenience. A well-built stack should enable unhindered inspection, warehouse hygiene, pest control, unhindered loading and off loading of bags.

When planning for stacking, it is advisable to plan for long term storage and not to plan for emergency stacks. Emergency stacks in most cases remain like that for a long time making it difficult to manage the warehouse. When under pressure the temptation to do hurried stacks is great but the subsequent costs are high. Prior to receiving commodities, an assessment of the usable capacity within the store must be made and a stack plan agreed upon.

The warehouse supervisor should plan the layout of the stacks in the warehouse. The stack plan depends on a number of factors and the following are key ones:

1. The quantity of commodities to be received
2. Varieties to be handled
3. Grades to be handled

4. The demand of each particular grain
5. Size of stacks
6. The size and configuration of the warehouse
7. Movement in the warehouse
8. Pest control and hygiene activities to be carried out during the storage period
9. The level of infestation

The quantity of commodity to be received determines the size and stacking position of the grain. If the warehouse expects to frequently receive large quantities of Grade A maize, then a large stacking area must be allocated to Grade 1 maize. The position must be easily and frequently accessible. Similarly if a certain variety is going to be dominant then that variety must be allocated a strategic position in the warehouse. Bags of different sizes and types should not be stacked together. If two types of bags are going to be received then separate stacking areas must be allocated to each type of bag. Ninety kilogram bags should not be stacked together with 50 kg bags because this affects the stability of the stack and inventory management. Likewise jute bags should not be staked together with polypropylene bags because it affects the stability of the stack.

The size and configuration of the warehouse also determines the size of stacks and their position. A square warehouse with doors all sides is easier to stack than a square warehouse with one door. The need to carry out pest control and hygiene activities in future has to be considered during stack planning. Pest control, hygiene and inspection activities require that more than a meter be left between stacks and walls to allow for movement of fumigation sheets, cleaning, inspection and ventilation. Stacks should also be clear of roof-trusses, and well clear of the roof itself.

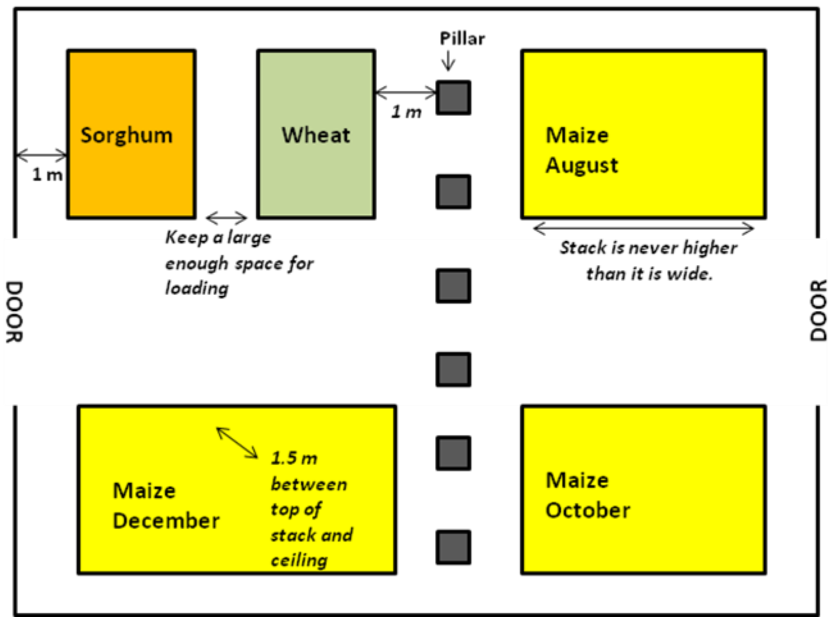
Where vehicles are going to enter the warehouse, enough space along the middle must be left to facilitate vehicle entry and movement.

Incoming stocks must be carefully inspected. Bagged commodities should be examined for signs of live insects and infested bags must be segregated. Damaged bags are best stored separately and re-bagged if they cannot be rejected. Particular care must be taken with any commodities which have been made wet by rainwater during transportation. Wet bags must not be built into a stack; both the bag and the contents should be re-dried. Commodities must be separated based on quality (grade), type of grain, type of packaging and should be properly labeled. See pages 81-83 for more information and examples of stack record and stack history sheets and examples.

Rules to remember when making a stack plan.

1. 1 meter distance between walls and stack
2. 1.5 meters distance between roof and top of stack
3. 1 meter distance between any pillars and stack
4. A stack must never be higher than it is wide
5. Access space must allow easy loading and unloading

EXAMPLE: A STACK PLAN



After making the stacking plan it helps to paint lines on the floor of the warehouse to guide where the stacks are going to be.

STACK CONSTRUCTION

Stacks must be correctly built. Badly built staks may collapse injuring people or causing damage to the equipment. Similarly, stacking against walls may cause structural damage, and solar-heat on the store exterior may be transmitted to goods, if they are stacked very close to the walls and roof.

DUNNAGE

Commodities should be placed on dunnage such as wooden pallets or platforms. If these are not available, carefully laid loose timbers will serve as dunnage although this is less satisfactory. Pallets or platforms should be made in easily moveable sections and the construction should be made to suit the bags that will be stacked on them, so that these do not sag or slip to the ground. The purpose for dunnage is to prevent moisture uptake through the floor and to allow for free circulation of air and fumigants. The arrangement for the availability of dunnage must be done in advance of receiving and commodities. Pallets and platforms should be checked each season for splinters of cracks which might cause tears in the bags – these should be repaired before use or removed.

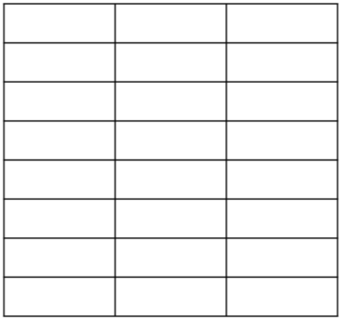

Dunnage (Source: ACDI/VOCA's Kenya Maize Handbook).

STACKING PATTERNS

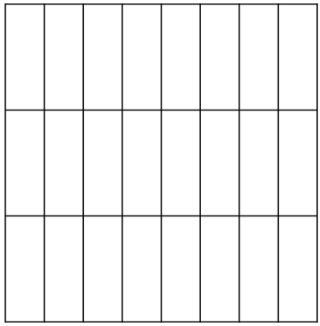
There are two types of stacking patterns used in grain stacking: the conventional method and the bonding method. The conventional method is for smaller (1000 bags) stacks and the more complicated bonding method is best suited for larger long term stacks.

Stacks constructed using the bonding methods are stable because the bags are placed in such a way that they hold together. The easiest (particularly for farmer and communal stores) is the conventional method, where bags are laid in one direction, and then the next layer in the opposite direction.

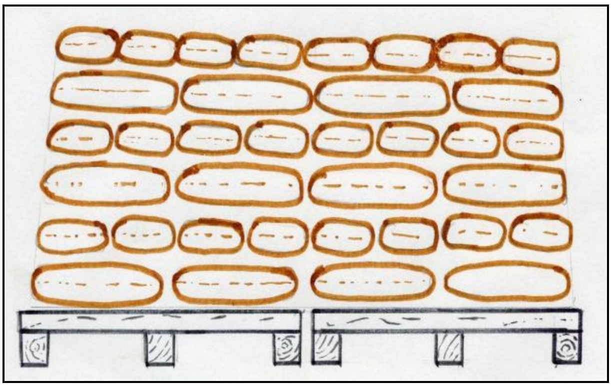
Conventional bonding



Top view of First layer



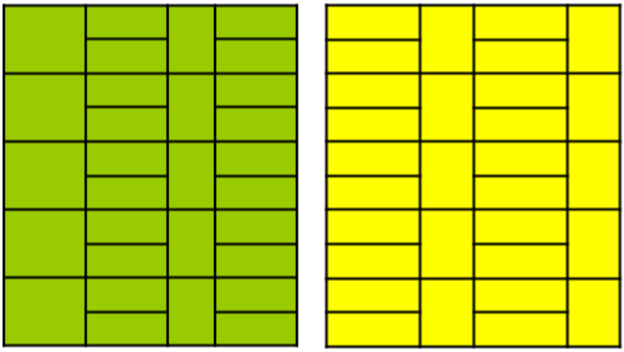
Top view of second layer

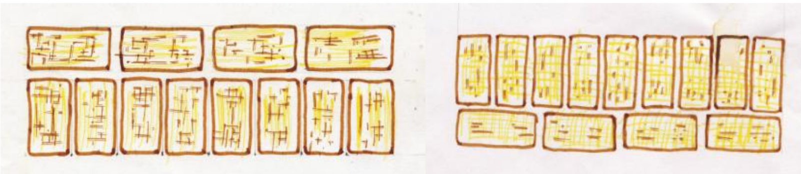


Side view of many layers of conventional bonding
(source: ACDI/VOCA's Kenya Maize Handbook).

A more stable but slightly more complicated pattern is the 3 bag or 5 bag unit methods. Stacking in 3 or 5 bags is preferable if the stacks are going to be large and for long periods.

3 & 5 bag bond





Top views of different layers arranged in 3 & 5 bog bonding patterns.
(source: ACDI/VOCA's Kenya Maize Handbook).

For all types of stacks, layer sizes should be gradually reduced by 'killing' a line after 5 layers or so. This reduction of the number of layers gradually tappers the whole stack making it not bulge out as it rises. The interior of a stack must be in regular rows which must be accurately represented by the outside layer bags.

A stack of polypropylene bags; note the space between the stacks, the use of pallets and the use of the three unit stacking method.

If bag elevators are not available stacking can be accomplished by building the stacks with steps. If this is carefully planned and executed the loss of stacking space is minimized. Stacking ladders which are easy to make can also be used to reach higher layers. To achieve the construction of such a stable stack with uniform layers, two trained stack builders must be employed whose sole responsibility is to direct the placement of bags at specific positions on the stack as the bags are brought to the stack.

Counting bags

The number of bags in each layer should be established and written at the corner of the layer with a black maker. The counting and writing of the bags must be done as the stack is constructed otherwise it will be difficult to write layers which are higher up later on.

SECTION 8 | WAREHOUSE RECORD KEEPING

The operation of a warehouse is not complete if the records are not properly maintained. The objective of keeping records is for the operator to understand the enterprise and report on it. Keeping and analyzing records facilitates decision making based on the actual facts affecting the business. In warehouse management, record keeping informs on volumes going in and out of the warehouse, balances in stock, losses due to storage and handling, any losses which might be due to spillage or sampling, and warehouse income. Clients who hire storage space also want records which show the status of their commodity in storage.

Also knowing what is in storage enables the operator to calculate the amount of chemicals to treat the commodities. The decision to store more grain in future is based on what is currently in storage, thus, such a decision would be difficult to make if present stocks are not known. Government agencies-estimate current food stocks in the country basing on what is in storage systems.

VERIFYING RECORDS

Certain tasks must be done periodically to check records:

On a daily basis

- Check stocks to balance the tallies of intake and dispatches

On a weekly basis

- Warehouse supervisor verifies total stock
- Warehouse supervisor verifies accuracy of the records
- Warehouse supervisor makes a physical count of the actual stocks to see if they agree with the book records
- Perform a weight check or bag count at the point of receipt and dispatch to verify the unit weights which must agree with the Dispatch or Delivery Notes
- Check the commodity receipt book that it is being used correctly

DOCUMENTS FOR RECORDING COMMODITIES

The following are some of the key documents for checking and recording of receipts, dispatches and status of the stacks with regards to age, quality and quantity of the commodity in the warehouse.

1. Delivery Note
2. Commodity Receipt / Goods Received Note
3. Weight Note
4. Stack Record Sheet
5. Stack History Sheet
6. Dispatch Note

DELIVERY NOTE

The delivery note captures information of the commodity from the farm to the receiving officer. The delivery note is generated by the transporter who will have the depositor (who may be a farmer or trader) sign after collecting the commodity from the farmers homestead. The information contained on the delivery note is self explanatory. If the transporter is carrying bags for a number of farmers or depositors, each depositor must have his/her own delivery note completed for the bags. The depositor or a representative must sign the delivery note at the time the bags are collected from the home. The security guard at the warehouse gate checks the bags in the truck and signs the delivery note to confirm the bags being delivered and records the details of the delivery note in the security gate book. The delivery note ends at the receiving or grading room where the commodity receipt is generated based initially on the delivery note information.

EXAMPLE OF A DELIVERY NOTE

<table>
<tr><td colspan="7">Delivery Note</td></tr>
<tr><td>Date</td><td colspan="5">Transporter:</td><td>D/Note #</td></tr>
<tr><td colspan="7">Transporter Address</td></tr>
<tr><td colspan="5">Name of depositor:</td><td colspan="2">Depositor's No:</td></tr>
<tr><td colspan="4">Depositor's Address:</td><td colspan="3">Farmer group:</td></tr>
<tr><td>Grain:</td><td colspan="3">Number of bags</td><td colspan="3">Commodity Receipt Number:</td></tr>
<tr><td colspan="2">Depositor's Signature</td><td></td><td></td><td colspan="3">Drivers Signature</td></tr>
<tr><td colspan="3">Security Guard Signature:</td><td colspan="4">Receiving Officer Signature:</td></tr>
</table>

COMMODITY RECEIPT

The commodity receipt is the primary document in the warehouse. All records like the stack record sheet, data base, and payment systems are updated using this document. It is used to capture official depositor's details and the technical information about the commodity being delivered into the warehouse. Information captured on the commodity receipt is the depositor's name and address, account number allocated by the warehouse and mobile phone number. The numbers of bags, gross mass, net mass and grading information are all also recorded on this document. Grading information relating to the commodity is also recorded on this document as the information is generated by the grader.

The commodity receipt is a certified documented such that once the information is recorded and signed for, it cannot be changed without the agreement of the depositor unless the mistake is a simple clerical error. The commodity receipt represents the undertaking of the warehouse to store the depositor's goods and return them to the depositor once the warehouse service costs have been paid. Apart from details of the farmer, the commodity receipt contains information relating to the warehouse and the commodity being delivered as follows:

Gross Mass	Weight of the commodity including the bags
Bag mass	Weight of the empty bags only
Warehouse	Name of the warehouse or buying point
Defective	Level of defective in the sample as a percentage
S.M.K.	Sound and Mature Kernels
Test mass	The test density of the grain being delivered
M.C.	Moisture content
E.M.	Extraneous matter or foreign matter
Grade	Relevant grading details of the commodity
Stack #	The stack # where the grain will be placed (optional)
Refunds	Refunds payable to farmer (e.g. for good bags used) (optional)
Warehouse charges	Any charges levied to the depositor by the warehouse

EXAMPLE: COMMODITY RECEIPT

Company Stamp							
		Commodity Receipt – Market Linkages Initiative					
Farmer's	Account No	Mobile Number	GBC/VAC	GBC/VAC Code	Grade	Receipt No	
Chamdimba		0999132043	Kapiri			000404	
Address/Village		Remarks	Gross Mass	M.C %	Test mass	Warehouse Charges	
Chintokoma		Male		Dry			
Date	Grain & Variety	No of bags	Bags Mass	Defective %	E.M	Refunds	Pay Refs
12 September 2010	G'nuts	4					
Farmer's. Signature	Received by	Graded by	Nett Mass	S.M.K	Stack No	Managers Signature	
			K180			[signature]	
Implemented by MLI funded by USAID							

WEIGHT NOTE

A weight note is a simple document used to record bags as they are removed from the stack, weighed and loaded onto a truck. It contains a series of boxes for recording the bags and weight. The weight note is an internal document which will then be used to generate a dispatch voucher or invoice which contains customer details and monitory value.

The bags and their mass are recorded on the weigh note according to the number of bags weighed on the scale at a time. The following weight note example shows how 20 bags are weighed and recorded. The information is then recorded onto the stack record sheet to reduce the stack by 20 bags and 898 kg. This is then transferred onto an accounting document or invoice.

WEIGHT NOTE EXAMPLE

Date......Stack number......Grade............ Document No..........

Bags	Mass	Bags	Mass	Bags	Mass	Bags	Mass	Bags	Mass	Bags	Mass
5	250										
5	249										
5	251										
5	248										
20	898										

STACK RECORD SHEET

The stack record sheet is a summary of the commodity receipts and weight notes for a particular stack. As grain is received from the grading room the information on the commodity receipt indicates the grade and therefore the stack supervisor knows which stack to load the grain onto. As the grain is loaded onto the stack the stack supervisor adjusts the stack record to reflect the deposit of bags and increase in weight. Any dispatches from the stack are also recorded and the running balances are maintained. Each stack has its own record sheet which is used to audit the stack.

STACK RECORD SHEET EXAMPLE

Grain......Grade...... Stack Number................Date stack started......

Intake					Dispatches					
Date	CR	Bags	Mass	Prog Total	Date	W/Note	Bags	Mass	Prog Total	Bal
Total										

DISPATCH VOUCHER/INVOICE

This is a record of individual transfers or sales from the warehouse. The dispatch voucher has details about the customer, number of bags and weight and the value of the commodity. The details of the transporter are also included in case there is need to trace the commodity. If the commodities are being moved from one warehouse to another this document is used. In essence it is both an invoice and a transfer document for the warehouse operator.

<table>
<tr><td colspan="9">Name of Warehouse and Address</td></tr>
<tr><td colspan="2">Date</td><td></td><td></td><td></td><td></td><td colspan="3">DV Number:</td></tr>
<tr><td rowspan="6">Customer</td><td colspan="3">Grain</td><td colspan="2">Grade</td><td colspan="3" rowspan="3">Transporter Details</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td colspan="2" rowspan="2">Moisture Content</td></tr>
<tr><td></td><td></td><td></td><td colspan="3">Truck Number</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4" rowspan="7"></td><td>Weight Note</td><td>Bags</td><td>Mass</td><td>Price</td><td>Total</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Driver Sign</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="4">Sales Officer Sign</td><td></td><td>Total</td><td></td><td></td><td></td></tr>
</table>

STACK HISTORY SHEET

The Stack History Sheet records information about the life of the stack and how it was constructed. The document is initiated when the first layer of the stack is constructed. The stack history sheet shows the number of bags on the stack per each layer and any activity done to the stack since it was constructed. Bags per each layer may differ depending on the construction pattern especially for larger stacks where as the stack rises the number of bags per layer is reduced to balance the stack. The layer count and stack history sheet help in accounting for stocks.

Stack History Sheet					
Date stack started................			Date stack Completed..............		
Commodity............			Stack Number...............		
Date	Layer Number	Configuration	Number of bags	Date of last treatment	Chemicals used

The reverse side of the history sheet is used to record activities or observations noted on the stack such as fumigations, when the stack was ventilated, inspections and observations, and dates when it rained. Maintaining such records helps in keeping a close watch on the stack.

STACK HISTORY SHEET EXAMPLE (REVERSE SIDE)

Date	Observations or any activities done on the stack
11.10.1999	Stack samples and moisture taken (recorded 10%)
2 .12 1999	Date inspection done (G.heavy)
01.01.1999	Fumigation done

OTHER RECORDS

These records are divided into two areas, those for general equipment and for consumables. Equipment covers machinery and tools used in the warehouse operations such as bag stitching machine and empty bags. Consumables include items which are used by the warehouse and need to be replaced.

EQUIPMENT RECORDS

The first part of the equipment records is an inventory listing all items of equipment that the warehouse owns. This includes weighing scales, cleaners, dryers, elevators, palates, forklifts, tarpaulins, fire extinguishers, and grading equipment. The inventory list should include the information when the equipment was last checked and when its next due to be checked. This way

the warehouse operator can quickly glance through this check list and manage his daily, weekly, and monthly tasks.
Each piece of equipment should have a set of records filed together. This should include information on the condition of the equipment and a comprehensive record of servicing carried out (date, parts replaced, other actions carried out, and next service period). Generally a warehouse operator should check the equipment records at least once a month to see what services might be needed that month.

CONSUMABLE RECORDS

These include items such as bags, thread, fumigation chemicals, grading chemicals, sample pots, record books, insurance cover and relevant licenses. Failure to order these items before they run out will cause significant problems when operations start. Therefore these records need to be checked regularly when the warehouse is receiving or loading out commodities. The records should be easily referenced and should include purchase date, cost, quantity purchased, balances in stock and levels in which new orders should be placed. The warehouse operator should maintain internal documentation which records when the item is issued for use. The warehouse operator should visually check stocks and match with records.

EXAMPLE OF CONSUMABLE RECORD

Record for.............					
Date	GRV	D V	Qty in	Qty out	Balance

SECTION 9 | STORAGE LOSSES

It is difficult to categorize and describe all of the precise categories of loss. Nevertheless, loss may be considered in terms of quantity or quality. This sections attempts to explain the many forms of loss.

Quantitative loss is a physical loss of substances as shown by a reduction in weight or volume. It is the form of loss that can most readily be measured and valued.

Qualitative loss is more difficult to assess and is perhaps best identified through comparison with well defined quality grades and standards. Nutritional loss and loss of seed are both aspects of quality loss.

TYPES OF LOSSES

WEIGHT LOSS

A reduction in weight is easily detected but it may not necessarily indicate a loss of foodstuff – it may be due to reduced moisture content. This is recognized in commerce by a "shrinkage factor". Weight loss may result from the feeding of insects, rodents and birds or from the growth of micro-organisms. Spillage which occurs during handling or through the activities of pests (especially rodents and birds) results in a loss.
Moisture changes may lead to an increase in weight, and in some cases production of water by an insect infestation may partly offset the weight loss caused by insect feeding.

Weight losses may go undetected at the village market if the trader sells his produce by volume. A useful way of indicating a loss in these circumstances is to take equal volumes of good and infested grain and to grind them into flour, the yield of flour from the infested sample will be much less than from the good, wholesome sample.

In commercial storage, produce is invariably sold by weight and one must be aware of malpractices such as adulteration with water, stones, earth or sand to make up a deficiency due to insect attack. In assessing loss it is important to take account of changes not only of moisture content but also changes in the amount of foreign matter present.

Theft from store is often regarded as a loss. Certainly it is a loss to the owner, but according to our definition of a storage loss, theft is more a "transfer of ownership", since what has been stolen is still available as food.

LOSS OF QUALITY

Quality of produce is assessed in different ways according to the circumstances considered important by the local population and traders concerned. Generally quality is assessed and products graded on the basis of appearance, shape, and size, but smell and flavor are sometimes included. Foreign matter content and contaminants are factors in loss of quality. The higher the standard set by the consumer the greater will be the potential for loss.

NUTRITIONAL LOSS

This in a sense is the product of the quantitative and qualitative losses; but more specifically, it is the loss in terms of nutritional value to human population concerned which, in turn, will depend on the value to the nutritional status of that population. Weight loss during storage is a measure of food loss, but the latter may be proportionately larger owing to selective feeding by pests.

Rodents and some insect larvae may feed preferentially on the germ of the grains, thus removing a large percentage of the protein and vitamin content. Weevils which feed mainly on the endosperm will reduce the carbohydrate content. Many pests eat the bran of cereals, thereby reducing the vitamin (especially thiamine) content. High moisture content and the associated growth of micro-organisms also lead to changes in vitamin content of the grain. In beans, loss of protein due to bruchid infestation may be serious as up to 25% of the dry matter may be crude protein.

LOSS OF SEED VIABILITY

This relates to loss in seed germination rate which is important because of its effect on future food supplies. Seed grain is usually more carefully stored than food grain owing to its greater potential value. Loss may be caused by changes of light, temperature, moisture content, excessive respiration, infestation and, in some cases, the methods used to control infestation. Insects that selectively attack the germ will cause a greater loss in germination than others.

COMMERCIAL LOSS

Commercial losses may occur as a direct consequence of any of the foregoing factors or indirectly as the cost of preventive or remedial actions required, including that of the necessary equipment. The following are some of the commercial losses

Monetary loss

Weight loss may result in an economic loss as will any downgrading of produce due to poor quality. Any control measures that have to be employed to render or keep a commodity saleable can be counted as an economic loss and this is perhaps the most easily accountable.

Loss of goodwill

This is not accountable but nonetheless it is very important, especially with regard to rising quality standards. A control measure that may seem uneconomic at first but leads to better custom or at least retains custom, is better than no control which results in loss of custom. This is particularly so in the field of export where a reputation for high quality produce is valuable to a country's economy.

Loss due to legal action

This may include damages awarded due to impairment of health of humans and animals, expenses incurred by third persons due to infestation traceable to a particular shipment and various actions due to contamination.

All of the losses discussed can be reduced. In most cases knowledge and experience can be major factors and improvement may be relatively rapid.

However, in cases where attitudes or beliefs are involved, such as consumer preference, much slower progress must be expected.

CAUSES OF LOSS AND DETERIORATION IN STORE

Loss and deterioration during the storage of food grains may arise in three ways:

- If the condition of the grain received into store is unsatisfactory
- If the storage place is unsuitable for safe storage
- If during storage there is inadequate store management or the environmental conditions become unfavorable

PRE-STORAGE FACTORS

Deterioration of food grains may begin in the field before harvest or during any of the operations of harvesting, drying, threshing or transport to store.

PESTS

Grain crops, particularly in the tropics, may be infested in the field by insects which fly out from nearby grain stores. The insects develop within the grains and so after harvest they are carried into store where they will later emerge if conditions are favorable. This has led to the belief that those insects 'spontaneously generate' from grain which has been stored for a short period.

Micro- organisms, fungi and bacteria may attack grains before harvest, especially if harvesting operations are so delayed that they extend into the beginning of a wet season. Rodents and birds frequently attack the standing crop and if grains are not actually removed they may be damaged and rendered more susceptible to attack by micro-organisms and insects in store.

TIMING

The timing of harvesting operations may have a significant effect on subsequent deterioration of grain. If harvesting begins too early there will be a high proportion of immature grains which, because of their high moisture content, will deteriorate rapidly in store. If harvesting is delayed, then the mature grain may suffer the attacks of insects, micro-organisms and vertebrate pests, as described above, and may be physically damaged by cracking through repeated wetting and drying (e.g. rain or dew followed by hot sun). Damage of this kind may be particularly severe in paddy/rice.

THRESHING

The method of threshing may result in cracked or broken grains. The grains may be separated from the straw mechanically, by hand or by trampling by animals on a threshing floor. In the latter situation grains often become contaminated with soil and other foreign matter.
It is frequently necessary to dry grain to safe moisture content for storage, that is, one which inhibits growth of micro-organisms and limits growth of insects. Grain may be dried naturally in the sun or by the use of supplementary heat in a drier. Care must be taken to avoid too rapid or over-drying as this may result in damage (e.g. cracking) which may in return render the grain susceptible to further deterioration in store.

STORAGE FACTORS

Deterioration during storage - caused by the principal agents of micro-organisms, insects and vertebrate pests (rodents and birds) - is influenced by the storage design and storage environment. It is obvious that a grain store should be structurally sound and water proof; but this is not sufficient to prevent deterioration. Growth of micro-organisms occurs not only when drying has been inadequate or when the grain is exposed in direct contact with water (e.g. rains or floodwater) but also when it is exposed to high humidity. The seriousness of the insect infestation tends to increase at higher temperatures and in the tropics prevailing temperatures are often conducive to maximum biological activity. A well-designed store must include features which limit high humidity and high temperatures.
Insects tend to move away from the produce they are infesting, into the fabric of the store, so ideally there should be a minimum of insect harborage for example cracks in floors and walls.

Rodents and birds which not only consume large quantities of stored grain but also contaminated even greater amounts with their excretions need to be excluded from stores.

STORAGE MANAGEMENT AND ENVIRONMENTAL FACTORS

Even when the requirements for an ideal store have been fulfilled, deterioration may still occur if the store is poorly managed and environmental conditions within a store become favorable for the development of insects or micro-organisms. For example, reservoirs of insect infestation may develop if grain residues build up through poor standards of hygiene or if infested produce remains in store longer than is necessary. Poorly controlled ventilation may also lead to undesirable high humidity and temperatures, and poor structural maintenance may lead to rodent infestation in the store.

Deterioration and subsequent loss of grain stocks may occur during storage unless steps are taken to ensure that the grain is received and stored in sound, dry, insect-free conditions and that they not exposed to re-infestation or adverse climatic conditions during storage.

SECTION 10 | COMMON PESTS

The main grain pest categories due to poor storage practices are insects, rodents and molds. Within insects termites are also included. Other pests which cause storage losses are birds and human beings who operate through theft and contaminating the grain.

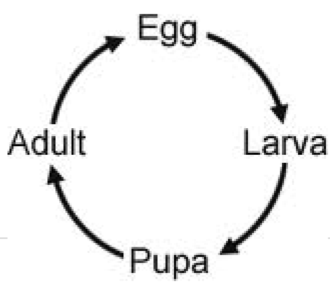
Insects

Insects reproduce by laying eggs, each of which hatches into an immature form that feeds and grows and eventually becomes an adult insect. In the case of many insects, the immature form differs greatly in form from the adult. The larva which hatches from the egg is very small, typically 1-3mm long. It begins to feed immediately after emerging.

When the larva is fully-grown, the final molt produces an immobile stage, which is known as the pupa. At the end of the pupation period (5 to 6 days), the fully formed adult emerges from the pupal skin. This type of metamorphosis which involves larva and pupa is known as "complete metamorphosis". Some insects produce an immature stage, which resembles the adult quite closely in form. These immature forms are known as nymphs. The type of metamorphosis which involves nymphs is known as "incomplete metamorphosis". Common storage pests undergo complete metamorphosis.

Complete Metamorphosis

All of the important insect pests of stored products are either beetles or moths. Although about 100 species are found, very few account to a large proportion of the damage caused to commodities. The following section is a



general account of a few representatives of common species.

It is convenient to describe insects that attack stored products as either primary or secondary pests. Primary pests are those species which are capable of invading an undamaged commodity and establishing an infestation. Secondary pests are restricted to commodities which have already been damaged. The damage may have been caused by man in the process of milling or grinding the product, or by the activity of primary pest.

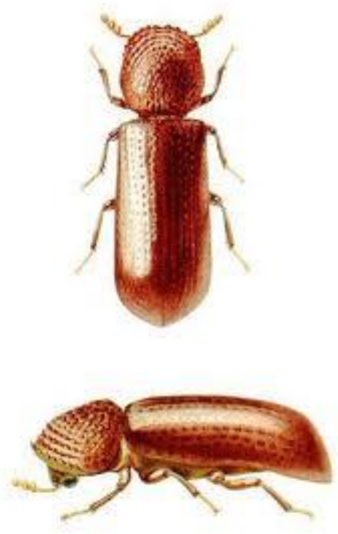
PRIMARY INSECTS

Insects which are able to attack grain which has not been damaged are called primary insects although they will still feed on damaged grain. The common primary insects are the *Sitophilus spp*, *Rhyzopertha dominica*, *Prostephanus truncatus*, *Sitotroga cerealella* and *Trogodema granarium*

SITOPHILUS SPP. (Weevil)

Beetle of the genus Sitophilus are important primary pests of whole cereal grains. The eggs are laid inside the grain and the new adult chews its way out leaving a characteristic hole in the grain. The adults are small (3 mm) and active creatures which are characterized by a narrow snout-like forward extension of the head (the rostrum) which carries the mouthparts. The antennae are ‘elbowed’ in form and are held in a right-angled position when the insect is at rest. The body color can range from a tan brown to dark brown. Optimum conditions are temperature 35 degrees and relative humidity 70%. Under these conditions life cycle can be completed in 35 days.

RHYZOPERTHA DOMINICA (Lesser grain borer)



Rhyzopertha dominica is wood boring insect which has become an important primary pest of cereals. The adults are small (3 mm) cylindrical brown beetles. The head is held beneath the prothorax (deflexed) so that it is obscured when the insect is viewed from above.

Like Sitopilus spp. the pre-adult stages of the grain borer develop within cereal grains. The adult *Rhyzopertha domica* does not excavate an egg cavity in the grain, but rather lays eggs loosely around the grain, placing them where possible in cracks in the grain surface. Larval development occurs more rapidly on whole grains than on flour. Larvae undergo 3 to 5 molts and develop to the pupal stage in about 17 days. Optimum temperature is 34 degrees and relative humidity 70%. Development is possible at moisture content as low as 9%. The larva which hatches from an egg chews its way into a grain (the larvae have legs and can move freely).

PROSTEPHANUS TRUNCATUS (Larger grain borer)

Prostephanus trancantus is principally a wood borer but some will breed in stored products. The body is cylindrical and the head is ventral to the prothorax so that it is visible from above. It grows to between 2.5 – 4.5 mm. The pest is believed to have originated from Central America, until the early eighties when it was identified in East Africa. Wherever it occurs it is always found to be one of the most important storage pests. After 3-6 to months

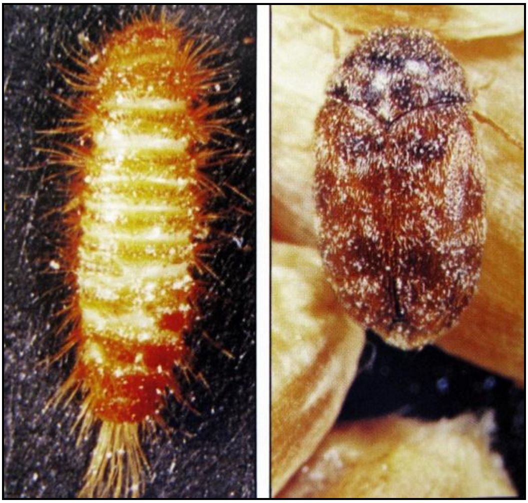
stored products can suffer weight losses of above 30%. No other storage pest has been recorded as causing such severe damage in farmer's stores after such a short period and under dry conditions of less than 11.2% (P.Golob et al 1982)
Infestation often starts in the field before harvest and continues through storage especially in unshelled maize. It has been reported to have attacked roots and tubers and wooden structures and utensils. The optimum conditions for development from egg through to adult are 32 degrees and at 80% relative humidity (Shires 1979). The pest has been known to be adapted to hot humid climates but now appears it is also well adapted to hot dry conditions as those of East and Central Africa.

SITOTROGA CEREALELLA (Anjoumois grain moth)

Sitotroga cerealella is an important primary pest of cereals. The forewings of newly emerged adults are covered with yellowish-golden scales, but in older adults the body is entirely gray. The hind-wing carries a fringe of very long hairs. *S. cerealla* can infest grain in the field before harvest, especially maize. The egg is laid in masses on the commodity, and upon hatching, the larvae bore into the grain. Subsequent development takes place within the grain but the larva may leave one grain and enter another, especially if the grains are small.

Pupation takes place within the grain or sometimes just outside. When pupation takes place within the grain the relatively feeble adult is able to push its way out through a window leaving a rather characteristic hole behind. The adult is rather short lived (7 – 14 days) and flies. The complete life cycle can take as little as 25 to 28 days at 30°C and 80% relative humidity. The adult is a good flier and attacks any cereal with grain large enough to support larval development.

TROGODEMA GRANARIUM (Khapra beetle - larva and adult)



This species is listed among primary pests as it is often the only insect found attacking otherwise intact grain. However, if the grain has previously been damaged, *T. granarium* attacks it much more successfully. It also attacks milled cereal product and therefore occupies a position intermediate between primary and secondary pests

T. granarium is very tolerant of high temperature (up to 40°C) and low humidity (down to 2% relative humidity). It is therefore a pest in hot, dry regions where other storage pests cannot survive. In addition the larvae are able to enter diapause (a resting stage) when physical conditions are unfavorable. In this state they can survive several years 7-8 of adverse conditions. When in diapauses the larvae usually hides in cracks therefore are protected against contact insecticide. Also their low metabolic activity reduces the rate of pesticide uptake and translocation making it to them. The presence of *T. granarium* on grain exported to some countries will result in an order to carry out expensive pest control measures or a rejection of the shipment.

SECONDARY PESTS

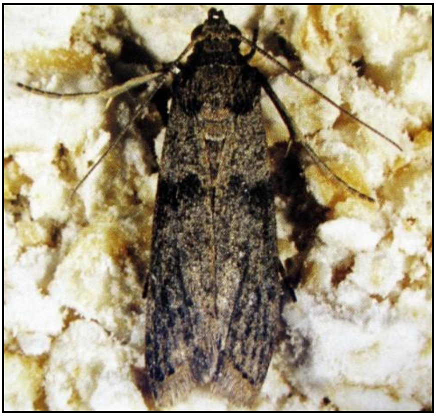
A large number of unrelated pests can be conveniently classified as secondary pests. These are predominately associated with commodities which have suffered previous physical damage caused by a primary infestation or a milling or handling process. Many are pests of cereal products, but others are associated with oil seeds, spices and other commodities.

TRIBOLIUM CASTANEUM (Red rust flour beetle)

Adult *T. castaneum* is brown, medium size (3-4 mm), parallel-sided beetles which are partially dorso-ventrally flattened. The larvae are cream or pale brown, naked and are very active. Adults live for many months under optimum conditions (33-35°C and about 70% relative humidity). Female lay eggs throughout their lives loosely among their food and the larvae feed and complete their life cycle without necessarily leaving the food commodity. Development can be very quick (about 30 days) and population growth is very rapid.

T. castaneum feeds on a range of commodities especially cereals, but also groundnuts, coffee, cocoa, dried fruit and occasionally pulses. They will also feed on animal tissues, including the bodies of dead insects.

EPHESTIA CAUTELLA (Tropical warehouse moth)



Ephestia cautella is a medium-sized moth 5-10 cm and it is a common secondary pest of stored products. In newly-emerged adults the fore-wings are grayish-brown in color, with an indistinct pattern. Older specimens which have lost most of their scales are dull grey in color

Adult *E. cautella* are fairly short lived (7-14 days) and do not feed. The females lay their eggs loosely on the surface of the commodity. The larvae move extensively through the commodity as they feed spinning copious quantities of webbing.

Pupation sites are usually cracks, crevices, and frequently the gaps between bags. Optimum conditions are temperature 32.5°C 70% relative humidity. Newly emerged adults can mate within a few hours of emergence, and eggs are laid soon afterwards (usually with 24 hours of emergence).

TERMITES, RODENTS AND BIRDS

Termite is a common name for numerous species of social insects that can damage stored grain and wooden structures such as furniture or houses. Termites are relatively primitive; they have thick waist and soft bodies and undergo incomplete metamorphosis. Nevertheless, they have developed remarkable patterns of social behavior that are almost as elaborate as those of the ants, social bees, and wasps.

TERMITE DAMAGE

Termite damage is very costly because it does not affect the storage product alone but also the infrastructure of the building especially wood. Their damage is disastrous to traditional structures mainly built from wood material. Before the termites have invaded the stored product the whole structure can collapse due to termite damage causing huge losses to the farmer. Inside the whole grain can be soiled and contaminated such that nothing is recovered for human consumption.

TERMITE CONTROL

To prevent damage by termites, building foundations should be built of materials other than wood. Because cracks may develop in such foundations and create passage ways to the wooden parts of the structure, the soil can be treated first with an insecticide to discourage termites from tunneling underneath. Control is obtained also by using treated wood. Check with your local authorities on recommendations on chemical treatments against termites for the ground and foundation. It is best to protect the building during construction rather than try to prevent a termite invasion, which would be very difficult to stop. Most termites cannot live without moisture, so the termite tunnels and hills should be exposed to dry air. This is best achieved if the building is built on high ground where the water table is low.

RODENTS

These are rats and mice which live in the fields and places where people live. They are considered to be formidable crop pests. This is particularly so in the developing countries as these animals feed on the same plant products as men and are therefore competing directly with him. The fact that they are found everywhere, their fertility, the extent of the damage they cause and their ability to reach all sources of food make the control of these pests a difficult matter and eradicating them a very uncertain business. They are responsible for a considerable percentage of losses throughout the post-harvest period, so it is imperative to take maximum preventive and remedial action against them.

Rodents are also of particular interest as they can cause severe damage to the commodity and also to bagging materials, electrical wiring and store structures. Apart from feeding on the grains they also spread droppings and urine while feeding. Rodents harbor fleas, lice and tapeworms and can spread protozoa and bacteria that can cause toxoplasmosis and leptospirosis. They also can spread ricketisia and hantaan fever. Common rodents found in storage include the house mouse and black rats.

BIRDS

Birds will normally roost far from the feeding grounds but a few do build nests on the buildings and can cause damage to the structures. The common grain pests among birds are feral pigeons, house sparrows and starlings. Birds are attracted to easily found loose grains. Birds contaminate grains through their droppings and urine and can spread salmonella. The best way to control birds is to ensure the building has wire mesh on the eaves, any flat surfaces outside the building and openings so that the birds do not have access in and out of the stores. Daily sweeping of the external areas of the store, collecting the grain and disposing of it away from the warehouse will also reduce the reason for the birds to come to the buildings.

MOLDS AND THEIR CONTROL

Molds are a group of fungi which propagate by producing spores. Once mold growth has started, each mold colony (mycelium) produces millions of microscopic spores within a few days. The spores require moisture to germinate and will grow only when the equilibrium relative humidity of the grain is favorable. Several thousand species of molds (microfungi) are known to exist, and because they are present everywhere, they cause spoilage of both raw and manufactured materials ranging from foods and feeding stuffs to timber, paints and textiles. Mold growth occurs on staple agricultural products both in the field and during storage

Climatic conditions in tropical countries often provide ideal conditions for rapid mold growth. The prevailing humidity, temperature and availability of plant and animal materials with the right nutrition all encourage mold growth. Molds can grow in aerobic gaseous environments, as well as environments with very little oxygen (0.1 to 0.2% oxygen) and some molds are anaerobic (Hocking A.D., 1985).

Mold spoilage of foods is obviously undesirable, and many molds are known to naturally produce mycotoxins in foods which if consumed could be a potential hazard to man or animals.

The two main types of storage molds are *aspergillus* and *penicillium*. Species of these molds are common on a great variety of plant and animal materials that are exposed to constant or intermittent relative humidity of 70 to 90%. The molds associated with cereal grains have been divided into two types: field and storage mold.

CONTROL OF STORAGE MOLDS

The most common species of storage molds are *aspergillus*, *penicillium* and *rhizopus* which are able to grow in conditions of reduced relative humidity (65% - 90%). This is equivalent to 13.5% to 14.5% moisture content.

Drying

The most generally used method to control molds in stored products is drying products to 'safe' moisture content levels. The absolute lower limit of relative humidity that will permit growth of storage molds at a temperature of 21-27 degrees is 70%. As mold growth may occur slowly below relative humidity of 70% or moisture content of 14%, this represents the maximum level of relative humidity & moisture content to which grain should be dried for prolonged storage. Some grains in particular maize which is harvested at high moisture contents must be further dried to prevent spoilage.

Low temperature

Reduced temperature in combination with low moisture is more effective for preventing mold bio-deterioration than just drying. This can be achieved by ventilation which consists of blowing or drawing ambient air through the grain. A low uniform moisture content coupled with a low uniform temperature through aeration reduces the possibility of moisture transfer within the grain and adds to the storage life of the grain.

Adequate ventilation and lower temperatures in colder climates can be used for crops up to about 17% moisture content. However, in tropical countries with higher temperatures the moisture content of the grain should not be more than 12.5% for long-term storage.

Anaerobic conditions

Reduced oxygen has been less successful than drying combined with low temperatures as a means of inhibiting mold growth in grains. Although molds are primarily aerobes, many can grow at slow rates at low levels of oxygen. Anaerobic conditions especially combined with preservatives have been successful for the storage of moist grain over a short period but this practice has not been applied commercially.

Chemical control

Fumigation helps to control mold growth on grains by killing insects that damage kernels exposing them to molds but the effect is not long-lasting. Some gases destroy both molds and insects.

EFFECTS OF STORAGE MOLDS

Certain molds produce chemical toxins called mycotoxins that cause toxic symptoms when foods containing them are ingested by human beings or animals. The term mycotoxin is derived from the Greek word"mykes" meaning fungus and the Latin word toxicum meaning poison. Mycotoxins may be present in food long after the molds responsible have died. (See page 30 for information on testing for aflatoxin.) Common storage molds (*Aspergillus sp*) produce mycotoxins called aflatoxins - usually associated with poor storage conditions.

- In food crops molds cause the loss of food value and in seed they destroy the capacity to germinate.
- Deterioration in food quality is also due to loss of aroma and flavor, discoloration and the deterioration in the physical condition of the grain. Biochemical changes like fermentation, souring, high fat acidity and bitterness makes the grain unpalatable
- Rancidity - This occurs in grains of high oil content. The fats are hydrolyzed and/or oxidized and this alters their structures thus leading to rancidity.
- Mold incidence also cause deterioration of the store fabric, especially material like wood which may rot and disintegrate
- Charring and even spontaneous combustion can happen because mold growth produces heat as well as moisture and is self accelerating.

Symptoms and health impacts of aflatoxin

Aflatoxin is produced in minute quantities, but its potency, prevalence and the ease with which it can permeate farmers' fields and storage area make this high carcinogenic metabolite particularly dangerous. You cannot see, smell, feel or taste aflatoxin in grains; laboratory testing is required to discover its presence.

Acute exposure to high levels of aflatoxin leads to aflotoxicosis, which can result in rapid death from liver failure. In 2004, the worst known outbreak of aflatoxin occurred in Kenya, 317 cases were reported and 125 people died. The minimum level of aflatoxin exposure required to cause aflatoxicosis is not known.

Chronic exposure to aflatoxins affects the incidence and severity of many infectious diseases over time. This type of extended aflatoxin exposure is implicated in the following for both humans and animals; immunodeficiency and immunosuppression, stunting and kwashiorkor, liver cancer (especially in people with hepatitis B or C, and liver disease). Animals which are fed grain with aflatoxin can pass on the aflatoxins on in milk, eggs and meat.

- Symptoms of acute aflatoxin poisoning are necrosis of the liver leading to liver damage.
- Chronic consumption makes aflatoxins potent liver carcinogens. Other chronic effects include lethargy, poor health, hepatitis and eventual death. The disease syndrome caused by aflatoxin is known as aflatoxicosis.

SECTION 11 | PEST CONTROL

Only trained professionals with certifications should handle and use pesticides. Always consult local authorities before making any decisions on the application of any pesticide.

When we talk of pest control what comes to mind is the control of pests using chemicals. Although this is true but this perception leaves out other methods of pest control which are non chemical like hygiene and rodent proofing. The section on maintaining good hygiene in warehouse management is a critical part of pest management. A broad based approach which reduces and avoids infestation through chemical and non chemical means is what has come to be known as integrated pest control (IPM). The following sections will cover all the methods of pest control which can be applied in storage management.

INTEGRATED PEST MANAGEMENT

IPM comprises strategies designed to reduce pest damage through the integration of other pest control options. It gives priority to non-chemical control measures, use of traditional methods and only defaults to the use of chemical controls when other options are unlikely to afford sufficient protection. In tropical agricultural systems, where pesticides are increasingly expensive and pose risks to farmers and consumers, reduction of pesticide use through IPM has many economic, social and environmental advantages.

DEFINITION OF IPM

IPM is a pest management system that utilizes all suitable techniques and methods to reduce pest damage by leveraging the natural regulating and limiting elements of the environment. In pest control, IPM is not the application of chemicals on pests but the reduction of pests through various strategies.

The importance of IPM is captured throughout this Storage Guide where attention is also given to other factors which affect the development of pests in storage. Areas like pre-storage handling, factors that affect grain in storage, inspection methods, storage hygiene, storage structures, and stacking are covered so that the way one understands and applies them can also be used as IPM strategies where chemical control is used as a last resort to pest control.

IPM STRATEGY

In a storage ecosystem, hygiene and good warehouse management are essential. They provide the framework for other supplementary infestation control methods. An IPM system would therefore supplement sanitation and good warehouse keeping with one or more combination of the following practices:

- Improved harvesting and threshing techniques
- Judicious use of residual insecticides
- Use of fumigants
- Use of ambient aeration, and refrigerated aeration
- Atmospheric gas modification (hermetic, CO2, N2)
- Biological control (parasites, predators (such as cats) and entomopathogens, pheromones)
- Use of resistant varieties if possible
- Storage management (FIFO)
- Adequate grain cleaning prior to storage
- Storage design (for pest (rodent and bird) exclusion
- Adequate grain cleaning prior to storage
- Monitoring, evaluation and inspection of stored commodities, storage structures and their immediate surroundings.
- Thermal disinfestations
- Irradiation techniques
- Insect resistant packaging
- Insect growth regulators

CONTACT INSECTICIDE TREATMENT

Insecticides are applied to grain in storage and on the premises with the following objectives in mind:

- To ensure an empty building which is intended to keep food is free from pests and also to reduce immediate re-infestation
- To ensure the safe keeping of food stored in a warehouse – protective treatment.
- To combat infestations which have developed

Why are contact insecticides suitable for treating grain for storage?

- They require simple equipment to apply.
- The formulations are not gaseous like fumigants, which require special skills and equipment.
- Approved insecticides generally combine high toxicity to insects with low toxicity to mammals.
- They provide extended protection both to the building and the grain (residual effect).

INSECTICIDE FORMULATIONS

Each contact insecticide is commercially available in different formulations, and it is important to use not only the correct insecticide but also the most appropriate formulation for each particular situation. There are several methods by which insecticides can be applied to control insect pest in food commodities.

DUSTING POWDERS

As the names says this is in powder form ranging in concentration from 1 to 5%. They are mostly used for admixing directly with raw cereal and pulse crops. They are sometimes also used for application to horizontal surfaces, such as floors in storage buildings, or on bag surfaces to control crawling insects. Some dusting powders are heat sensitive in that if you apply them when the grain is still warm from drying in the sun they become inactive and their effectiveness against insects is significantly reduced.

SOLUBLE POWDERS

These are concentrated formulations intended for surface application (as suspensions in water) to store fabrics, bag surfaces, and for disinfesting railway wagons, trucks, ship holds, barges, and other containers. They usually contain 20% to 80% by weight of the active ingredient. Soluble powders must be diluted in accordance with instructions on the label and are most often applied in a spray.

LIQUID CONCENTRATIONS

These are available in two types: emulsion concentrates intended for dispersion in water as an emulsion, and suspension concentrations which are diluted in a suitable solvent such as oil to form a true solution. Suspension concentrations are used generally for the same purpose as soluble powders but, in addition, can be used for direct treatment of grain. Liquid concentrates may also contain 20 to 80% active ingredients.

In practice there may be little or no choice concerning which formulation is used. Emulsions tend to be more readily available than soluble powders. They are also easier to mix and apply, and in addition, they have a wider field of application in crop protection.

OIL SOLUTIONS

These are mainly used in fogging machines and smoke generators and they are intended for control of flying insects. Concentrations of insecticides are usually too low to form a deposit which will be effective against crawling insects. These formulations are only effective in stores, which have few permanent ventilation openings, and are best used around dusk when flying insects are most active.

APPLICATION OF INSECTICIDES

Proper application of insecticides is an art and as such requires skill. Failure of the control or other adverse effects is usually blamed on the insecticide. In fact in 90% of the cases, the blame can be placed on the application, incorrect concentration of dosage, faulty equipment or poor technique. To achieve effective application of an insecticide, it is important to understand

the nature of the surfaces to be treated, how to use the equipment properly and the dilution rates.
However, irrespective of the application method, the aim is to obtain an even deposit of the spray mixture on all surfaces.

Before application do the following:

- Ensure that that the correct compound has been selected for the required treatment.
- Ensure that the product label has been read and note has been taken of the 'warning' and 'precautionary' statements.
- Ensure that all personnel engaged in the operation have been made fully aware of the potential hazards and when applicable, are adequately protected.
- Ensure that those working and living close range have been notified

Application equipment

- Always select good, sound equipment and make sure that it will adequately perform the operations required.
- Keep equipment mechanically in good working order and attend to leaks immediately. Clean equipment thoroughly after the day's work – never allow excess pesticide to remain in the machine overnight or longer. Dispose of washing water where it will not contaminate drinking water, rivers, and dams or grazing.
- Equipment is an important factor for the success of the application. Pressure, nozzle placement and directional setting, nozzle sizes and type and delivery rate are all of major importance. Checking and setting must be done regularly and can best be done on the day before application with clean water under practical conditions.
- Before starting the application of an insecticide, it is imperative to ensure that the equipment to be used will adequately deliver the prescribed amount of pesticide precisely where it is needed.

Physical nature of the surfaces

- Glass or metal surfaces provide a hard, non- porous surface into which insecticides cannot penetrate. Residual insecticides will persist well on these surfaces irrespective of the type of formulation.
- On rough surfaces such as wood, the insecticide may be lodged within the surface while insects walk above it.
- Similarly on porous surfaces such as cement or concrete the insecticide may pass into the surface.
- Painting of surfaces may be reducing the porosity but this may not prevent the insecticides from being absorbed or dissolved into the surface – especially where solvents are applied into the insecticide.
- Chemically active surfaces such as cement and mud which are alkaline may also react with and degrade the insecticide.

Application procedures & rates

For treating bagged produce, the outside of the bags is sprayed as they are stacked up, without soaking them and then when the stack is complete, the operation is terminated by treating the top and the sides. To treat 100 square meters, 5 liters of water are needed. The volume of insecticide to be added depends on the concentration.

TREATMENT OF COMPLETED STACKS

Stack spraying is done to cut down on the number of times grain is fumigated during its life in a stack. Repeated fumigations lead to build-up of toxic residues in grain. To reduce the number of times a stack is fumigated, overall stack spraying can be done as a standard procedure. Care should be taken to prevent cross infestation from a nearby stack – therefore fumigation of all stacks should be coordinated as a holistic action, and care must be taken when new grain is taken into the warehouse that it does not have the opportunity to infest already treated grain.

The decision on when to spray a stack

a) A stack should be sprayed at three month intervals
b) If an inspection shows the infestation to be General Light (G/L) the stack can be sprayed only and not fumigated.

c) If a stack is above G/light the stacks can be sprayed and fumigated. This is best done by spraying immediately before fumigation.

d) If an incomplete stack is infested and bags are still being put onto it, such a stack should only be sprayed and be fumigated when grain has stopped coming in or when the stack is full.

How to Spray a Stack

The spraying of small stacks can be done using hand held sprayers based on application rates indicated on the label of the container. For the speed and movement of the spray hand, "the point of water runoff" should be the guide. The "water runoff point" is that point when the water from the spray onto the surface being sprayed starts to run off or trickle. An eye for that observation requires some practice and experience with the equipment. However this is very quickly adapted by an agile operator. Using "the point of runoff" as a cue removes the ambiguity of calibrating the spray and coming up with hand speed movement after measuring deposit rates which is a cumbersome process but necessary when working on large areas.

For spraying of large stacks which require calibration of equipment based on surface area and the use of specialized equipment you are advised to contact a certified pest control practitioner.

TREATMENT OF GRANARIES AND SILOS

Granaries and silos are best treated using dusting powders and this is done layer by layer as the grain is put into the store rather than before you put the grain inside. The amount of insecticide is based on the weight of the grain and the following weights of common grains per cubic meter help in estimating the weight of grains.

Maize cobs 500 kg
Maize grain 800 kg
Paddy 500 kg
Unshelled groundnut – 352 kg
Wheat – 768 kg
Rice – 864 kg
Millet – 624 kg

When the amount of insecticides to be used is determined the grain is treated layer by layer as it is put into the granary or silo. This is known as the sandwich method.

- Measure the height structure.
- Determine the number of 20 cm sections going up by dividing the height by 20 cm.
- Determine the amount of insecticide to be sprinkled in each section. This may likely be based on or layer by dividing the total dosage by the number of 20 cm sections
- Sprinkle the inside walls and floor of the store with a layer of insecticide powder.
- Completely cover the layer of the floor with grain up to 20 cm.
- Sprinkle the same amount of powder evenly
- Put another layer of grain on top of the first layer 20 cm high
- Go on filling the store with a layer of grain until the store is full.
- When the store is filled cover the top layer with a thick coating of powder and then close the store in the usual way.

RATES OF DILUTION FOR CONCENTRATES

In order to treat grain which is to be put into bags, the powder is first mixed with the grain using a shovel on a sheet or in a rotary drum of the type used for disinfecting seed. For the insecticide to be more effective it must be properly mixed and the dose of powder calculated accurately according to the weight of the grain and the grain itself must be sufficiently dry. In centralized storage facilities, bulk grain is treated on the belt conveyor, at the foot of the elevator. The advantages of dust-on powders are their low cost and the fact that no special equipment is needed for applying them. However, they have the disadvantages of causing dust and not sticking well to maize grains.

Since most insecticides are marketed in concentrate form, they must be diluted prior to use. The insecticide may be in the form of a soluble powder or emulsifiable concentrate.

RESPONSIBILITIES OF THE PERSON APPLYING INSECTICIDES

- Application equipment: Is movement, speed, and spray pressure correct and agitation adequate? Are there any leaks, or blockages? Is the nozzle setting correct?
- Applicator: Is the person obtaining coverage and is wetting sufficient, excessive or inadequate? Is he personally protected? Does he smoke, drink or eat during operation? Does he wash hands and face before eating during a break?
- Insecticide drift: Is there excessive drift? Is drift contaminating adjacent crops, grazing, rivers, dams, food, utensils or personnel?
- Insecticide spillage: Has any applicator or other personnel been heavily contaminated? Has there been spillage on the ground? – This should be dealt with immediately.
- Surface to be sprayed: Has he determined the type of surface to be sprayed and how absorbent it is?
- Area coverage: Under normal conditions a 5-litre mix of pesticide should cover about100 sq. meters of surface area.

N.B. The aim is to wet a surface thoroughly up to the point of runoff.

AFTER APPLICATION, DO THE FOLLOWING:

- Is the equipment properly washed and rinsed and is the wash water disposed in such a manner that it will not contaminate the environment? Is the equipment dried and serviced before storage?
- Has the personnel engaged in the operation washed themselves and changed into clean clothing?
- Has the filter material in the mask or respirator been replaced?
- Are all empty containers accounted for? Have they been properly disposed of? Has all unused insecticide been returned to storage?
- Have all concerned been notified that the treatment has taken place? Where grain has been treated directly, it should not be consumed until after 45 days.

OTHER POINTS TO NOTE

- The date and address of premises treated should be noted.
- The chemical and dilution used should also be noted.
- Treatment cycle: Application of insecticides and the frequency of retreatment depend on the type of insect, insecticides selected and their formulations, the effectiveness of the dosage used, and the type of sites to be treated (target area). Hence the manufacturer's recommendations should be considered when deciding on the treatment cycle.

TRANSPORTATION AND STORAGE OF INSECTICIDES

- When transporting insecticides ensure that they are packed and loaded in such a manner that the containers will not break and will not spill.
- Cover all pesticides to prevent exposure to excessive heat.
- Always pack them separately from food and feed.
- Never transport personnel in a closed cab if pesticides are present.
- Should any pesticide be transferred to containers, which normally hold food or drink, they should be immediately labeled clearly.
- Extremely toxic pesticides must be kept under lock and key. Storerooms must be kept clean and well ventilated.
- A proper record should be kept of the use of all pesticides.
- All pesticides should be stored separately and securely, well away from food commodities.
- They should only be accessed by designated staff members who are trained to use them.

When pesticides are stored, no matter how well they have been packed; they must be separated from food and feeds.

DISPOSAL OF EMPTY CONTAINERS AND UNUSED CHEMICALS

Regardless of the toxicity of a particular pesticide, the empty containers and the remaining contents must be disposed of in a responsible manner as per in country regulations. Burying or burning may be recommended by local authorities.

All metal, glass or plastic containers must be punctured, flattened or shattered and then buried. Aerosol containers however, must not be punctured or burned. A hole deep enough to allow the contents to be covered by at least 0.5 meters of soil is required. Combustible containers (paper or wood) can first of all be burnt in a hole. Keep out of the smoke. The hole should not be dug within 100 meters of a sunken dam, well, borehole or spring. If this is impractical due to small quantities, lock empty containers away until their quantity justifies the effort.

POISONING AND FIRST AID TREATMENT

Watch continuously for symptoms of poisoning and attend to patient immediately. The labels of all toxic pesticides give the symptoms of poisoning, first aid treatments and the prescribed antidote. If the patient is taken to a medical officer the label of the pesticide should also be available.

FUMIGATION

Fumigation is a process where pests infesting commodities or the fabric of buildings are killed by applying a gas. Fumigation has an advantage over contact insecticides in that it can penetrate to all parts of the infested commodity rather than only those which are accessible. It also produces an immediate and complete kill of the infestation present if the gas is applied properly.

However, fumigation has the disadvantage that it does not provide lasting protection like contact insecticides. As a result re-infestation may occur within a short period of time. For this reason fumigation is normally used in conjunction with other means of pest control including the maintenance of good storage practices which are aimed at minimizing infestation.

HOW FUMIGATION WORKS

When fumigants are applied to commodities there are two physical processes which occur. Firstly the gas will diffuse into the air spaces in and around the produce, and secondly it will be absorbed into the surface of the produce. Therefore for a fumigation to be effective these processes must balance in such a way that an adequate concentration of gas is achieved throughout the grain body. This concentration must be maintained for a sufficient period of time to kill the insects. For this reason all fumigations must be carried out under gas-tight conditions. To achieve gas-tight conditions, the store ventilation can be blocked, but the more common approach is to use fumigation sheets which are different from general purpose tarpaulins. They are much denser to prevent quick gas dispersion. The following are specifications of fumigation sheets

- Size for outdoor large stacks 30 meters X 18 meters
- Size for indoor stacks 18 meters X 15 meters
- Thickness 300 to 400 microns

TYPES OF FUMIGANTS

Fumigants may be classified into two groups of liquids and solids. Liquids come in two forms: those with boiling points above ambient temperatures and those with boiling points at or below normal ambient temperatures.

Liquids with boiling points above ambient temperatures are applied in liquid form by pouring or spraying and vaporize insitu to produce a fumigant gas. Liquids with boiling points below ambient temperature are handled in liquid form in cylinders or cans under pressure. They are applied through nozzles, which vaporize the liquid gas so that only the gaseous phase comes into contact with the commodity. "Solid" fumigants are applied as solid materials which react with atmospheric moisture liberating a fumigant gas.

FUMIGATION TYPES AND PROCEDURES

During fumigation, it must be ensured that the treatment is completely effective and that there is no damage to the commodity being fumigated. Most of all you must ensure that there is no hazard to operators or other persons in the vicinity of the fumigation. These objectives cannot be achieved unless the operational staff who are going to carry out the fumigation have been properly trained in techniques of fumigation. Such training must be under the supervision of a qualified instructor with extensive knowledge and practical experience of carrying out fumigations under the relevant conditions and who must have the authority to certify that the trainee has achieved the level of competence required.

Rates of application of fumigants which achieve complete kill of all stages of common insects have been established by experimentation. These rates are dependent on ambient temperature as fumigants are more effective at higher temperatures. The type of commodity and the species of pest which are present must also be taken into account when deciding on the fumigant to use and the amount to be applied. It is vital that fumigations be carried out so as to achieve 100 percent mortality of the insects present otherwise failure to do so can lead to insects developing resistance to the fumigant.

TYPES OF FUMIGATIONS

There are many types of fumigations which can be used to control pests. Each type is identified by the storage structure or system. The following is a short list of fumigation types.

- Chamber fumigation – for fumigating commodities in an airtight chamber
- Ship and barge – when fumigating commodities in ships and barges without moving the commodities
- Cargo containers – when fumigating in cargo containers. These must also be airtight
- Silo fumigation – automated way of fumigating commodity being put in silos

- Whole store fumigation – fumigating commodities in warehouses with impermeable walls
- Stack fumigation - bagged produce under fumigation sheets properly secured to the ground. This is one of the most common fumigation procedures in warehouses

Since the focus of this guide is storage of commodities in warehouse, we encourage the reader to consult with local authorities on recommendations for stack fumigation and other recommended techniques. The local recommendations should include guidance on types of treatments, dosage rates, temperatures, and days of exposure.

Notes:

1. For control of *Sitophilus spp.*, *Trogoderma spp.*, and *Ephestia spp.* and mites, exposures longer than the minimum lengths given are likely to be necessary and the highest dosage in the range recommended will be required.
2. Do not attempt to fumigate for less than the minimum exposure period recommended. Where possible give the maximum possible exposure period.

RODENT CONTROL

Like insect control, rodent control involves chemical and non chemical control strategies. Chemical control involves the use of poisons and non chemical control involves the use of preventive measures, barriers and hygiene. The sections in this guide on hygiene and inspection outline many of the non-chemical strategies for minimizing proliferation of rodents, so in this section we focus on active and chemical methods.

Rodent baits are very poisonous to humans.
Use with extreme caution!

ACTIVE METHODS OF RODENT CONTROL

Active rodent control is confined in practice to attempting to poison the pest with toxic substances which act by being inhaled or ingested, or through contact. One hundred percent destruction of the pests is usually not possible, but any efforts to eradicate rodents must be done in a way to attempt to kill all of the target population. Killing a small percentage only creates the possibility of quick regrowth in the population and even possible resistance to rodenticides. Ninety to 95% destruction of the rodent population is a good result.

TYPE OF RODENTICIDES

A rodenticide or raticide is any substance or preparation intended to destroy rodents. This comes in the formulation of:

- Powder
- Pellets
- Wax blocks
- Liquid

A distinction is normally made between two main categories of products: fast–acting rodenticides (acute or violent poisons) and slow-acting rodenticides (chronic poisons and anti coagulants). These poisons are applied in two ways – either spread on the ground where the animal passes (highway poisons) or incorporated in baits. Fumigation can also be used to control rodents. For this method of treatment refer to the section on fumigation.

ACUTE POISONS

These poisons work suddenly, causing a violent, spectacular death as soon as they are ingested, which inevitably means that the survivors will refuse the bait, as these animals, particularly the brown rat, are able to associate cause and effect. This type of poison cannot therefore be expected to have a lasting effect. If the rat only swallows a dose which is too weak to lead to its death, it will gradually acquire resistance to the poison ('mithridatism'). This phenomenon, together with the fact that the survivors are repelled by the bait after the first few deaths, explains why this method frequently fails.

Some acute poisons are so highly dangerous to human and domestic animals that in some countries their use is banned by law. Normally, they must be used outside and not in premises containing foodstuffs.

CHRONIC POISONS

A feature of these poisons is that they act only after repeated ingestion of doses on a number of successive days. As death does not occur immediately or in a violent fashion, as with the acute poisons the animal's suspicion is not alerted.

Normally these are **anticoagulants** which are substances that stop blood from clotting and lower the rate at which prothrombiun is secreted by the liver. Eventually this induces death by internal bleeding. Anticoagulants are synthetic products found in the form of:

- Cereal-based bait, ready for use
- Waxed blocks or capsules

CHEMOSTERILANTS

Chemosterilants are usually hormonal substances, which interfere with reproduction. They are highly effective but they are not in wide spread use and they are extremely expensive.

USE OF RODENTICIDES

Except for the gaseous products, which are not used very much against rodents in agriculture, rodenticides are employed in the form of bait or highway poison.

CHOICE OF BAIT

The bait must be acceptable to the animal, which means that it must be palatable and more attractive than its usual food. This encourages the rodents to eat it in preference to the commodity. This type of bait is far more readily accepted in empty stores than in places where rodents have an unlimited amount of grain available. Where there is plenty of grain, the poison may be added to the water or better still make use of liquid rodenticide, provided that there is nothing else for them to drink. This restricts the application of this method to the dry season.

BAIT PLACING

The bait must be placed in a spot, which is accessible to the rodents and positioned between their nest and their usual source of food, but preferably in places which are not exposed. The bait must never be put on the bare ground but in small containers. It is a good idea to position these containers when they are empty, either on a permanent basis or at the start of the storage period. Placing them permanently helps when filling them because the animal is already accustomed to their presence and its instinctive suspicion is not aroused, which would be the case if they were suddenly to be placed overnight.

The baiting points must be kept regularly supplied until all consumption has ceased, no baiting point should ever be left empty so as not to interrupt the daily intake of poison, and thus risk a build-up of resistance in the animals.

BAIT LOCATION

The location of each baiting point should be marked on a plan and an inspection carried out every 2 days. Those points visited by the rodents being noted but fresh bait being put where necessary. In the case of the brown rat, the bait may not be touched during the first week. After a fortnight a weekly inspection is sufficient. After 3 to 4 weeks if there is no longer any rodent activity there is no need to visit the traps. Pick up the containers and dead rats and dispose of appropriately.

The density of baiting points will depend on the species and the extent of the invasion. In the case of the brown rat these points will be located in sheltered spots (inside pipes, in boxes, behind planks or sheets of metal leaning up against the walls). A dozen or so points are needed for a surface area of about 3,500 square meters and they should not be spaced more that 20 meters apart.

If dealing with the black rat which is more active than the brown rat, there should be more baiting points and a number of them should be located on the beams, timbers or on top of the walls, which are the rat's favorite places. Mice are more difficult to entice towards the baiting points and, beside, anticoagulants are not totally successful. It is therefore necessary to place more baits than for rats. The bait used against field rat should be protected from bad weather. It is therefore made up into paraffin wax blocks or capsules.

HIGHWAY POISONS

Highway poisons are anticoagulants, in powder form, which are put down in places where rodents normally pass. The rodents poison themselves by licking their fur, which is impregnated with toxic powder. This technique in fact applies only to the brown rat, as it is the only one always to follow the same path. More over the black rat's body is higher off the ground because its legs are longer and only a little powder sticks to its fur. This method gives good results, but is more expensive than baiting.

PRECAUTIONS

It should constantly be borne in mind that rodenticides are extremely dangerous products and therefore stringent precautions must be taken when making up the bait. The poisons must be kept in their original packaging and locked up. Rubber gloves must always be worn when handling them. The containers used should bear the words "danger: poison" and should never be used for other purposes. Empty containers should be destroyed or holes made in them so that they cannot be reused

BARRIERS

The need to block all openings can sometimes be avoided by placing **barriers** on rodent access routes. For example, where rodents are entering a store beneath the eaves and only reach the top of the wall by means of an overhead cable, it is much simpler to attach a rodent guard to the cable than to screen all the space under the eaves. Most of the points where rodents can enter a building will be revealed by a careful survey of the exterior, but rodents may be harbored within the building fabric itself, so it is also necessary to examine the building from the inside.

Modern stores are generally more easily proofed than old buildings because the points where rodents can enter are usually fewer and also they have fewer places for rodents to harbor within the building fabric should be made rodent-proof from the outset, since the cost of proofing during construction is much less difficult than proofing done after the building is complete. The attention of architects and builders should be drawn to the need for rodent proofing at the design stage of any new food store. (For further reading on this, see Designs and Construction of Fumigable Warehouses by N.R.I.).

PROOF POINTS OF ENTRY

Badly fitting or rotting hinged doors may allow mice or even rats to squeeze underneath or the apertures may soon be enlarged by their gnawing. This can be prevented by fitting a metal plate to the base of the door. Sliding doors are particularly difficult to proof unless they are made very close fitting by the erection of a movable metal barrier one meter high. This will prevent the rodents that get through the sliding doors from entering the store itself.

Windows, ventilators and eaves are common points of entry, particularly for the roof rat. Expanded metal screens should be permanently fitted to the window and ventilators and the eaves should be sealed with concrete. As an added precaution, rats and mice can be prevented from gaining access to the upper part of a building by fitting metal baffle to all pipes and cables that lead to the roof or window level. In brick or other rough walled buildings paint with a band of gloss paint on a smooth mortar round the exterior below window level but at least one meter above the ground. This makes a barrier which is too smooth for the rodent to climb. Holes through which pipes and cables pass into a building can be sealed with concrete or plates. Possible entrance from sewers, broken drains or drain covers should also be blocked.

Kicking plates should be made from 0.9 mm galvanized iron sheet (not aluminum) approximately 300 mm high, fixed to the outer face of wooden doors and finishing within 6mm of the threshold or step. Plates should also be fixed to any exposed wooden window doorframe. Expanded metal should have a 6 mm x 25 mm mesh, be 0.6 mm thick and galvanized. Paint bands should be at least 150 mm in depth and applied to a surface that has been previously rendered with cement/sand mortar. One coat of primer should be applied prior to two undercoats and a final topcoat of hard gloss. Light-colored paints allow easy detection of any mark made by rodents

Some temporary stores are made almost entirely of rubber or soft plastic and are therefore readily penetrated by rats and mice. They should be sited well away from possible source of infestation and, where necessary, should be completely surrounded by a rodent barrier at least one meter high.

Kicking plates on doors inhibit rodents from gnawing and creating crevices beneath doors. (Source: Flickr/Moosicom)

Notes

Notes

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APPENDIX 2: DEFINITIONS

Bin: tank or other container in a warehouse in which bulk grain is stored
Broken grain: grain and pieces of grain which will pass with thorough shaking through the grading sieve
Certified warehouse: a warehouse that has been certified by the EAGC
Chipped grain: grain which has been chipped or cracked
Commingled (grain): a commodity of the same type, variety (if appropriate) and grade deposited by two or more depositors and held together in storage so that any part of the common deposit may be issued in delivery against a warehouse receipt, irrespective of the original depositor
Depositor: a person to whom a GRN for storage of grain has been issued
Defective grain: is discoloured by heat, fermentation, germinated, weather-damaged, fungus or virus, immature or insect damaged grain
Discolored: grain which is markedly discolored by weathering or by heating caused by fermentation but does not include other colored varieties
Insect damaged grain: has been attacked and damaged by any pest
Diseased: grain visibly infected with fungus or other agents
EAGC: Eastern Africa Grain Council
Equilibrium relative humidity: In this content, this refers to the state at which the grain neither gains nor loses moisture with the air around it.
Foreign Matter: substances that are not the actual commodity, this can include straw, husks, stones, pieces of cob, dust, and other rubbish. Foreign matter can also be referred to as extraneous matter
Germinated grain: sprouted grain in which the process of germination is visible within the embryo
Grain: products commonly classed as grain, such as but not limited to maize, wheat, barley, sorghum, paddy and milled rice, sunflower seeds, beans, pulses and lentils, soybeans and such other products as are ordinarily stored in grain warehouses, subject to approval by the EAGC
Grader: a person in the employ or contracted by the warehouse operator to grade the commodity to be deposited or in store according to the methods and grades laid out by the EAGC
Grades: standards approved by the EAGC for use in grading or classifying grain or grain products received or stored in warehouses

Goods received note (GRN): a grain storage receipt giving evidence of a quantity of grain deposited, grade and other information
Hygroscopic: all stored grains and their products are hygroscopic, that is, they lose moisture to dry air and gain moisture from humid air until there is no moisture movement (an equilibrium is reached)
Hectoliter: a unit of volume equal to 100 liters
Identity preserved (grain): commodity deposited by one depositor and held in storage so that it will remain attributable to that depositor which may or may not be of a recognizable grade but must meet storage criteria
Inspector: Appointed by EAGC to inspect aspects detailed by contract
Key system: a method for the safe stacking of sacks in a warehouse
Lot: the total quantity deposited and registered on one GRN
Moisture migration: the process whereby temperature changes can influence moisture levels. Hot and cold regions within a bag or stack of grain create a cycle in which warmer, moist air rises and cold air falls, shifting moisture to different regions where it condenses.
Moisture Content: amount of moisture contained in grain expressed as a percentage of the weight of the grain.
Organoleptic tests: tests that pertain to the sensory properties of a particular grain such as taste, color, odor and feel
Person: individuals, corporations, partnerships and all associations of two (2) or more persons have a joint or common interest
Private warehouse: accepts deposits from specific depositors
Public warehouse: a warehouse accepting deposits from anyone
Sampler: a person in the employ or contracted by the warehouse operator to sample the commodity to be deposited or in store according to the procedures laid out by the EAGC
S.M.K: sound mature kernels
Shelf-life: the period of time that a commodity, following grading, will retain the grade assigned to it as specified by the EAGC
Shrivelled grain: Grain wrinkled over its entire surface and the embryo area
Station: two or more warehouse structures which do not exceed 8 kilometers in distance operated by one (1) company or person
Trash: Vegetable matter other than grain that will not pass through a sieve
Transport: any type of vehicle that carries freight

Warehouse: any building, structure or other protected enclosure used for the purpose of storing grain for a consideration and certified by the EAGC
Warehouse operator: person who operators a grain warehouse
Weigher: a person in the employ or contracted by the warehouse operator to weigh the commodity to be deposited on the weighing devices available at the warehouse

APPENDIX 3: GRADING SCHEDULES

MAIZE GRADING PROCEDURES

1. Obtain a representative sample of not less than 1 kg
2. Check for infestation and record accordingly.
3. Mix and quarter
4. **Moisture level -** Use 100 grams to test for moisture
5. Obtain 500 grams from the original sample and mix and quarter to obtain a working sample of 200 grams
6. Transfer the working samples to a No. 6 sieve and thoroughly sieve the grain by shaking. Make sure the material which falls through is captured.
7. **Broken grain** - Remove by hand any broken grains and grain fragments from the top sieve and add the material which passed through the sieve in stage 7 and record the weight.
8. **Pest damaged grain** - Remove pest damaged grains. Record the weight.
9. **Rotten, diseased, and discolored grains** - Remove by hand any rotten, diseased and discolored grains and record the weight
10. **Colored grains** - Remove colored grains by hand. Record the weight
11. **Foreign matter** - Remove by hand any foreign matter. Record the weight
12. Determine percentages of the weighed characteristics (broken etc) and classify.

MALAWI MAIZE GRADING SCHEDULE				
GRADE	A	B	C	D
Moisture content (% max)	12.5	12.5	12.5	12.5
Test density (kg/hl min)	70.0	68.0	66.0	-
Extraneous matter (% max)	0.5	0.75	1.0	4.0
Trash	0.1	0.1	0.25	0.3
Broken and chipped (% max)	6.0	8.0	10.0	14.0
Brown pigmented (% max)	6.0	8.0	-	-
Defective (% Max) (discolored, diseased, germinated, insect damaged, other colored, shriveled, stained, undeveloped)	6.0	12.0	17.0	22

SHELLED GROUNDNUTS GRADING PROCEDURES

1. Take representative sample amounting to 2- 5 kg for shelled
2. Thoroughly mix and reduce to working sample No. 1 of 1 kg for shelled
3. Determine moisture content
4. Check purity of variety 96% (If less than 96% treat as mixed
5. Determine percentage.
   i) Unshelled groundnuts
   ii) Extraneous matter– any matter other than groundnuts using sieves 7 & 6 for large varieties and 6 & 6.75 for small varieties
6. Obtain 200 g from above working sample and determine the following:
   i) Diseased kernels i.e. kernels visibly moldy or fermented -Sound Mature Kernel (SMK)
   ii) Defective – broken, diseased, germinated, insect – damaged and undeveloped kernels
   iii) Split kernels – nuts with separate cotyledons or parts not passing through a No. 6.75 sieve
   iv) Apparent mature kernels (A.M.K.) (may contain concealed disease)
   v) SMK – Sound Mature Kernels

A. Classify

ZIMBABWE SHELLED GROUNDNUTS GRADING SCHEDULE			
GRADE	A	B	C
Moisture Content (% max)	7.0	7.0	7.0
Test Density	25.0	20.0	15.0
Stones (% max)	0.1	0.1	0.1
Extraneous Matter (% max)	1.0	2.0	3.0
Unshelled Groundnuts (% max)	2.0	2.0	2.0
Splits (% max)	5.0	10.0	15.0
Diseased kernels (% max)	3.0	3.0	3.0
Broken skin (% max)	5.0	10.0	15.0
Sound and mature kernels (% min)	70.0	65.0	60.0
Aflatoxin (ppb-t max)	20.0	20.0	-
Oil Minimum	45.0	40.0	-

APPENDIX 4: DETAILED TABLE OF CONTENTS

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