

POST-HARVEST HANDLING TRAINING MANUAL FOR EXTENSION WORKERS



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Acronyms and Abbreviations

BRIDGE	Building Responsibility for Delivery of Government Services
CAG	Community Action Group
MAF	Ministry of Agriculture and Forestry
NBG	Northern Bahr el Ghazal
RSS	Republic of South Sudan
TOT	Training of Trainers
USAID	United States Agency for International Development
WSG	Women's Support Group
YATC	Yei Agricultural Training Center

Foreword

The U.S. Agency for International Development (USAID)-funded Building Responsibility for Delivery of Government Services (BRIDGE) Program has worked since 2009 to strengthen the ability of government to meet the needs of its people in Northern Bahr el Ghazal (NBG), Warrap¹, Unity, Jonglei, and, to a limited extent, in Upper Nile State. In Warrap, BRIDGE has provided substantial training and material support to farmers and technical assistance to the Ministry of Agriculture and Forestry (MAF), employing a “Training of Trainers” (TOT) approach that emphasizes the paramount importance of building the government’s capacity, both at the state and local (county) level, to take the lead in improving food security, livelihoods and economic growth through the advancement of improved agricultural practices.

BRIDGE agriculture programs and participants have benefitted from strong working relationships between BRIDGE and MAF, with technical expertise and instruction provided by the Yei Agriculture Training Center (YATC), located in Central Equatoria State. Collaboratively, this partnership has helped government extension workers in BRIDGE target states provide extensive training on new techniques including ox-plowing (animal traction) and crop production/management to more than 1,000 farmers. Material support provided by BRIDGE to growers has included farm equipment and tools (ox-plows and hand tools including rakes, hoes, picks and shovels) and distribution of more than 10 metric tons of staple crop seeds including sorghum, maize, sesame and groundnuts to ensure farmers can immediately begin to practice their newly gained skills.

This Post-Harvest Handling Training Manual is supplemental to two previously completed technical guides, the Animal Traction and Crop Production training manuals developed collaboratively by the MAF, BRIDGE and YATC. It is meant to assist Warrap agricultural extension workers to plan and carry out post-harvest management training sessions effectively to farmers at the county, payam and boma levels. The use of improved crop handling and storage techniques by farmers will help them to better protect their harvested crops from damage by exposure to the elements, diseases, insect pests and rodents, with the goal of increasing the amount of food available for local consumption, and enabling farmers to maximize gains through the sale of additional surplus harvests at market.

The manual is intended to help farmers acquire additional knowledge and experience during participatory and practical training exercises with agricultural

¹ From FY 2009 – FY 2011, BRIDGE agriculture programs were implemented in NBG, Warrap and Unity. In FY 2012, BRIDGE program approach was adjusted and agriculture sector work was focused on Warrap addressing sector integrated planning and budgeting support for MAF, coupled with technical assistance for extension workers.

extension workers. Subsequent to training, it is anticipated that MAF extension staff in cooperation with BRIDGE will conduct follow-up visits to growers, to ensure they are actively able to adopt the improved/best practices in their fields. It is hoped that this manual will be useful, and that it will be further adapted to include lessons emerging from field experiences in order to enhance the work already being performed by state extension service officials in support of South Sudanese farmers.

Important Note to Trainers

Agricultural extension workers, for whom this manual is intended, are advised to ensure that they *thoroughly* understand the lessons described herein, before undertaking training exercises for targeted farmers. In the event of questions or concerns about the content of the manual, and/or if clarification is required, trainers are strongly encouraged to contact BRIDGE agricultural specialists for assistance. The lessons described within this manual are prepared so that trainees can easily learn from discussions, questions and answers in the process of training. Extension workers should be aware that farmers generally possess a good understanding of their production situation, as well as the physical and social environment that influences their production and production capacities. Therefore, during trainings, **extension workers should recognize that farmers, though they may have questions, are not ignorant of the various subjects under discussion. Trainers are expected to listen carefully and respectfully** to farmers' ideas and opinions during each session, and to understand exactly what is required (i.e., elaboration, clarification, repetition, or additional practical application) to ensure farmers can readily utilize new techniques and skills.

Extension trainers are advised to inform farmers that **they should feel comfortable when raising issues or questions of importance to them.** Farmers need to be able to share their views, discuss constraints, and achieve collective understanding of challenges. In other words, the extension workers need to know that the purpose of training farmers is to build on existing indigenous knowledge without undermining the traditional practices. Extension workers should understand that they are taking farmers from “the known to the unknown.”

Further, extension workers are strongly advised not to provide answers or conclusions based solely on their personal opinions or views. When questions arise, trainers should invite and encourage *the participants* themselves to find solutions, first. **It should be acknowledged at the outset that not all trainers will be able to answer all conceivable questions.** Trainers should not feel embarrassed if they are unable to provide answers to all questions, though they should make diligent attempts to research and follow-up with informative responses, as appropriate, to outstanding questions.

Such participatory methods will enable beneficiaries to achieve the paramount goals of post-harvest handling training, which are to increase household food production, improve community welfare, and to successfully bridge the annual food gap that threatens the lives of thousands of people in South Sudan.

Introduction:

Post-harvest handling or management is the stage immediately following the harvest. It determines the final quality of product. Post-harvest management activities include:

- Drying
- Threshing
- Transportation
- Storage

NB: Although standard post-harvest losses incurred by farmers is consistently estimated at about 10 percent, cereals losses can be as high as 13 to 15 percent. These losses impact greatly on household food vulnerability and cash income (livelihoods).

Section 1: The Process of Harvesting

Discussion Points (45 minutes)

- ✓ Process of harvesting in your community
- ✓ Tools used for harvesting
- ✓ Stage and timing of harvesting
- ✓ Precautions during harvesting

Tools used for Harvesting in Your Area

- Molodo
- Sickle
- Knife/spear, etc.

Stage and Timing of Harvesting

- The purpose of the crop or use for which the crop was intended; e.g. sorghum for silage/fodder/feed harvested before flowering and for production harvested after grains matures.
- Market demand; e.g. maize harvested at green (fresh maize) or dry (dry maize grains) stage depending on market demand.
- Weather conditions – most crops are harvested during dry conditions.
- Prevailing market price and profit margins – harvesting can be delayed in order to obtain better prices at a later date.
- At times farmers are forced to harvest their crops early to avoid floods (especially in lowlands) and to prevent destruction by livestock released before harvests.

Precautions During Harvesting

- During harvesting, care should be taken to make sure that produce is not affected in quality or quantity.
- The crop should be harvested at the right stage depending on the intended use.
- The timing should also be correct and weather conditions should be dry because wet weather enhances rotting of produce.
- Delayed harvesting is not encouraged as many crops can get spoiled, thus reducing the quality and quantity available for consumption and sale.

Section 2: Post-Harvest Handling Practices

Discussion Points:

- ✓ How drying is carried out in the community; give recommendations on best drying practices.
- ✓ The reasons for drying and the methods for testing moisture content in the grain (sorghum/maize).
- ✓ How local communities determine appropriate levels of grain moisture content.
- ✓ The common threshing practices carried out by the community.
- ✓ The recommendations and general guidelines for improved threshing efficiency and yield.
- ✓ How cleaning, sorting and grading is done in the community; recommend improved practices.
- ✓ Show pictures of testing the moisture content of grain sorghum/maize.

Drying

Grains are usually dried until the correct moisture content (10 to 13 percent) for optimum storage is attained. Reasons for drying to reach a moisture content level of 10 to 13 percent include:

- Prevention of mould growth
- Reduction of the likelihood of insect attack
- Prevention of grain germination

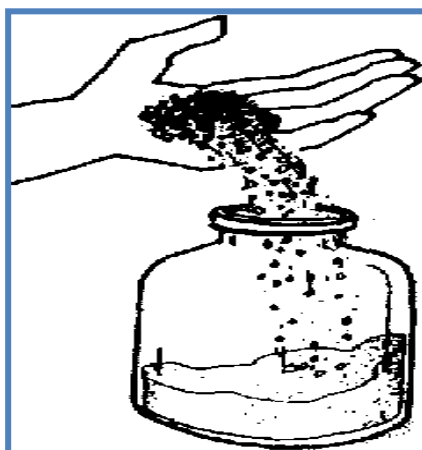
To measure the moisture content or dryness of grains, two simple methods are recommended:

- Salt test
- Biting grain method

The salt test is performed in the following manner:

- Dry common salt (non-iodized) is mixed with the grain sample in a glass jar and shaken.
- The equilibrium relative humidity of dry salt is 75 percent at ambient temperatures.
- The equilibrium moisture content of grain at 75 percent relative humidity is about 15 percent.
- So, if the salt in the grain sample adheres to the walls of the glass, it has absorbed moisture from the air which must therefore have been at a relative humidity greater than 75 percent.
- This means that the grain had moisture content greater than 15 percent moisture content, and is unsuitable for storage in bulk.

NB: The salt method is not precise, but it costs little and is simple to carry out.



Above: the salt method of measuring moisture content

The biting test is even simpler to perform and can help determine suitability of grains for storage:

- A dry grain is tested by biting. If suitable for storage it will be brittle, hard and break easily into many parts.

Threshing/Shelling

This is the act of removing sorghum and maize grains from the cobs or heads, or beans and nuts from the pods. The time required for threshing depends on:

- Variety of grain, bean or nut
- The degree of dryness of the grain
- The method of threshing

Common Threshing Practices:

- Beating with sticks on the ground or in sacks, or using a mortar and pestle
- Grinding on stones and motor
- Threshing machines (for large scale commercial farms)

General Guidelines for Improved Threshing Efficiency:

- Reduce losses during winnowing by threshing on mats, cement blocks or smeared ground.
- Thresh early to reduce crop exposure to birds, rats, and other pests in the field.
- Dry thoroughly to reduce the moisture content of the grain before storage; (moisture content should be at 10 to 12 percent, as noted above).
- Sorting is very important, especially when maintaining some crops as seeds, or improving the quality for marketing.
- The grain may be stored as un-threshed panicles (in the case of sorghum) or threshed before storage.
- In other countries, motorized threshers are used but are very expensive.

Causes and Methods of Loss Prevention and Control

Discuss the principle causes of quality/quantity losses and/or deterioration in stored grains:

- Insects
- Moulds
- Rodents
- Birds

Insects

Discussion Points:

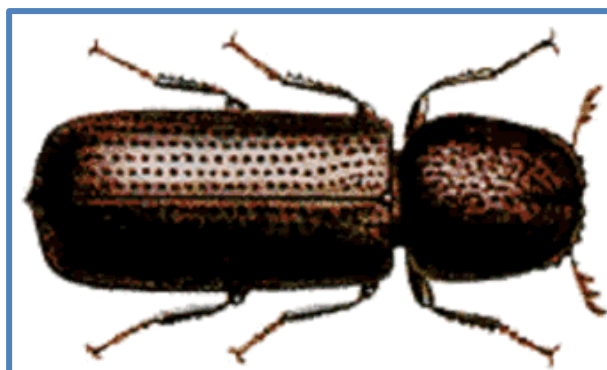
- ✓ Types of insect storage pests and examples
- ✓ Losses caused by insect pests
- ✓ Sources of insect infestation
- ✓ Control measures for insect pests

Primary Pests:

- Are capable of attacking and breeding inside previously undamaged grains/beans/nuts.
- Are very common in farm stores soon after harvest.
- Can occur in the plant once it has reached maturity in the field.

Examples of Common Primary Insect Pests Include:

- Weevils, *Sitophilus* species
- Larger grain borer, *Prostephanus truncates*
- Lesser/smaller grain borer, *Rhyzopertha dominica*
- Moths found commonly in grain stores, *Sitotroga cerealella*, the Angoumois grain moth; it is frequently found in stores of cob maize, especially soon after harvest.



1 Lesser Grain Borer, *Rhyzopertha dominica*



2 Sorghum Maize Weevil, *Sitophilus zeamais*



3 Angoumois Grain Moth, *Sitotroga cerealella*
Source: www.knowledgebank.irri.org



4 Red Flour Beetle. Source: www.rkmp.co.in



5 Indian Meal Moth.

Secondary Pests:

- Only attack and breed in grains that have already been damaged or grain that has been processed into flour or a similar product
- Tend to be most common once the grain has been damaged by primary pests and therefore are found after grain has been stored for several months

Losses Caused by Insects Include:

- Weight loss
- Loss in quality/market value
- Promotion of mould development
- Reduced germination in seed material
- Reduced nutritional value

Sources of Infestation:

- Infested residues from the previous year, stored at home or on the farm
- The structure of the store itself, i.e. from:
 - Thatch, bamboo or timber of a traditional crib
 - Cracks in the wall of a silo, rumba or warehouse
 - Old sacks and dunnage (used to support sacks or bags)
- Natural habitats, such as:
 - Under the bark of trees
 - In rotting wood
 - In seed pods

Methods of Controlling Insects in Stored Cereals:

- Chemical (effective but expensive and dangerous for farmers if not handled with care; can also have negative environmental consequences such as toxic contamination)
- Non-chemical methods (recommended) include:
 - Timely harvest of crops. Should be done when crop reaches physiological maturity. This reduces damage and losses due to birds, insect pests, rodents and termites, and also reduces chances of transporting pests from field to the store.
 - Adequate drying of harvested crops. Grains should be well dried in the sun before storage. This prevents germination, growth of fungi and attack by insects. Drying can be done the traditional way, by spreading the crop on clean bare ground for one to three weeks depending on the weather. Drying grains can also be done for one day by spreading on tarpaulin sheet. Note that if grains have

been attacked by weevils, drying the grains for just one day will kill weevils, including larvae.

- Sterilization of food grains. This is done by spreading food grains on concrete floor, tarpaulin or a black plastic sheeting and covering tightly with clear plastic sheet under direct sunlight for 30 to 60 minutes. This destroys pests which have attacked the grain.
- Use a mixture of ash and chili peppers mixed with grain. Dry the chilis and pound them into fine powder. Sieve cold wood ash from the fire place. Mix two kgs of wood ash with one table spoon of chili powder. Make sure they are thoroughly mixed with approximately three kgs of grain and the mix is ready for storage. (This is mainly for seeds.)
- Use of neem products. Mature neem leaves, if dried under shade, is used to control weevils. Mix four kgs of neem powder with 100 kgs of grain.
- Neem powder from seeds can also be used. Ripe neem seeds are harvested, the outer coat peeled off and washed with water. The clean seeds are then dried under a shade. The dry seeds are then pounded slowly to open the kernels. The kernels are removed by winnowing. The balance is then pounded into a powder. Two kgs of powder is mixed with 100 kgs of grain.
- Use of hot pepper (chedher/sheta). Use four table spoons of well-ground pepper mixed thoroughly with 20 kgs of grain.
- Use of tobacco. Tobacco, though poisonous, can be used for seed storage. Mix five kgs of ground tobacco with 50 kgs of grain seeds.
- Use of sand. Dry sand mixed with grain seeds at a 50:50 ratio is an effective way of controlling weevils. The sand seals all the air spaces between the grains making it impossible for pests to survive.
- Storage of grain in air tight containers. All insects, including weevils, need air to breathe. So storing grains in such tight containers such as gourds, pots, or jerricans can keep away weevils.
- Smoking. Farmers can build a wood fire to place under granaries so that smoke enters the cobs or pods of grains and shells of beans or nuts.
- Storing new grains in a clean environment. Clean and clear all old grains from the store in good time before harvest, and burn all trash. Also farmers are advised not to mix old grains with new ones.
- Proper threshing and cleaning of grains. Cleaning and sorting of grains to remove broken, infested and dirty grains is important.
- Regular inspection of stored grains. This gives farmers an opportunity to take action before weevils start damaging grains, either by sun drying of the grain/beans/nuts, or through the application of organic chemicals.
- Area surrounding the store to be kept clean and tall grass cut regularly. Old fenced can act as a hideout for rats.

Moulds

Moisture encourages the development of moulds during storage. Farmers can control moulds through:

- Timely harvesting of crops as soon as they reach maturity. This reduces chances of crops falling down into wet soil.
- Dry grains well in the sun before storage. If the weather is wet, stored grain can be removed again and dried out in the sun.
- Grains stored in sacks should be placed on a raised rack or logs to prevent direct contact with the floor. Also the sacks should be placed in an alternating pattern to allow air to pass through them.
- Grain in storage cribs/houses or in jute sacks should be well ventilated, to allow air to pass through the grain.
- Roofs of cribs should be kept in good condition to prevent leakage of water into the crib.

Discussion Points:

- Maize cobs, sorghum and millet heads and pods of pulses that fall to the ground can come into contact with mould spores that live in the soil.
- Repeated planting of a crop in the same field may increase the risk of infection by mould.
- Poor handling techniques used at harvest during drying, threshing and transportation can spread mould.
- Insect infestation in storage.

NB: All of these moulds produce harmful Mycotoxins.

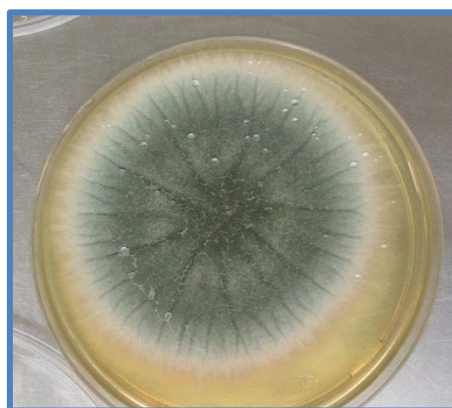
Prevention/Control of Moulds:

- Dry the grain as quickly as possible to a moisture content that is low enough for safe storage.
- Ensure that grain saved for seed is healthy and free of pests and diseases.
- Avoid drought stress either by using irrigation or by planting early to avoid rain failure towards the end of the growing season.
- Keep the crop clean and free of weeds while it is growing.
- Practice crop rotation as much as possible.
- Where possible, plant disease resistant varieties (however, there are no *Aspergillus* resistant varieties).
- Avoid nutrient stress by applying organic or inorganic fertilizer, but doing so at the appropriate time and with recommended quantities.



7 Aspergillus (ear rot)

Source: <http://www.ent.iastate.edu>



6 Aspergillus mycelium, (green mould).

Source: www.cosmosbiomedacal.com

Termites

Termites can be Controlled Through:

- Timely harvest of crops, (sorghum); i.e., they should be harvested immediately after reaching physiological maturity to minimize susceptibility to attack by termites.
- Use of strong and resistant poles when constructing granaries. Some local tree species cannot be attacked by termites, e.g., coconut timber or deleb trees.
- Application of crude oil or diesel at the base of the poles used to construct granaries.
- Removal of bark from the poles supporting the granaries.
- Physical removal.
- Spreading of ash at the base of the granaries, and sweeping regularly.
- Use of a mixture of cow urine with salt stored for about three days. The mixture is poured at the base of poles. It completely destroys all the termites.

Rodents

Discussion Points:

- ✓ Losses/damages cause by rodents in stored grains
- ✓ Clues to the presence of rodents in the stores
- ✓ Major species of rats
- ✓ Control measures for rodents
- ✓ Show different pictures of rats and



8 Rodent

rat traps

Losses/Damage Caused by Rodents in Stores:

- Rats and mice damage storage containers
- Rats eat some of the stored produce, carry some away to their nests and
- They spoil much more with droppings, urine and hairs

Three Species of Rodents are Major Pests of Stored Produce:

- *Rattus rattus* (black rat) and *Rattus norvegicus* (brown rat)
- *Mus musculus* (house mouse)
- *Praomys natalensis* (multi-mamma rat)

Signs of the Presence of Rats in Stores:

- Droppings
- Loose earth from burrowing
- Footprints on dusty floors
- Greasy marks on set routes of travel, e.g., on beams or along electrical wiring
- Holed sacks with grain escaping
- Gnawing damage to building fabric

Control Methods:

- Keep the store clean and tidy and have rodent-proofing in place.
- Rat guards (no lower than one meter above the ground); should be attached to the legs and supports of grain stores.
- Stores should be built at least one meter away from trees, poles or buildings.
- Traps should be used inside the house or storeroom.
- Poisoning of rodents with rodenticides (but expensive and dangerous to human and animal health, also detrimental to environment; therefore should be carefully administered).
- Keeping the compounds and surroundings in the village free from rubbish.
- Bundles of thorns can be used as rat guards. They prevent the rats from climbing up the granary. The thorns are also used to block the tunnels or holes dug by the rats.

Birds

Discussion Points:

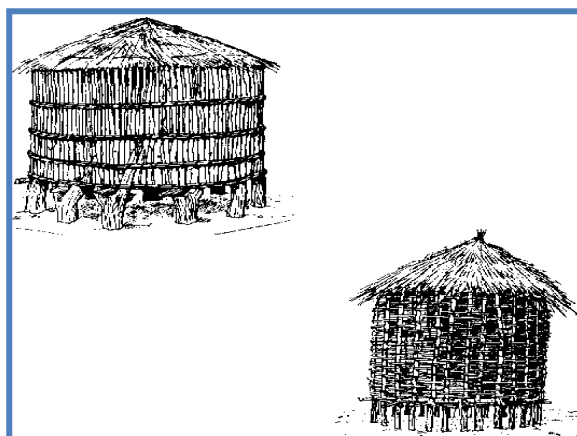
- ✓ Losses caused by birds
- ✓ Control measures

Losses Caused by Birds:

- Some species of birds commonly feed on stored grain.
- They also contaminate the grain with their droppings and feathers.

Bird Control:

- The store should be kept in good condition and the entrance or door to the store kept closed.
- The area around the store and compound should be kept clean as birds are attracted by spilled grain.



9 Traditional Granaries

Storage Facilities:

Discussion Points:

- ✓ Discussion of different types storage facilities including their advantages/disadvantages.
- ✓ Factors influencing the choice of storage facilities.
- ✓ Structures used for seed and food grains and pulses storage.
- ✓ Show pictures of different storage structures.

Types of Traditional Storage Containers/Facilities:

- Granaries
- Clay pots
- Gourds
- Jute bags
- Metal drums and bins
- Baskets
- Underground pits
- Bins of stone or mud plaster

Advantages:

- Made from local materials, hence cheap.
- Do not require technical skills

Disadvantages:

- Rats and weevils can attack.
- Rotting of grains
- Limited in size

Improved/Modern Storage Facilities (e.g. improved crib)

Advantages:

- Long life span
- Rodent proof
- Can store large quantities of grain
- Easy to maintain

Disadvantages:

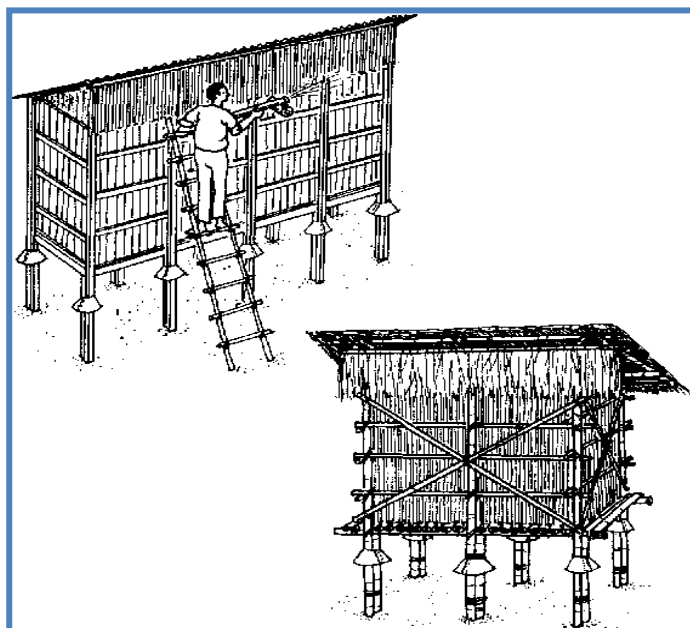
- Quite expensive to construct
- Requires technical skills to design/erect

Factors Influencing the Choice of Storage Facilities:

- The quantity of produce to be stored
- The period or duration of storage
- Availability of construction materials
- The cost of construction

Seed Storage

- Grain may be stored in sealed pots or gourds, or in tins or bottles.
- Plastic water containers with screw-on lids make ideal seed stores.
- Larger quantities of maize seed are stored by suspending entire cobs from the roof eaves or overhang of the house; they may also be suspended from trees.



10 Modern or Improved Elevated Storage Bins, with Rodent Guards

Food Grain/Pulse Storage:

- Platforms and frames
- Drying and storage cribs
- Baskets
- Solid wall bins
- Metal storage bins
- Underground storage
- Bag storage
- Metal drums

Storage Practices

The Four Pillars of Good Storage Practice Include:

1. Ensuring that the crop going into the store is in good condition.
2. Keeping the store in good condition.
3. Practicing good store hygiene.
4. Maintaining the condition of crops and stores throughout the storage season.

Ensuring that the Crop Going into the Store is in Good Condition:

- Good quality whole grain is less likely to suffer insect attack than poor quality damaged grain.
- The grain should be cleaned well and any damaged grain removed.
- The grain should be well dried.
- The crop should be carefully handled once it has dried to ensure that grain remains intact.

Keeping the Store in Good Condition:

- A good store will keep the grain dry and cool. It should provide protection against rodents, birds and browsing domestic animals and poultry. It should be theft proof.
- Stores should be sited in areas that are not prone to flooding; the soil should allow water to drain away readily.
- They should not be placed where high winds might damage the structure or near trees, which might provide access points from which rodents can jump onto the store roof or platform.
- The store should have a roof to keep rain off the structure and to provide shade during the heat of the day.
- To prevent groundwater soaking into the store, the structure must be raised off the ground.

- The store must be kept in good repair to stop the roof leaking or the sides collapsing.
- At the beginning of the new storage season the empty store must be cleaned.

Practicing Good Store Hygiene:

- This means keeping everything as clean as is practically possible.
- The store surroundings should be tidied so that there is no vegetation or rubbish to hinder inspection or to provide breeding grounds for insects and rodents.
- Livestock should be kept away from the store; they should not be allowed to browse or sleep under the store; droppings should be cleared up as they attract rodents.
- Whenever the storage containers are empty they should be cleaned. Secondhand sacks should be dipped into boiling water to kill any insects and then dried in the sun.
- Grain residues should be removed from sacks by turning them inside out and thoroughly brushing them. Holes should be stitched.
- Grass should be burnt inside solid walled bins and mud plastered baskets to kill off insects and mould spores.
- Old grain should be stored separately from the new crop and it should be used first.

Maintaining the Condition of the Crop and the Store Throughout the Storage Season

- Pests can attack the store at any time so it is important to inspect the store and crop regularly.
- Store inspections should start as soon as the grain is put in store and then conducted routinely at weekly intervals. This is because insects may be brought in with the crop.
- Even if the crop is insect-free at the start of storage, regular inspection is necessary to spot insects that might fly in from a neighbor's store, trees and vegetation or from grain purchased from the market.
- For shelled grain and pulses stored in bags, baskets or bins, the grain should be removed from store and adult insects removed by sun drying or sieving and winnowing the grain.
- The store should be quickly repaired if it becomes damaged.
- Good storage practice is the key to maintaining grain quality.