



# **Framer's Training Manual on Post Harvest Management of Sorghum, Groundnut and Rice**



**Project on  
Enhanced Value Addition and Strengthening Value Chains in the Greater  
Bahr el Ghazal Region**

**Funded by: The European Union (EU)**

**Implemented by: The United Nations Industrial Development  
Organization (UNIDO)**

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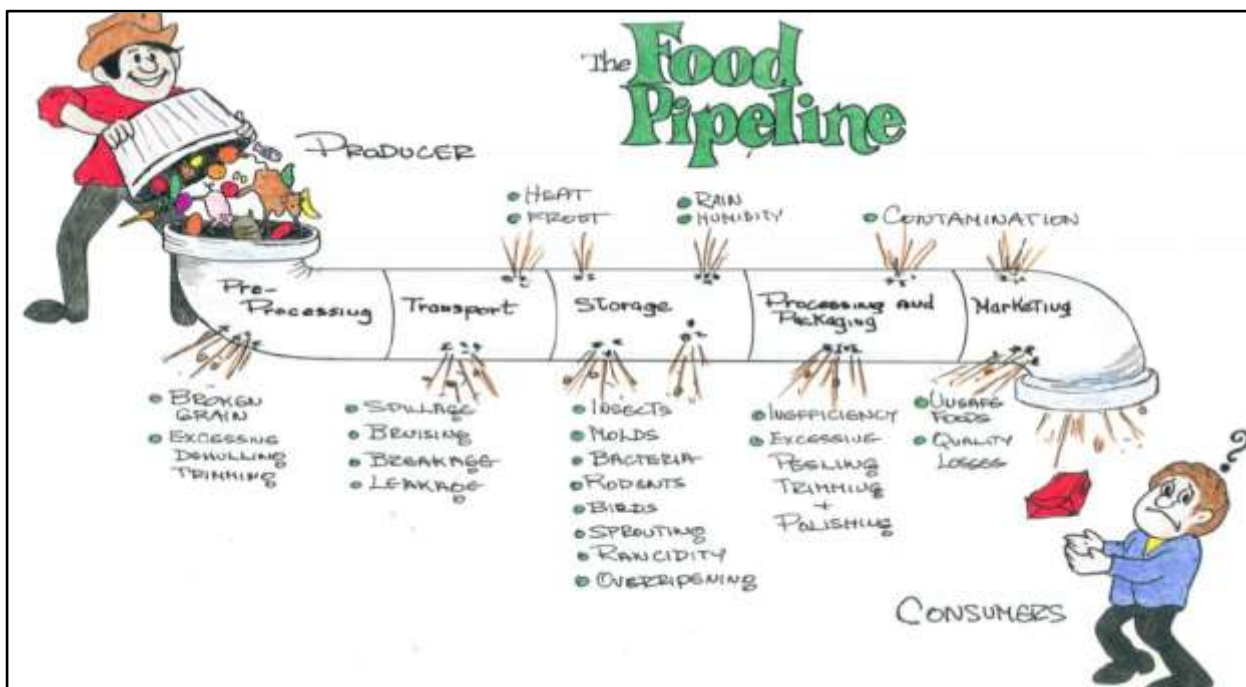
## 1. INTRODUCTION

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



Post-harvest losses refers to quantitative and qualitative losses that occur to grains after harvesting due to a series of operations the grains undergoes through such as: Inappropriate pre-harvest practices; inadequate farming equipment, poor grain handling (quality losses) - causing financial losses and food safety issues, poor grain drying systems - causing moisture related problems (rotting, moulds etc.), poor grain storage systems-causing grain losses from pest infestations

Post-harvest losses incurred by farmers are estimated at about 10%, cereal losses can be as high as 13% - 15%. These losses impact greatly on household food vulnerability and cash income (livelihood). In general, post-harvest losses can be minimized by proper post-harvest management practices. These losses can easily be explained using the food pipeline (after Bourne, 1977).



**Figure 1-1: The food Pipeline (Source: Bourne, 1977, mimeo)**

This training manual provides information useful for farmers training on post-harvest handling practices of groundnuts, sorghum and rice. Adopting such practices would help reduce post-harvest losses considerably.



## PART 1

### 2. POST-HARVEST HANDLING PROCESSING PRACTICES OF GROUNDNUTS (*Arachis hypogea*)





## 2.1. Specific objectives

At the end of this training session, the farmer is expected to know how to:

1. Minimize pre-harvest infestation,
2. How to prepare before the harvest,
3. When is the right time of harvesting,
4. Precautions to take during harvesting,
5. How grain should be transported to the house,
6. Utilization of the crop.

## 2.2. Introduction

Groundnut is widely grown worldwide as a food and cash crop. It is one of the highest paying crop with fairly stable prices. Household consumption is quite high with preference to the brown/red-kennelled varieties because of their reputed taste.

## 2.3. Uses of the crop

- It is a useful crop rotation crop. Being a legume, it can fix atmospheric nitrogen and this benefits subsequent crops especially when groundnuts are incorporated into the soil during ploughing. This maintains soil fertility.
- It controls soil erosion by providing ground cover.
- All parts of the plant can be put to use. The plant stalks are fed to the cattle in the form of green, dried and silage. Groundnut shells, haulms and hay are good fodder.
- Groundnut cake is good feed for livestock and is also used as manure.
- Is used as a vegetable cooking oil.
- Kernels are used directly as food or snacks for human consumption.
- A large number of food products are prepared from groundnuts-Boiled nuts, groundnut butter, and bakery products etc.

## 2.4. What makes good quality groundnuts?

- i. **Purity level:** This refers to the absence of foreign materials in grain such as stones, rotten grains, broken or discolored grains. Most buyers prefer groundnuts with 95% level of purity.
- ii. **Moisture content:** The best quality groundnuts as measured by a moisture meter should have a moisture content of 7-8%.
- iii. **Shelling percentage:** This means that when shelling, at least 65% of the weight should be grain weight while the other 25% is trash. A lower weight shows poor quality groundnuts with high deficiencies of calcium during the pegging stage.
- iv. **Damage:** This refers to the proportion of groundnuts that are mechanically or physically damaged (cracked/broken) during the post-harvest handling process.
- v. **Aflatoxin:** These are poisonous substances produced by fungi and make the grain unfit for consumption. Good quality groundnuts should be aflatoxin free.



**Figure 2-1: Good groundnuts in the shells (NARO)**

## **2.5. Section 1: The process of harvesting groundnuts**

### **2.5.1. Discussion points (45 minutes)**

- ✓ Preparation before harvesting and tools used for harvesting,
- ✓ Timing of harvesting,
- ✓ Indicators of harvesting time,
- ✓ Precautions during harvesting,
- ✓ Process of harvesting in your community.

### **2.5.2. Tools used for harvesting in your area**

- Molodo
- Sickle
- Knife /spear, etc.

### **2.5.3. Timing for harvesting**

It is very important to harvest groundnuts at the correct time. If harvested too early, the seeds will shrink when drying which lowers the oil content and quality of the seed. Delays in harvesting will result in poor quality seed due to mould infections and subsequent aflatoxin contamination of the seeds/pods. Late harvesting also reduces yield because higher proportions of the pods are left in the ground due to the pegs being weak and the pods breaking off. Late harvesting also causes some non-dormant varieties to begin sprouting in the field resulting in yield losses.

**Table 2-1: Challenges of both early and late harvesting of groundnuts**

| <b>Challenges of early harvesting</b> | <b>Challenges of late harvesting</b>  |
|---------------------------------------|---|
| Drop in oil content                   | Difficult to uproot as pods remain in the soil due to weakening of the pegs |
| Not saleable, low income              | Sprouting of less dormant varieties   |

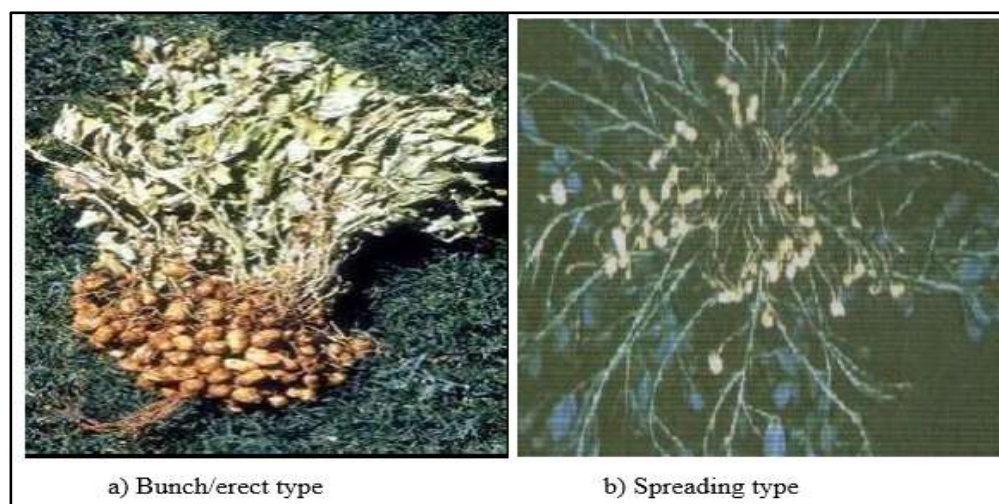
| Challenges of early harvesting | Challenges of late harvesting  |
|--------------------------------|--------------------------------|
|                                |                                |
| Shrinkage of seeds             | Low income                     |
| Weight loss                    | Mould infections of seeds/pods |
| Poor/low quality seeds         |                                |

#### 2.5.4. Indicators for harvesting timing

- A proper time to commence harvest is when a good number of pods are fully developed and are intact.
- Maturity of pods is achieved when the vines begin to turn yellow and leaf shedding starts.
- It is recommended that a few plants (3-5) should be pulled up and the pods removed and shed. The insides of the shells should be examined, if majority of the pods (70% upwards) have dark markings inside the shell and the seeds are plump and the correct **colour for that variety, then the groundnuts are mature and ready for harvest.**
- The estimated period of maturity for each variety can be used as a rough guide (i.e. the calendar method).

#### 2.5.5. Harvesting process

The actual method of harvest used depends upon the type of groundnut grown. In bunch types Figure 2-2(a), pod development is confined to the base of the plant and the pegs carrying the pods into the soil are thick and strong. Almost all the pods are recovered with the plants when they are pulled out of the soil. That is why the bunch type of groundnut is mostly harvested by pulling out the plants with manual labour. The spreading or semi – spreading groundnut types Figure 2-2(b) produce pods all along the running stem. This type of groundnut is harvested either manual or by using a blade harrow or ox-plough. The soil should be sufficiently moist for easy harvesting and without losing pods in the soil. Figure 2-3 shows the process of hand pulling of groundnuts.



**Figure 2-2: Different growth types of groundnuts**



**Figure 2-3: Manual harvesting (hand pulling) of groundnut plants**

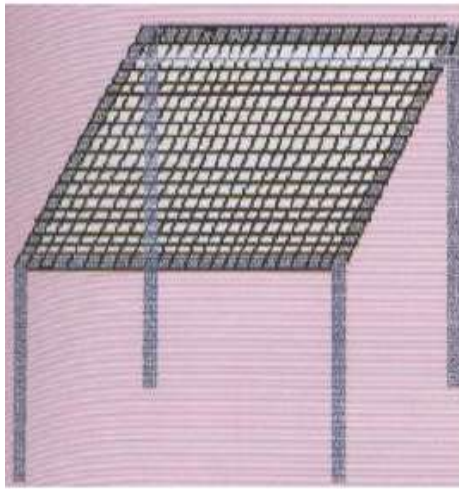
#### **2.5.5.1. Stripping/Plucking**

This is the process of removing pods from the plants. It is done manually by the small-scale farmers as shown in Figure 2-4, or using a simple plucking machine, shown in Figure 2-5 (a) or with the aid of a stripper Figure 2-5(b). The simple plucking machine is constructed of wooden frames covered with a stretched piece of chicken netting can speed up the process. The dried/wilted plants are held by the leaves and the roots/pods drawn across the stretched chicken wire. The pods get caught in the wire and are pulled off, dropping below the frame.



**Figure 2-4: Manual stripping of groundnut pods**





(a) Simple plucking machine



(b) Stripping of pods with a stripper

**Figure 2-5: Improved methods of stripping groundnuts**

## **2.6. Section 2: Stages in post-harvest handling of groundnuts**

### **2.6.1. Discussion points: (1 hour 30 mins)**

- How farmers clean their groundnuts after harvesting,
- 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 groundnut,
- 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 sorting and grading is done in the community; recommend improved practices,
- Show pictures.

### **2.6.2. Cleaning**

- Shake off soil from the pods to discourage fungal growth
- Removal of soil from the pods shortens length of drying period

### **2.6.3. Drying**

The correct drying or curing of the harvested groundnuts is very important as poor curing can help induce fungal growth (producing aflatoxin contamination) and reduce seed quality for consumption, marketing and germination for the following seasons planting. For good storage and germination, the moisture content of the pods should be reduced to 6-8%. There are different ways of drying the pods, some of which are better than others. It is particularly important to note that if the pods are exposed to the sun for too long the seed quality can deteriorate considerably and germination can be affected.

#### **2.6.3.1. Reasons for drying**

- ✓ Reduce fungal attack and contamination with aflatoxin,
- ✓ For safe storage and maintaining a high germination percentage for the following season.

### **2.6.3.2. Drying in windrows**

If the harvested groundnut plant are left to dry on the soil surface where they have been lifted, the pod are likely to be in contact with the soil, which can contain moisture and be at a higher temperature. This method can easily affect the quality of the seed, particularly if there is rain during the drying period. If field drying is used, it is better to use windrows, where plants are laid in rows to catch the wind and dry more quickly as shown in Figure 2-6. The drying of pods in windrows (3-5 days) should produce the required level of moisture before the pods are picked or stripped. Excessive exposure to the sun can affect the quality of the seed



**Figure 2-6: Drying of groundnuts in windrows**

### **2.6.3.3. Drying on mats**

The plants can be picked from the windrow and spread in a thin layer in the sun to dry, as shown in Figure 2-7 or mat for 2-5 days to achieve safe moisture storage. Pods should be covered or taken indoors during wet weather. They can also be picked immediately after lifting and then dried in the sun as above for 6-8 days. Once again, excessive exposure to the sun can affect the quality of the seed



**Figure 2-7: Groundnut spread on the ground**

#### **2.6.3.4. Curing**

After 2-3 days of wilting, it is safe to begin natural curing. The following factors should be considered:

- **Shade:** Exposure to direct sunlight results in quality deterioration. It is recommended that plants be stacked with pods innermost and foliage outermost,
- **Ventilation:** Adequate air circulation is important to allow steady moisture loss,
- **Drainage:** Ensure good drainage to avoid windrows and cocks being spoiled by standing in water during wet weather.

The A frame (Figure 2-8) is used for curing the crop after wilting. The wilted plants are placed on the A-frame with the pods facing down. They are left for 3-4 weeks to dry.



**Figure 2-8: A-frame used for plant/pod drying**

#### **2.6.4. Storage**

The points to note while drying groundnuts are:

- The best way to store groundnuts is in their shell,
- Store the groundnuts when the moisture content is between 7-8%,
- Never bag groundnuts for storage when the pods are still damp,
- Before storage remove broken, damaged, poor and fungus- infected nuts,
- Store in a well ventilated and cool place,
- Do not store in plastic bags as they restrict air circulation and this promote fungal infection,
- Apply Actellic super (pirimiphosmethyl) on unshelled pods before storage to control storage pests.

##### **2.6.4.1. Storage in bags**

- Gunny bags are recommended as they allow air circulation. They should not be covered with plastic or tarpaulin (canvas) which may restrict ventilation and increase condensation.
- Bags should be stored away from the ground on wooden slats. If bags are stacked, a gap should be left between stacks
- Do not stack more than 10 bags high.





**Figure 2-9: Bag storage of groundnuts in shell**

#### **2.6.4.2. Hermetic storage - PICS bag**

This is a recent technology in grain storage in which the sack is lined with two tough layers of polythene bags as shown in Figure 2-10. This ensures reduced oxygen supply and increased carbon dioxide in storage. These conditions are not suitable for respiration of storage pest.



**Figure 2-10: Hermetic bag storage (PICS bag)**

#### **2.6.4.3. Other methods of storage**

Storage in clay pots, woven baskets or storing loose may be used, but the pods should be kept off the ground.

#### **2.6.5. Shelling**

- Groundnut shelling should be done only when the seeds are needed for consumption, planting or marketing,
- During shelling process, discolored, mouldy or shriveled seeds should be removed.

##### **2.6.5.1. Shelling by hand**

Hand shelling is labour intensive but is effective for small scale farmers especially for selection of planting seed for the following season. It is not recommended to put pods in sacks and beat as this causes damage to the seeds. The hand shelling process is shown in Figure 2-11.



**Figure 2-11: Hand shelling**

#### **2.6.5.2. Mechanical shellers**

There are a number of mechanical hand shellers on the market that can shell groundnuts at a rate of up to six bags an hour. The rotary types have the advantage of continuous operation (rather than shelling in batches) and new designs produce very little wastage in terms of damaged seed. Figure 2-12 shows ground nut sample shellers used for shelling.



**Figure 2-12: Groundnuts sample shellers**

### **2.7. Section 3: Aflatoxin problem in groundnut**

#### **2.7.1. What are Aflatoxins?**

They are poisonous substances produced by certain fungi. Small quantities of aflatoxin can cause fatal liver cancer in both animals and humans and eventually death. Aflatoxin contamination is serious quality problem in groundnuts.

## **2.7.2. What causes contamination of groundnuts by Aflatoxin?**

### **2.7.2.1. At pre-harvest**

- End of season moisture stress to the crop for more than 20 days,
- Growth cracks and mechanical injury to the pod,
- Insects damage to pods by termites or pod borers,
- Death caused by diseases (stem, root, and pod rots) at pod maturity stage,
- Nematodes damage to the pod.

### **2.7.2.2. At post-harvest**

- Harvesting over mature crop,
- Mechanical damage to the pod at the time of harvest,
- Stacking the harvest when pod moisture is more than 10% or under humidity conditions,
- Storing haulms with immature pods,
- Pod rotting due to roof leakage or high moisture levels,
- Insect damage during storage.

## **2.7.3. What are the effects of aflatoxins contamination?**

- Aflatoxin causes marked deterioration in pod and kernel quality because of fungal growth as shown in Figure 2-13,
- Contaminated kernels are unfit for consumption. If eaten in sufficient quantities aflatoxin can cause sickness, hepatitis and/or liver cancer. It is, therefore, extremely important to ensure good management of ground nut crops and suspect seed should be destroyed rather than used for human or animal consumption,
- Reduced price for the produce,
- Causes decay in both seeds and non-emerged seedlings,
- Severely affects the export of groundnut and its by products.



**Figure 2-13: comparison of aflatoxin contaminated and uncontaminated groundnuts**

## **2.7.4. What are the symptoms for Aflatoxin poisoning?**

The following are the major effects of aflatoxin poisoning:

- Swollen stomach, hands and legs,
- Fever,
- Sweating,
- Yellow eyes -Jaundice,
- Liver cancer,
- Reduced immunity,
- Stunted growth in children,
- Death in humans and domestic animals.

#### **2.7.5. How can the effects of Aflatoxins be minimized?**

The effects of aflatoxin can be minimized by the following methods:

- Harvesting the crops as soon as it is mature, any delay will encourage the development of fungus,
- Avoiding damaging pods during cropping,
- Removing soil from the pods before leaving to dry,
- Ensuring that the correct drying procedures are used and that damaged, shriveled, or rotten pods are removed before storage,
- Store the pods under dry, well-ventilated conditions to ensure the moisture content remains low, thus discouraging fungal growth,
- Avoid damaging the seed during shelling and destroy any discolored, shriveled or mould seed,
- Avoid pod damage by insects as this can leave the pods / seeds susceptible to fungal infection,
- Pre – harvest contamination is severe during drought and extra care should be taken to clean the seed, especially the smaller seed.



**PART 3**  
**3. POST-HARVEST HANDLING PRACTICES OF SORGHUM**  
*(Sorghum Bicolor)*



### **3.1. Introduction (15 mins)**

Sorghum is the fifth most important grain crop after wheat, maize, rice and barley, which is indigenous to Africa. It belongs to the grass family graminea. It is mainly grown on low potential, shallow soils with a high clay content, which usually are not suitable for the production of maize. It is grown mostly in an annual rainfall range of 300 to 750 mm. It is grown in areas, which are too dry for maize.

### **3.2. Uses of the crop**

The various uses for the crop are:

- It is a potential food security crop since it is draught tolerant,
- It is recommended for special cases such as diabetic and infants since it is rich in essential minerals,
- It is used as a livestock feed,
- It is used for industrial manufacture of ethanol,
- It is used traditionally for brewing purposes,
- House thatching or fencing.

### **3.3. Section 1: The process of harvesting sorghum**

#### **3.3.1. Discussion Points (1 hour)**

- ✓ Tools used for harvesting,
- ✓ Stage and timing of harvesting
- ✓ Indicators of harvesting time,
- ✓ Process of harvesting in your community.

#### **3.3.2. Tools used for harvesting in your area**

- Molodo
- Sickle
- Knife/spear, etc.

#### **3.3.3. Stage and timing of harvesting**

- Time of harvest influences yield, quality and storage life of crop,
- Prematurely harvested sorghum crop has high moisture content and low quality,
- Delayed harvesting leads to excess shattering, are pre disposed to pests, germination and increased field losses(Heads of sorghum that fall to the ground come into contact with fungi in the soil,
- Harvest at the right time and moisture content,
- 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 time's farmers are forced to harvest their crops early to avoid floods (especially in low lands) and to prevent destruction by livestock released before harvests.

#### **3.3.4. 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.

#### **3.3.5. Harvesting process of sorghum**

- For Sorghum, harvesting is harvested by hand.
- The panicle is cut from the standing stalk at about 16 -20% moisture content.

### **3.4. Section 2: Post-harvest handling practices**

#### **3.4.1. Discussion Points (45 mins)**

- ✓ 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.

#### **3.4.2. Drying**

- Grains are usually dried until the correct moisture content (10 to 12 %) for optimum storage is attained. The reasons for drying to reach a moisture content level of 10 to 13 percent include:
  - Prevention of mould growth and aflatoxin contamination of the grains,
  - Reduction of the likelihood of insect attack,
  - Prevention of grain germination.

Field drying is mostly practiced where the panicles are stack into bundles in the field and allowed to dry in the sun. But they should be kept off the ground whilst being dried.

#### **3.4.3. Measurement of grains' moisture content**

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

##### **i). Salt test**

- 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,



- Therefore, 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***

#### **ii). Smelling a sample of grain for mouldy smell**

- Take a representative sample of the produce under consideration in a convenient container,
- Move the container with sample close to your nose,
- Smell the sample: The smell of the produce should be typical. Other smells e.g. of chemicals, mouldiness, rot etc. should not be detectable .

#### **iii). Biting grain method**

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.

### **3.4.4. Threshing/Shelling**

This is the act of removing sorghum and grains from the heads. The time required for threshing depends on:

- Variety of grain,
- The degree of dryness of the grain,
- The method of threshing.

#### **3.4.4.1. 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).

#### **3.4.4.2. 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.

### **3.4.5. Cleaning/winnowing**

Grain cleaning is achieved by winnowing to remove the low density materials such as leaf, stalk and empty seeds.

### **3.4.6. Sorting**

It is done to remove the heavy material (stones, soil) which cannot be removed by winnowing.

### 3.5. Section 3: Causes of losses and loss management (1 hour)

The principle causes of quality/quantity losses and/or deterioration in stored grains are:

- Insects
- Moulds
- Rodents
- Birds

#### 3.5.1. Insects

##### 3.5.1.1. Discussion points

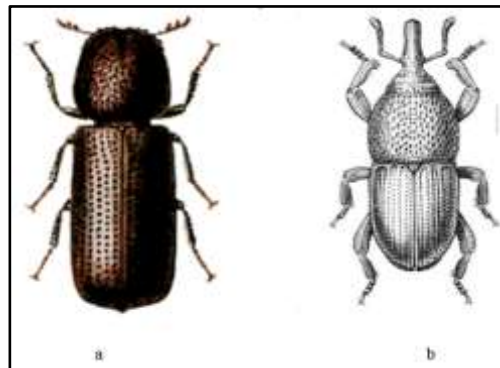
- ✓ Types of insect storage pests and examples,
- ✓ Losses caused by insect pests,
- ✓ Sources of insect infestation,
- ✓ Control measures for insect pests.

##### 3.5.1.2. Primary pests

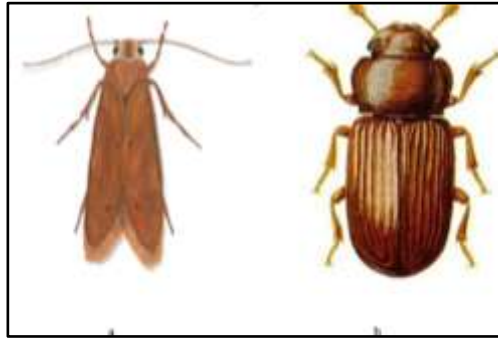
- Are capable of attacking and breeding inside previously undamaged grains/beans/nuts,
- Are very common in farm stores soon after harvest,
- Can occur in the plant once it has reached maturity in the field.

##### 3.5.1.3. Common examples of primary insect pests

- Lesser/smaller grain borer, *Rhyzopertha dominica*, shown in Figure 3-1(a),
- Larger grain borer, *Prostephanus truncates*,
- Weevils, *Sitophilus* species Figure 3-1 (b),
- Moths found commonly in grain stores, *Sitotroga cerealella*, the Angoumois grain moth shown in Figure 3-2; it is frequently found in stores of cob maize, especially soon after harvest.



**Figure 3-1: Lesser Grain Borer, *Rhyzopertha dominica* (a), Sorghum /Maize Weevil, *Sitophilus Zeamais* (Source: USAID, 2012)**



**Figure 3-2: Angoumois grain moth, *Sitotroga cerealella* (a), Red flour beetle (b)**  
(Source: USAID, 2012)



**Figure 3-3: Indian meal moth** (Source: USAID, 2012)

#### **3.5.1.4. 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.

#### **3.5.1.5. Losses caused by insects**

The losses caused by insects include:

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

#### **3.5.1.6. 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.

### 3.5.1.7. Methods of controlling insects in stored cereals (30 mins)

The methods used for controlling insects in stored cereals are either chemical or non-chemical methods:

#### i). Chemical methods

It is effective but expensive and dangerous for farmers if not handled with care; can also have negative environmental consequences such as toxic contamination.



**Figure 3-4: Mixing insecticide with threshed grain**

#### ii). Non-chemical methods (recommended)

- Timely harvest of crops: harvesting should be done when crop reaches physiological maturity. This reduces damage and losses due to birds, insect pests, rodents and termites, and 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 chilies 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.

### **3.5.2. 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.

#### **3.5.2.1. Discussion points**

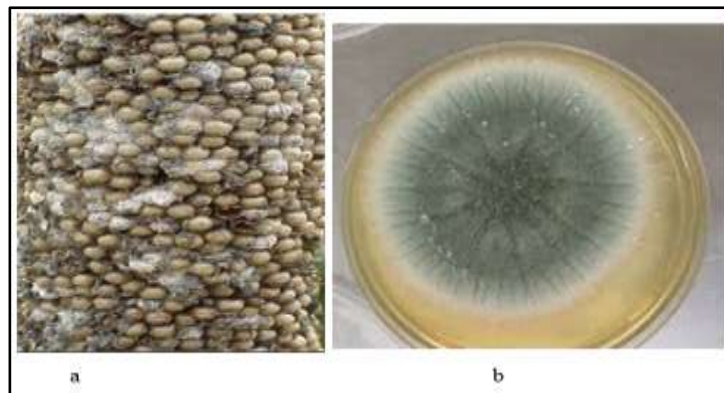
- ✓ Maize cobs, sorghum and millet heads and pods of pulses that fall to the ground can come into contact with mould spores that live in the soil,
- ✓ Repeated planting of a crop in the same field may increase the risk of infection by mould,

- ✓ 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 (shown in Figure 3-5).**

### 3.5.2.2. 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.



**Figure 3-5: *Aspergillus* (ear rot) (a), and *Aspergillus mycelium*, (green mould) (b)**  
(Source: USAID, Post-Harvest handling training manual for extension workers, October 2012)

### 3.5.3. 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.

### **3.5.4. Rodents**

#### **3.5.4.1. Discussion points (15 min)**

- ✓ 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.

#### **3.5.4.2. 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,
- They spoil much more with droppings, urine and hairs.

#### **3.5.4.3. 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).

#### **3.5.4.4. 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.

#### **3.5.4.5. 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.





**Figure 3-6: Rats climbing into the store**



**Figure 3-7: Rat guards to stop rat climbing to the granary**

### **3.5.5. Birds**

#### **3.5.5.1. Discussion points**

- ✓ Losses caused by birds
- ✓ Control measures

#### **3.5.5.2. Losses caused by birds**

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

#### **3.5.5.3. 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.

### **3.6. Storage facilities**

#### **3.6.1. Group discussion questions (30 mins)**

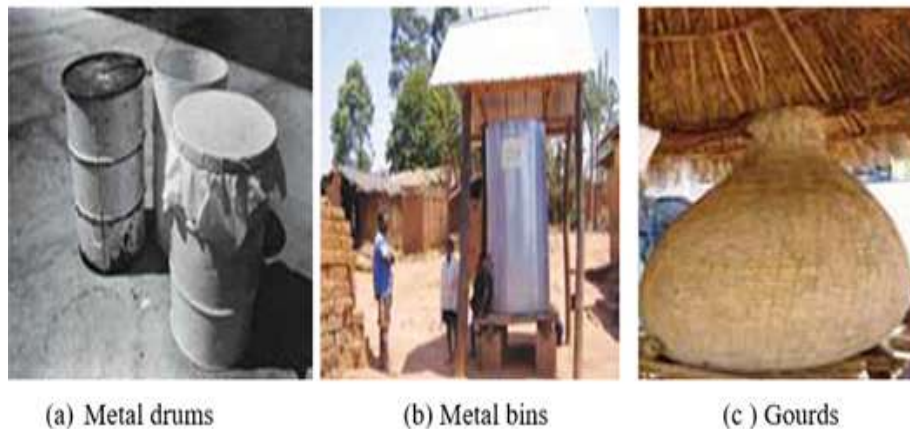
- ✓ How long should a farmer store grain?
- ✓ What are some of the losses incurred by farmers during storage?
- ✓ What are the factors that lead to poor storage?
- ✓ How does poor storage affect grain quality?

- ✓ What are some of the common pests that affect grain during storage?

### 3.6.2. Types of traditional storage containers/facilities

Some of the common traditional storage facilities shown in Figure 3-8 are:

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



**Figure 3-8: Traditional containers used for seed storage**



**Figure 3-9: Traditional containers used for seed storage - (a) Traditional baskets; (b) Underground pit**

#### 3.6.2.1. Factors that influence 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.

### **3.6.3. 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.

### **3.6.4. Storage practices**

The Four pillars of good Storage practice include:

- Ensuring that the crop going into the store is in good condition,
- Keeping the store in good condition,
- Practicing good store hygiene,
- Maintaining the condition of crops and stores throughout the storage season.

#### **3.6.4.1. 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.

#### **3.6.4.2. 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.

#### **3.6.4.3. 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. Second hand 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.

#### **3.6.4.4. 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.

**PART 4**  
**4. POST-HARVEST HANDLING AND MANAGEMNET OF RICE**  
*(sorghum bicolor)*



## 4.1. Introduction

Post-harvest management of rice includes:

- Harvesting,
- Threshing,
- Winnowing/Cleaning,
- Drying,
- Storage
- Protection
- Milling the rice crop.

Harvesting and threshing methods of rice vary widely from farmer to farmer and also from country to country. The levels of mechanization, from country to country also differ widely. The methods may either be manual, animal or mechanical operated (FAO, 2007).

## 4.2. Harvesting (45 mins)

### 4.2.1. General objective

The objective of the section is to provide practical information on how and when to harvest by using visual indicators, in order to optimise the quantity obtained and the quality of the paddy.

### 4.2.2. Specific objective

At the end of the training period, the farmer should be able to harvest at the appropriate time using simple visual signs and methods and be aware of the exiting improved technologies for harvesting that can fit their production system.

### 4.2.3. How to harvest

Rice harvesting is mainly carried out in Sub-Saharan Africa manually. The process involves cutting of the rice plants at maturity stage, pre-drying, threshing, winnowing, drying and bulking. Several of these post production activities have direct bearing on the quality of paddy available for processing. The steps involved with rice post-harvest activities are considered below:

- The optimal stage to harvest a rice crop is when the grain moisture content is between 20 - 25% or when 80 - 85% of the grains are straw coloured and the grains in the lower parts of the panicle are in the hard doe stage. This is about 30 days after flowering.
- If the crop is harvested too late, many grains are lost through shattering or drying out and are cracked during threshing. Cracked grains do not germinate and they also break during milling.
- If rice is harvested too early, there will also be many immature seed grains and this will reduce quality.
- Immature rice kernels are very slender and chalky and this results in excessive amounts of bran and broken grains during milling.

The two harvesting methods that are mostly used in SSA are Panicle and Sickle harvesting. Panicle harvesting provides less harvesting losses when compared to sickle harvesting even though sickle harvesting is much quicker and has the potential of saving time and labor cost.

**Note:** Appropriate time of harvest (avoiding early/late harvest) is very important in controlling the quality of harvested paddy. Appropriate time of harvest therefore become a matter for consideration in the rice post production technology.

**Appropriate time for harvest is indicated by:**

- The period when at least 80% of the panicles have reached full maturity,



- The moisture content of the grains should be between 20 - 22%,
- The grain should have full ripened colour (mainly yellow),
- When the grain husk is removed, the grain is white and hard.

#### **4.2.4. How to observe the paddy field in order to determine an optimum harvest time**

- Observe your field to notice when the panicles, not the rice plant starts getting yellowish in appearance. Do not confuse the colour of the straw with the yellowish colour of the panicles. Yellowish colour of the straw may result from early senescence of the leaves.
- Pay attention to the panicles and observe when individual panicles in different parts of the field, have up to 80% maturity in the upper part of the panicle.
- Harvesting should start immediately.
- Waiting for the remaining 20% to mature may lead to shattering of the upper grains which are very often better filled thus resulting in yield reduction.

**Note: It is very difficult to convince farmers to harvest at the appropriate time.**

Trainers are encouraged to conduct simple demonstrations through comparison in a given area in the farmer's field using these indicators. An area should be harvested at the optimum time and a similar area harvested at the period decided by the farmer. These should be threshed and milled separately for the farmer to observe the advantages in harvesting at the optimum time.

##### **4.2.4.1. Points to remember during harvesting**

- Paddy is the rice grain enclosed in the husk before it is milled.
- Timeliness in harvesting paddy rice is important in determining grain quality and yield.
- Harvesting should begin when 80 per cent of the grains (or 8 out of 10 grains) in the main panicles of plants are clear, firm, and straw-coloured; the rest should be hard.
- Harvest when paddy rice moisture is less than 25 per cent, about 30 -32 days after flowering.
- If harvesting by hand, grasp the plant about 15 cm-20 cm from the soil or ground level then cut with a sickle 15 cm from ground level.
- If harvested too early, there will be many immature grains which will reduce head rice yield and quality. Immature rice kernels are very slender and chalky, and will result in excessive amounts of bran and broken grains.
- If harvesting is too late, many grains will be lost due to shattering or drying out and cracking during threshing.
- Cracked grains break during milling.
- If moisture content is allowed to vary, grain fissuring (cracking), spoilage through yellowing, and development of odours can occur

##### **4.2.4.2. Problems of late harvesting**

- Lodging,
- Over drying of grain,
- Shattering,
- Rodent/bird attack,
- Contamination when panicles touch the ground.

##### **4.2.4.3. Problems of early harvesting**

- Many of immature grains,



- Discoloured grains,
- Timely harvesting will ensure high paddy yield, a quality product for parboiling or milling and high milling recovery with low kernel breakage.

#### 4.2.4.4. Manual harvesting

The most common manual harvester is the sickle but sometimes the cutlass is used. (Manual harvesting operation using a sickle as shown in Figure 4-1).



**Figure 4-1: Harvesting rice with sickles at the plant height of 4-5 cm from the ground**

When the knife is used, harvesting is panicle by panicle, making harvesting more laborious and time consuming. This method is mainly used where traditional varieties with uneven maturity times are grown. When sickles and cutlasses are used in harvesting, the entire plant is cut as opposed to panicle by panicle harvesting with knives. In areas where sickle or cutlass harvesting is unavoidable farmers are encouraged to engage as much labour as possible so as to reduce the harvesting period. The harvested paddy should **not** be put on bare floor/ground to avoid contamination with stones and mud and mould growth. Harvested paddy should be spread on:

- Plastic sheets,
- Tarpaulins,
- Traditional mats.

Harvesting rice with sickles at the plant height of 4-5 cm from the ground.

#### 4.2.4.5. Mechanical harvesting

Mechanical harvesting may be carried out by the use of combine harvesters shown in **Error! eference source not found.** or reapers shown in Figure 4-2. They have the advantage of threshing as they are harvesting. The problem with the combine harvester is the high initial and maintenance costs coupled with its unavailability and lack of spare parts in most areas in West Africa. In addition, when this method is used in fields with well-dried grains, many of the grains fall or are broken by the tines. Generally, the use of combine harvesters is most appropriate on farms that are relatively large with good leveling and water control. The rice variety should be one that matures evenly and should not be of short variety. To perform optimally the use of combine harvesters require the following:

- Large farm sizes,
- Good level and dried surface area (not water logged),
- Erect rice plants (not lodged),
- Personnel trained in the use of the equipment,
- Availability of spare parts and machine repairs/maintenance.



**Figure 4-2: The full conventional combine harvester**

The reaper represents an alternative to combine and manual harvesting. However, they are generally unavailable to most farmers in the sub-regions although some countries have tried them. Trials need to be carried out on these in the other countries and disseminated fully in the sub-region.



**Figure 4-3: Reaper**

#### **4.3. Threshing (30 mins)**

- Threshing is the post-harvest operation of separating the paddy grains from the rice straw. This is a very important operation in rice post-harvest handling, which if not handled properly results in broken /damaged grains and mixing with other foreign matter including sand, stones and other rice varieties which present more challenges for processing.
- Threshing is usually done either manually or mechanically. Mechanical threshing can be carried out by use of combine harvesters. In areas where the farm sizes and outputs are small the use of combine harvesters is difficult. Although this ensures efficient threshing the problems associated with the use of combine harvesters in harvesting as already stated above also apply here hence the use of combine harvesters are limited.

- In manual threshing several methods are available. In some places threshing is done using legs to march on the straw, others beat the straw against drums, others put the straw in bags and beat it against tree trunks, stones etc. while others use sticks to beat rice straw heap.

#### **4.3.1. Problems of manual threshing**

- This method is time consuming, laborious, slow and output is quite low. Contamination of paddy with sand, stone, immature grain and other foreign materials is high. There is also loss of grain leading to reduction in overall output.

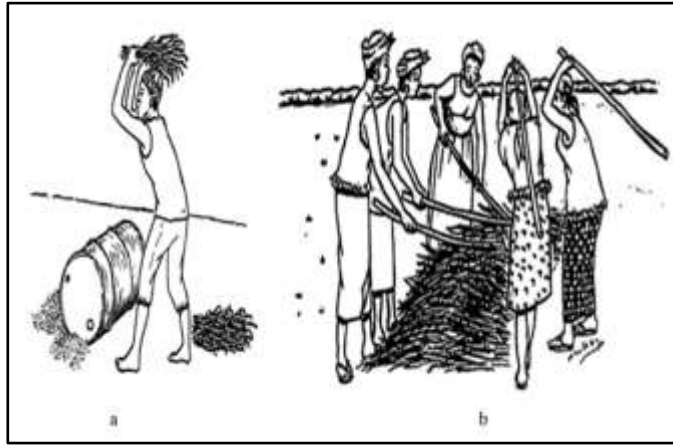


**Figure 4-4: Farmer threshing the rice, using wooden frame**

#### **Intermediate technology**

There is however an intermediate technology for rice threshing. This involves the use of semi motorised and completely motorised rice threshers. These are already available in several places in sub Saharan Africa, particularly in irrigated areas or developed low lands.

There is the technology of threshing which uses a pedal thresher (Figure 4-6). The pedals are attached to an overhead drum that is perforated to create fingers. As the machine is pedaled and the straw placed on the drum the resulting centripetal forces loosens the grain from the straw. The output is about 500 kg per day. This is an improvement over the manual threshing. However the pedal thresher is very laborious, has limited output and is suited for only small farms. It also requires the winnowing of the paddy after threshing. There is already an improvement on the pedal thresher (Figure 4-8). This pedal is replaced with a motor, such that the operator stands and places the straw over the exposed spike- like drum. It gives higher output and is less drudgery but still suited for small farms.



**Figure 4-5: Different types of manual threshing methods (a) Drum and, (b) Using sticks**



**Figure 4-6: Mechanical Pedal thresher (INRAB-Benin)**



**Figure 4-7: Mechanical motorized thresher (INRAB-Benin)**



The motorized thresher is a machine linked to a motor drive device carrying a perforated drum with metal or plastic paddles under which lies a sieve system. The drum turns the paddles and loosens the grains from the straw by aspiration, while the straw and other dirt is blown out through the exhaust pipe and the grains fall under the drum through the sieve (Figure 4-8). The thresher provides clean paddy without damaging the grain because of its axial flow system. This thresher which is an International Rice Research Institute (IRRI) model was modified and adapted by the African Rice Centre (AfricaRice) in collaboration with Senegalese National Agricultural Research Systems (NARS).



**Figure 4-8: Improved motorized thresher/cleaner (ADRAO/SAED/ISRA, Senegal)**

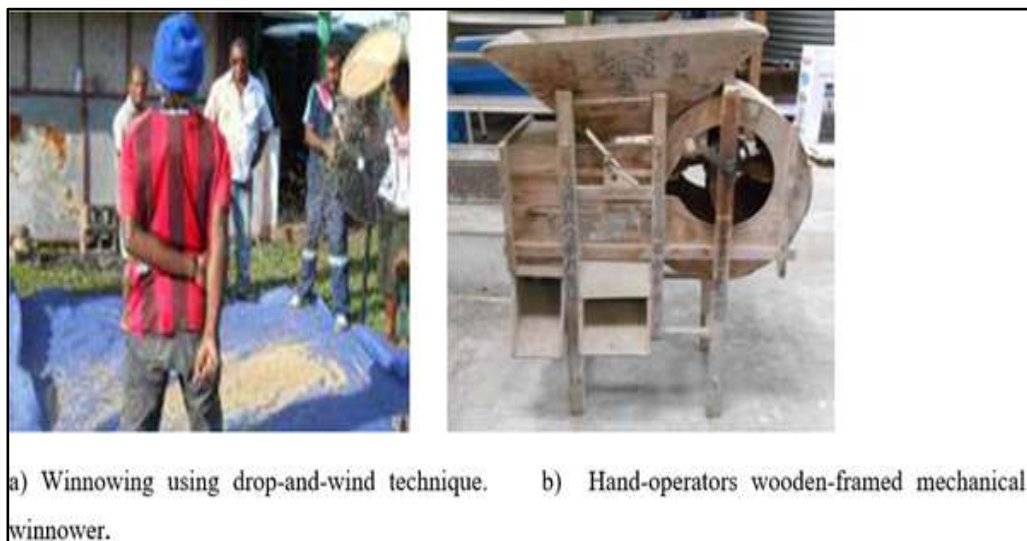
#### **4.4. Winnowing/Cleaning**

This is the process of removing rice straw, sand, small stones weeds, chaff and other extraneous materials from the harvested paddy. Winnowing is an important step for obtaining clean paddy for storage and further processing. This is necessary to avoid contamination of the milled product with insect parts, stones, chaff etc. It also protects the machine from dust, stones etc. thereby prolonging its life. Winnowing could be done by aspiration, manually and mechanically. Good winnowing practice involves:

- Use of plastic sheets /traditional mats (tarpaulins etc.),
- A clean environment,
- The operator should not re-contaminate the winnowed grains with dust, sand and other foreign matter.

##### **4.4.1. Manual winnowing**

In manual winnowing the threshed materials are thrown up along the flow of the wind blowing away all the chaff and lighter materials. In manual winnowing, materials of the same density as the rice grains are also retained. The process requires much labour, is slow and low in output.



**Figure 4-9: Manual winnowing techniques (Source: JICA, February 2015)**

#### **4.4.2. Mechanical winnowing**

In mechanical winnowing blowers and cyclones (hand operated and motorised) are available.. With hand operated blowers, the operator winds the machine to generate a centripetal force which separates the grains from the chaff. The grains drop to the bottom while the chaff is blown out through the exhaust. This has a larger output than the manual winnowing and the problem of recontamination is eliminated. The motorised winnowers operate the same way but have increased output. They are however more expensive and are limited in availability. There is also the problem of the cost of fuel, maintenance and spare parts.



**Figure 4-10: Motorized winnowers (Rep of BENIN)**

#### **Points to remember when threshing and winnowing**

- Thresh paddy rice immediately after cutting. The longer cut panicles remain in a stack, the higher their chances of turning yellow and discolouring during milling.
- Thresh using a drum or a wooden surface to reduce discoloration. Hit the rice panicle on the drum or wood.
- To avoid contamination, never thresh rice on the ground. Thresh on tarpaulin or canvas.



- Remove all kinds of dockage (impurities) from threshed grain such as insects, rice straws, and leaves as soon as possible after harvesting, and before storage. Clean grain has a higher value than grain contaminated with straws, chaff, weed seeds, soil, rubbish, stones and other non-grain materials.
- Winnow (remove light and chaffy material) at threshing to avoid contamination and black rice. Modern rice mills with destoners reduce the burden of winnowing. However, winnowing is still essential as it will increase the value of the paddy.
- Maintain clean grain to improve storability, milling output and quality, and to reduce price penalties when selling.

#### 4.5. Drying

The important points to remember during drying are:

- Dry the paddy rice immediately after threshing,
- Sun-dry for four hours a day, for two to three days,
- Dry on tarpaulin to reduce stones and dirt. You may dry paddy directly on concrete only if it has been swept thoroughly,
- Spread grain in thin layers (5 cm – 10 cm deep) on the tarpaulin or floor, and then turn and stir seven to eight times a day. This distributes moisture more evenly and increases the rate of drying (the paddy exhibits better milling quality when dried to a moisture content of 14 per cent),
- Bite between teeth to test moisture content. If it is soft, continue drying. When it breaks into two, moisture content is around 14 –15 per cent,
- Do not over-dry the paddy since it increases breakage in the rice grain during milling, and reduces quality, and the price you will receive.

##### 4.5.1. Drying methods

- Paddy rice is manually dried by spreading under the sun for about 2 to 3 hours and then placing under the shed to equilibrate the moisture gradient and gradually dry down to 12 to 14 % moisture. However millers are encouraged to have moisture meters to effectively ensure that the moisture content comes to about 12 to 14%.

**Note: Mechanical dryers exits but are mainly found in huge commercial rice milling concerns. This is due to the cost of these dryers and the expertise to maintain them.**



**Figure 4-11: Natural drying methods**

## **4.6. Milling**

This technically refers to the removal of the husk to obtain 'brown rice' and gently polishing off the bran to obtain a whole milled grain. It involves hulling and polishing. While hulling involves removing the husk from the Paddy with minimum damage to the grain and separating the husk from the Paddy to produce brown rice. Milling combines a series of mechanical processes that may remove the hull, the outer layers and the embryo of the rice grain. Polishing on the other hand refer to the process of removing the 'Subaleurone' layer after whitening to give the rice grains a shiny appearance. Milling is accomplished by friction and abrasion processes that remove the bran layer from the brown rice grains; friction between the grains breaks and peels off the bran, while with abrasion, a rough surface peels off the bran.

### **4.6.1. Objectives of milling**

- To remove the rice husk,
- To remove the rice bran and polish the rice kernel to increase appeal,
- To improve packaging and storage.

### **4.6.2. Equipment for milling**

Most varieties of milling machines currently in use in Sub Sahara African (SSA) countries have capacities between 100kg/h to over 1 ton/h. They may either be rubber roll mills or single pass "Eengelberg" hullers. Rubber roll mills may have pre-cleaners, destoners, graders including rotary sifters. Rubber rolls wear out very fast and maintenance is not very easy as compared with Engelberg mills that are easy to maintain. Engelberg hullers have no pre-cleaner; they are single pass, with no graders. The Engelberg mills have to be redesigned to include aspirators. If paddy has to be milled using rubber rolls it should be free of sand, stones and other impurities that contribute to the deterioration of the rolls. The paddy should also have a moisture content of between 12 to 14%.

There is in existence several medium and large scale milling machines. The medium types are about 3 tons per hour capacity. They are combined with de-stoners, cleaners, de-hullers using rubber rolls with polisher and grader (alveolar grader and rotary sifters) and automatic weighing balance and bagging system. Some of the machines, depending on the make may not have all these accessories but minimally, they have paddy cleaner, de-huller, polishers and grader.

The large scale commercial millers have all the processes with all the accessories listed above including sometimes large silo for storage and mechanical dryers. The output is more than 5tons per hour.

### **Intermediate technology**

Single pass milling machine is wide spread over West Africa. For small scale rice milling using the single pass, improvement can be made by adding to it a paddy cleaner and a grading system. This improvement can be locally done by artisans. The paddy cleaner can be fabricated locally in most countries in the region.

## **4.7. Grading**

Grading is the process of sorting the milled rice grains into categories based on the visual observation and moisture content measurements. Visual observations will indicate whole grains, broken grains, off-types (grains of other variety), colored grains, and presence of the

un-milled paddy. The following are factors used for sorting and grading milled grains into several categories depending on the operator's end-use:

- Moisture content,
- Head rice and broken percentage,
- Defectives,
- Impurities (Foreign matters, vain paddy and immature grains),
- Presence of un-milled paddy.

It is important to take care of moisture content of milled rice. If the moisture content of milled rice is high, the product gets mouldy. If rice is not consumed soon after milling, and rice is requiring long shelf-life or storage would need high milling degree for removing all the bran.

#### **4.8. Bagging and packaging**

- Paddy rice should be stored in bags and placed on a raised floor to avoid moisture accumulation.
- It must be stored in an environment of 13 –14 per cent moisture and protected from insects and rodents.
- Storing rice as paddy has two advantages: (a) rodents and insects struggle to gnaw through the outer covering (husk); and (b) most customers prefer freshly milled rice.
- Store paddy in 50 kg to 100 kg sacks made from jute, polypropylene or woven plastic, stacked under a roof or in a shed.
- Periodically fumigate to control insects.
- For extended periods of time while maintaining its quality (13 -14 per cent moisture content) protect paddy rice from insects and rodents using environmentally recommended fumigants and putting it in bags even when using granaries (made of timber, mud or cement) or large woven baskets; and from absorbing moisture from rainfall or the surrounding moist air.

##### **4.8.1. Group Discussion Questions**

- ✓ What do you understand by postharvest losses?
- ✓ How long does it take to harvest your crop?
- ✓ What are the components of postharvest management?
- ✓ How should rice be harvested? Shelled? Dried?
- ✓ What are the causes of insect infestation in maize?
- ✓ What is the best way to bag and package rice for storage or transport to market?
- ✓ What are the environmental conditions conducive for aflatoxin development in rice grains?
- ✓ What steps can farmers take to prevent aflatoxin infestation on rice grains?
- ✓ How is rice harvested (when), threshed and winnowed, dried and bagged?
- ✓ What is the recommended moisture content for rice? How is the moisture content measured (use of traditional or modern method)?
- ✓ What are some tips of using a moisture meter? Demonstrate the use of moisture meter.

##### **4.8.2. Storage and pest control**

The purpose of grain storage facility is to provide safe storage conditions for rice grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi.

- Grain moisture content should be maintained at 14% w.b. or less.

- Don't put rice bags directly on the floor. Those bags should be laid on the rack above 20 cm above the floor.
- The longer the grain needs to be stored, the lower the required moisture content will need to be.
- Grain and paddy seed stored at moisture contents above 14% w.b. may experience the growth of moulds, rapid loss of viability and a reduction in eating quality.
- If the moisture content of paddy inside bag is high, open all mouths of bags to release vapor and heat coming from the paddy itself. It's better to spread such paddy of high moisture content on plastic sheet for room conditions drying.

#### **4.8.3. Factors responsible for poor grain storage**

- i). Poor storage structures (stores) or location.
- ii). Inadequate drying resulting in moisture levels that are too high for safe storage.
- iii). Pests.
- iv). Inadequate knowledge on good storage practices.
- v). Poor store management.
- vi). Weather and other natural causes. Environmental conditions can become unfavourable.

#### **4.8.4. Basic requirements and recommendations for good storage**

The four pillars of good storage practice include:

##### **i. Ensuring that the crop going into store is in good condition**

- Good quality whole grain is less likely to suffer from insect attacks than poor quality damaged grain,
- The grain should be checked after maturity while the crop is still standing in the field,
- Grain that shows signs of infestation or damage should be separated out before harvest and either discarded, reserved for animal feed or, depending on the type and extent of damage, kept for immediate consumption,
- The grain should be cleaned well and any that is damaged removed,
- Careful winnowing will remove many live adult insects. Straw, chaff, weed seeds, stones and dirt must be removed. These materials will hold water and their removal will allow grain to dry faster. Any rubbish should be burnt,
- The grain should be well-dried. Good drying is essential. Damp grain will become mouldy. Insects are less likely to attack well-dried grain. If the crop is to be dried in the field, it should not be heaped directly on the ground, to prevent moisture from being taken up. Similarly, when grain is dried at the homestead, it must be kept off the soil.

##### **ii. Keeping the store in good condition**

- A good store will keep grain dry and cool.
- It should provide protection against rodents, birds and browsing domestic animals like poultry.
- It should be theft proof.
- Stores should be sited in areas that are not prone to flooding and should allow water to drain off readily.
- They should not be placed where high winds can 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 provide shade during the heat of the day.
- Without shade, changes in temperature inside the store between day and night may be so great that as the store cools at night condensation occurs and wets the grain, which in turn may lead to the development of moulds.



**Figure 4-12: Rice storage methods (Source: *Eastern Africa Grain Institute-Farmers training manual*)**

### **iii. Practicing good store hygiene**

- This means keeping everything as clean as possible.
- 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. Clearing the ground around the store will make it easy to spot termite trails.
- Livestock should be kept away from the store; they should not be allowed to browse or sleep under it. Droppings should be cleared up as they attract rodents.
- Whenever storage containers are empty, they should be cleaned. Second-hand 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. Holes should be stitched.
- Grass should be burnt inside solid walled bins and mud plastered baskets to kill off insects and mould spores. It is good practice to sprinkle the inside walls and floor of the structure with insecticide to kill remaining insect pests.
- Old grain should be stored separately from the new crop and should be used first.

### **iv. Maintaining the condition of the crop and store throughout the storage season**

- Pests can attack the store at any time, so it is important to inspect it and the produce regularly. The earlier a problem is spotted the sooner action can be taken to control it. Early action will prevent damage from becoming severe.
- If insect pests occur regularly, treat the grain with insecticide as soon as possible. Maize cobs can be sprayed with insecticide but it is more effective to shell the cobs and mix with insecticide dust.

- It is important to shell and treat pulses, especially beans and cowpeas, which become infested very quickly.
- Store inspections should start as soon as grain is stored and then conducted weekly. This is because insects may be brought in with the produce, which might have become infested in the field during harvesting or drying. The store may also have harboured an infestation from the previous season.

#### **4.8.5. Requirements of good store management**

There is need for good storage management practice among farmers, if grain is to remain in suitable and marketable condition throughout the storage period. Good storage management requires:

- a). A good storage site,
- b). Produce in a suitable condition,
- c). Intake of grain orderly and controlled,
- d). Storage period controlled,
- e). Quality maintenance ensured,
- f). Security against theft and loss,
- g). Any loss identifiable and accountable,
- h). End use requirement is satisfied.

Consistent adherence to these requirements will help achieve the following:

- a) Know the quantity in store at any given time,
- b) Reduce grain loss in storage,
- c) Quickly recognise causal agents of losses,
- d) Control agents of losses.

### **4.9. Pest control**

#### **4.9.1. Common pests during storage**

The main grain pest categories due to poor storage practices are insects including termites, rodents and moulds. Other pests that cause storage losses are birds and human beings who steal and contaminate the grain.

##### **4.9.1.1. Primary pests**

Primary insects are those that attack grain that has not been damaged, although they still feed on damaged grain. Common primary insects are termites, Rodents and birds.

#### **Termites, Rodents and Birds**

- A common name for numerous species of social insects that can damage stored grain and wooden structures such as furniture or houses.
- Rats and mice are responsible for a considerable percentage of losses throughout the postharvest period.
- Rodents are also of particular interest because not only can they cause severe damage to the commodity but also to bagging materials, electrical wiring and store structures.
- The common grain pests among birds are feral pigeons, house sparrows and starlings. Birds are attracted to easily found loose grains. They contaminate grains with their droppings and urine and can spread salmonella.

#### **4.9.2. Moulds**

- Moulds are a group of fungi, which propagate by producing spores.



- Once mould growth has started, each 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 favourable.
- Mould growth occurs on staple agricultural products both in the field and during storage.

#### **4.9.3. Pest Control**

- Pest control involves the use of chemicals and other non-chemical pest control methods (hygiene in warehouse, store management and rodent proofing).
- Integrated Pest Management (IPM) involves the use of chemical and non-chemical methods of pest control. All can be applied in storage management.
- IPM gives priority to non-chemical control measures, use of traditional methods and only defaults to use of chemical controls when other options are unlikely to offer sufficient protection.
- An IPM system would, therefore, supplement sanitation and good warehouse keeping with a combination of one or more of the following practices:
  - i. Improved harvesting and threshing techniques.
  - ii. Judicious use of residual insecticides.
  - iii. Use of fumigants.
  - iv. Use of ambient aeration, and refrigerated aeration.
  - v. Atmospheric gas modification (hermetic, CO<sub>2</sub>, N<sub>2</sub>).
  - vi. Biological control (parasites, predators (such as cats) and entomopathogens, pheromones).
  - vii. Use of resistant varieties if possible.
  - viii. Storage management.
  - ix. Adequate grain cleaning prior to storage.
  - x. Storage design (for pest (rodent and bird) exclusion).
  - xi. Adequate grain cleaning prior to storage.
  - xii. Monitoring, evaluation and inspection of stored commodities, storage structures and their immediate surroundings.
  - xiii. Thermal disinfestations.
  - xiv. Irradiation techniques.
  - xv. Insect-resistant packaging.

##### **4.9.3.1. Group discussion questions**

- ✓ How long should a farmer store grain?
- ✓ What are some of the losses incurred by farmers during storage?
- ✓ What are the factors that lead to poor storage?
- ✓ How does poor storage affect grain quality?
- ✓ What are some of the common pests that affect grain during storage?
- ✓ What integrated pest management measures can be used to ensure stored grain is safe from pests, rodents, aflatoxin etc.?
- ✓ What are the requirements for good stores?
- ✓ What the requirements of good storage management?
- ✓ What are some of the equipment that a farmer will use in storage?

#### **4.10. Grain quality and standards**

##### **4.10.1. General quality parameters**

All produce intended for human consumption should be free from:

- ✓ Foreign odours,
- ✓ Moulds and live pests,
- ✓ Rat droppings,
- ✓ Toxic or noxious weed seed,
- ✓ Other injurious contaminants.

Some of these grain characteristics can be defined as follows:

- a. Moisture content: Amount of moisture contained in grain expressed as a percentage of the weight of the grain.
- b. Foreign matter: Substances that are not the actual commodity, which can include straw, husks, stones, pieces of cob, dust, and other rubbish. Foreign matter can also be referred to as extraneous matter.
- c. Trash: Any vegetable matter other than grain, which will not pass through a grading sieve.
- d. Defective grain: Grain that is discoloured by heat, fermentation, germinated, weather-damaged, visibly infected with fungus or virus, immature or insect damaged.
- e. Discoloured: Grains which are markedly discoloured by weathering or by heating caused by fermentation, but does not include other coloured varieties.
- f. Insect damaged grain: Grain that has been attacked and damaged by insect or animal pests.
- g. Diseased: Grain visibly infected by fungus or other agents.
- h. Chipped grain: Grain which has been chipped or cracked.
- i. Broken grain: Grain and pieces of grain which will pass through the grading sieve with thorough shaking.
- j. Germinated grain: Sprouted grain in which the process of germination is visible within the embryo.
- k. Shrivelled grain: Grain which is shrivelled over its entire surface and embryo area.
- l. Stained grain: Grain which is stained by soil or any foreign agent but does not include discoloured grain.
- m. Other coloured grain: Grain of a colour or partly coloured grain present in grain other than the grain being analysed.
- n. Undeveloped grain: Grain which is thin and papery in appearance, which is small and wrinkled.
- o. Stones: Any mineral material, which will not readily disintegrate or dissolve in water.
- p. Contaminant: Foreign substances or chemicals in the grain. This includes soluble elements which cannot be removed like excretions of pests and other animal, plant material, pesticides, oils, pathogenic organisms and toxins from fungal infections.

#### 4.10.2. Tips on conditions of good quality grain

To reduce the incidence of spoilage and deterioration, the grain must satisfy the following storage conditions:

- Be **dry** and at safe moisture levels for storage, since high-moisture grain is easily attacked by moulds.
- Be **healthy** with a minimum of broken or bruised kernels, since damaged grain is readily attacked by insect pests and moulds.
- Be **clean** and free from contamination by foreign matter, mammalian and insect excrements and grass, since these conditions facilitate infestation by grain spoiling moulds.
- Be **free** from all stages of insect pests since these eat and quickly destroy grain.

- Be **cool** and with temperatures within range of those of the storage environment, since temperature determines optimum conditions for insect pests, rodents and moulds, and uneven temperatures cause moisture migration in storage.

#### **4.10.3. Group discussion questions**

- ✓ What is quality in reference to grains?
- ✓ What are the general parameters of quality?
- ✓ How do you carry out a rapid quality test for grains?
- ✓ What characteristics affect the grade and quality of grains?
- ✓ What are some of the conditions of good quality grain?
- ✓ Why is quality an important factor in improving farmer incomes and access to better markets?

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