Crop Production and Marketing Management Level – IV

Based on March 2018, Version 3 Occupational standards (OS).

Module Title: Maintaining Grain Quality in Storage

LG Code: AGR CPM4 M17 LO (1-4) LG (74-77)

TTLM Code: AGR CPM40921

September 2021

Adama, Ethiopia

East Africa Skills for Transformation and Regional Integration Project (EASTRIP

Contents

LG #74	Lo # 1- Maintain hygiene in storage areas

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Testing grain storage conditions
- Identifying the need for grain storage repairs and maintenance
- Applying treatments for grain storage facilities
- Recording grain storage application treatments

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Test *grain* storage conditions
- Identify the need for *grain* storage repairs and maintenance
- Apply treatments for grain storage facilities
- Record grain storage application treatments

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).

Information Sheet 1- Testing storage condition and facility

1.1. Introduction

Grain storage involves more than just placing grain in a suitably sized receptacle until it is needed. The grain is a major asset in which the grower has invested preparation, sowing and harvesting costs. The asset must be protected because while grain is in storage its quality, and thus its value, deteriorates. High temperature and high moisture are the most significant factors affecting grain quality in storage. Each can cause rapid decline in germination, malting quality, baking quality, colour, oil composition, and many other quality characteristics.

Insects and moulds impair the quality of grain directly by their feeding and development, and indirectly through generation of heat and moisture. High temperatures and moistures favour development of insects and moulds. Development of insects is limited by temperatures below 15°C, and by moistures below 9% in cereal grains. Development of moulds is limited by temperatures below 10°C, and by moistures below 13% in cereal grains.

Spraying with insecticides or fumigating minimises insect problems but leaves chemical residues in grain, which break down with time. Presence of residues, and their concentration, affects acceptability of the grain to markets. Some markets prefer grain without residues. Grain buyers will not knowingly accept grain treated at rates higher than those specified on the label, or within the specified withholding period. Good hygiene combined with automatically controlled aeration is sufficient for some growers to maintain grain quality without using any residual treatment. Fumigation with phosphine leaves minimal residues, provided tablet formulations are not mixed with the grain. Check with buyers before spraying grain with insecticides. It is critical to carefully manage stored grain to prevent grain deterioration and possible serious economic loss. The principal objective in any grain storage system is to maintain the stored grains in good condition so as to avoid deterioration both in quantity and quality. During storage, the grain must remain dry and clean. Grain storage can be extended for up to 2 years without any significant reduction in quantity and quality. However, the majority of farmers sells off their grains cheaply soon after harvesting due to anticipated losses in storage and later buy food at exorbitant prices. There are improved storage structures that can prolong the

storage duration until market prices for grains are favorable.

Seeds can be stored for a long period of times in the form of genetic resource conservation and short term until they dry for planting and/or marketing.

- Important conditions for short term grain storage
  - ✓ Low moisture content of products (8-15%)
  - ✓ Low temperature in the store to suppress pathogens and insects
  - ✓ Good aeration to facilitate moisture loss
  - ✓ Appropriate protection of the product from rain, insect pests and rodents
  - ✓ Appropriate storage structures protect the seed from rats and rodents.
- Important conditions for long term grain storage
  - ✓ Low temperature (-10^{o}c, +4^{o}c)
  - ✓ Moisture<10% usually 6-8%
  - ✓ About 14%RH
  - ✓ Viability checking every 10 years.

In biodiversity (gene bank) seed can be stored safely 50-100 years.

In both cases temperature and moisture are the major factors determining the duration of seed viability in store (shelf-life) and development of insect pests and bacterial and fungal disease. **1%** reduction of seed moisture content doubles the safe storage period and Reduction of storage temperature by **5^{o}c** doubles the safe storage". A grain on the other hand, includes cereals and pulses meant for human consumption.

Table 1 Deference between grain and seed

	Seed	**Grain**
1	It is the result of well-planned seed programme	It is the part of commercial produce saved for sowing or planting purposes
2	It can be related to the initial breeders seed	Its varietal purity is unknown
3	During production, effort is made to rogue out off-types, diseased plants, objectionable weeds and other crop plants at appropriate stages of crop growth which	No such effort is made. Hence, the purity and health status may be inferior

	ensures satisfactory seed purity and health.	
4	The seed is scientifically processed, treated and packed and labelled with proper lot identity.	The grain used as seed may be manually cleaned. In some cases, prior to sowing it may also be treated. This is not labelled
5	The seed is tested for planting quality namely, germination, purity, admixture of weed seeds and other crop seeds, seed health and seed moisture content.	Routine seed testing is not done.
6	The seed quality is usually supervised by an agency not related with production (seed certification agency)	There is no quality control.
7	The seed has to essentially meet the "quality standards". The quality is therefore well known. The labels, certification tags on the seed containers serves as quality marks.	No such standards apply here. The quality is non-descript and not known.

1.2 Testing grain storage conditions

Safe storage of grains for longer periods is possible if three conditions are met:

1. Grain is maintained at moisture levels of 14% or less and seed is stored at 12% or less
2. Grain is protected from insects, rodents and birds
3. Grain is protected from re-wetting by rain or imbibing moisture from the surrounding air.

The longer the grain needs to be stored, the lower the required moisture content will need to be. Grain and seed stored at moisture contents above 14% may experience the growth of molds, rapid loss of viability and a reduction in eating quality.

The following table 1 shows the 'safe' moisture content required for different storage periods.

Storage period	**Required moisture content for safe storage**	**Potential problems**
2 to 3 weeks	14 – 18 %	Molds, discoloration, respiration loss
8 to 12 months	12- 13 %	Insect damage
More than 1 year	9 % or less	Loss of viability

A rule of thumb for seed is that the life of the seed will be halved for every 1% increase in moisture content or a 5ºC increase in storage temperature

To minimize seed deterioration, the following storage indices have been identified:

- for 6 months, T°C + RH% must not exceed 80
- for 18 months, T°C + RH% must not exceed 70
- for 5 years, T°C + RH% must not exceed 55

1.2.1. Grain damage by fungi will be reduced when grain and seed is:

- ✓ Stored at moisture contents below 13-14%. It is important to be aware that there is variation in moisture content through a grain mass and fungi will grow where moisture is suitable and not according to the average moisture content of the grain stack
- ✓ Stored at temperatures below 20ºC and above 40ºC.
- ✓ Not cracked and broken kernels or contain large amount of foreign material - broken or cracked kernels are more likely to be contaminated going into storage and more likely to be invaded once they are in storage than whole kernels.
- ✓ Free from fungi coming into store. Grains moderately invaded by storage fungi develop damage at lower moisture content, at a lower temperature and in a shorter time period than grain free or almost free of storage fungi.

- ✓ Stored for a shorter period. Grain that is to be stored for only a few weeks before processing can be stored safely with a higher moisture content and more extensive invasion by storage fungi and can be kept at a higher temperature than grain that is to be stored for months or years.

Free from insect and mites. Insects and mites can carry fungal spores on their bodies thus introducing storage fungi into the grain mass. Insect activity in a grain mass leads to an increase in both the temperature and moisture content of the grain surrounding the insect infestation. In these 'hot spots' conditions may be favorable for mold growth

1.2.2. Components of the Grain Storage System

The primary concern in storage is the safety of the product. For perishable crops, the product quality and quantity have to be maintained or deterioration has to be minimized. To be able to achieve this purpose the five aspects of storage has to be considered, attended to and understood, namely:

1. The stored product
2. The storage structure
3. The environmental factors
4. The storage pests
5. The personnel involved

1.2.3 Storage facilities

The storage facility covers all types of temporary and permanent storage, complete with installed aeration, and controlled atmosphere or refrigeration

Losses in storage can be minimized or prevented by adopting any or combination of the following:

- **Chemical Control**
- ✓ Insect control
- ✓ Mold, fungi and bacteria control
- **Biological Control**
- ✓ Predators and parasites
- ✓ Entomogenous fungi
- ✓ Entomopathogenic diseases
- ✓ Varietal resistance

- **Physical Control**

✓ Air conditioning (temperature & R.H. control)

✓ Drying (moisture control)

✓ Controlled atmosphere (gas concentration control)

✓ Aeration

✓ Heat disinfestations

✓ Irradiation

✓ Trapping e.g. rodent trap, light trap, pheromone trap

- **Proper Design of Structure**

✓ Weather tight

✓ Rodent and bird proof

✓ Gas tight

1.2.4. Storage Hygiene

Good hygiene in the grain store or storage depot is important in maintaining grain and seed quality.

Guidelines for hygiene in the grain store include:

✓ Keep storage areas clean. This means sweeping the floor, removing cobwebs and dust, and collecting and removing any grain spills.

✓ Clean storage rooms after they are emptied and this may include spraying walls, crevices and wooden pallets with an insecticide before using them again

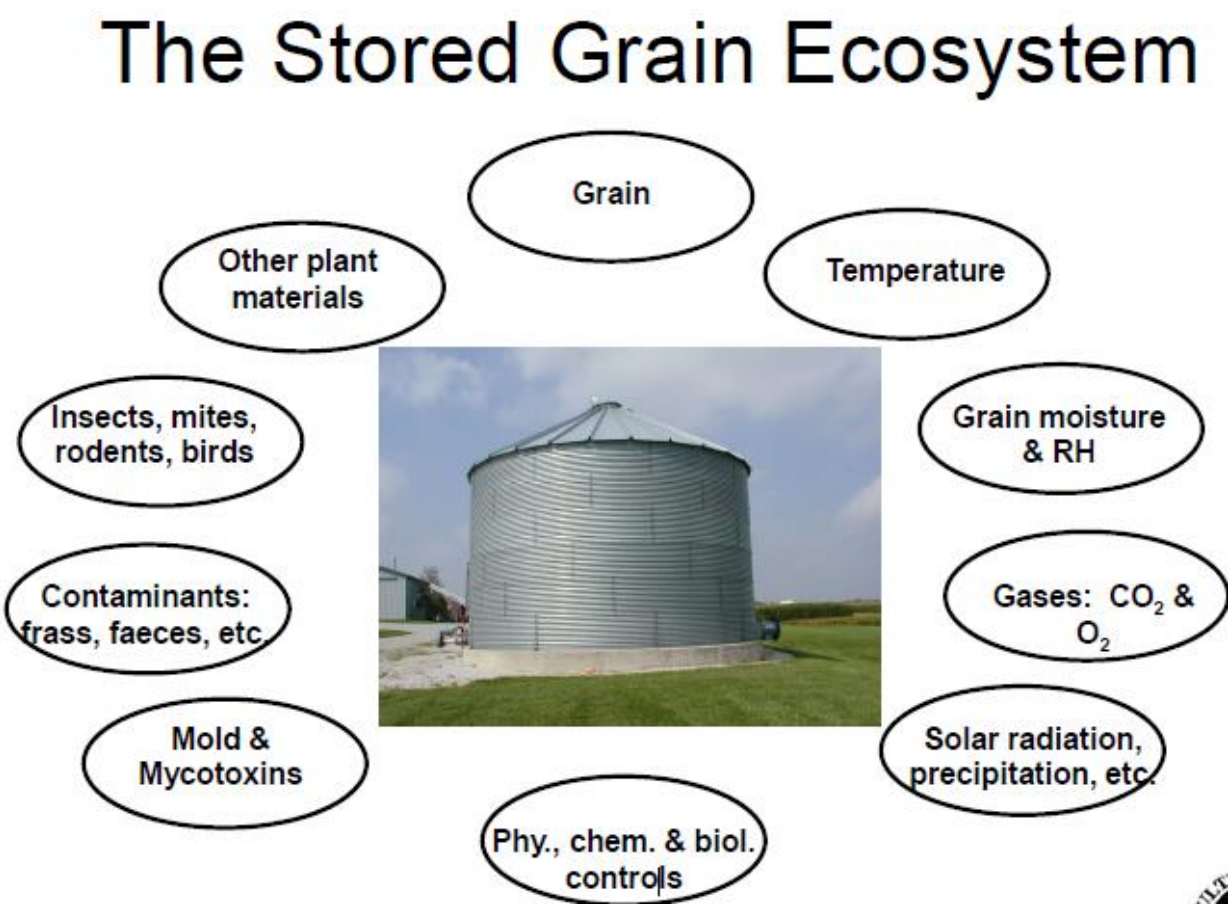
✓ Placing rat-traps and barriers in drying and storage areas. Cats deter and help control rats and mice

✓ Inspect storage room regularly to keep it vermin proof.

✓ Storage room regularly to keep it vermin proof.

Check the condition of stored grain about every two weeks while grain is cooling , then about monthly after grain has cooled .a check should include ; measurement of moisture content and temperature at several locations .moisture measurement accuracy is dependent on the grain temperature ,so it is best to collect a grain sample , let it warm to room temperature in a plastic bag or other sealed container ,then check the moisture

content .also be sure to cover fans and ducts after the grain has been cooled for winter storage to prevalent snow from blowing into the bin



1.2.5. Types of Storage

Storage systems maybe classified according to storage capacity, handling method or container structural materials.

- **Temporary Storage Methods**
  - ✓ Aerial Storage
  - ✓ Storage on the ground, or on drying floors
  - ✓ Open Timber Platforms
- **Long-term Storage Methods**

- ✓ Storage baskets (cribs) made exclusively of plant materials
- ✓ Gourds, earthenware pots
- ✓ Jars
- ✓ Solid wall bins

1.2.6. Moisture Content

If grain moisture content is too high, even the best aeration equipment and monitoring management will not keep the grain from spoiling - it only delays the inevitable. Recommended moisture contents are given in Table 1. These recommendations assume the grain is high quality and aerated to control temperatures and moisture migration. Reduce the recommended moisture contents by 1 percentage point when storing low quality grain. This includes immature grain, severely cracked and damaged grain, and grain subject to previous insect or mold activity. Also reduce the recommended moisture contents by at least 1 percentage point for grain in temporary or emergency storage.

Table 1. **Maximum** recommended moisture contents for properly managed, high quality, aerated grain.

Storage Period	Corn and Sorghum	Soybeans
Fed by April	18%	13%
Marketed by June	15.5%	13%
Up to one year	14%	12%
Over one year	13%	11%

Going into storage at the proper moisture content does not guarantee grain will remain at that moisture. Grain may be rewet as a result of bin roof or sidewall leaks.

Self-check 1	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Directions: Choose the correct answer. Write the letter only.

1. Which one the Type: Temporary Storage Methods pts 2
   a) Aerial Storage
   b) Storage on the ground, or on drying floor
   c) Open Timber Platforms
   d) All
2. What is the Long-term Storage Methods? pts 2
   a) cribs
   b) Gourds, earthenware pots
   c) Solid wall bins
   d) All
3. ----------Good hygiene in the grain store or storage depot is important in maintaining grain and seed quality. pts 2
   a) Storage Hygiene
   b) Gourds, earthenware pots
   c) Solid wall bins
4. _____ covers all types of temporary and permanent storage, complete with installed aeration, and controlled atmosphere or refrigeration pts 2
   a) storage facility
   b) Low temperature (-10^{o}c, +4^{o}c)
   c) Moisture<10% usually 6-8%
   d) About 14%RH

Test II: Short Answer Questions

1. What is Components of the Grain Storage System (5)
2. List down the Types of Storage and mention each method (10 point)

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 22 points Unsatisfactory - below 22 points

Information Sheet 2 - Identifying the need for grain storage repairs and maintenance

2.1. Introduction

The purpose of any grain storage facility is to provide safe storage conditions for the grain in order to prevent grain loss caused by adverse weather, moisture, rodents, birds, insects and micro-organisms like fungi by allowing proper storage hygiene and also for:

- ✓ Ease of loading and unloading.
- ✓ Efficient use of space.
- ✓ Ease of maintenance and management.
- ✓ Prevention of moisture re-entering the grain after drying

- **Cleaning and repairing your storage place**:--
  - ✓ Your storage room or building must be clean. Insects live and have families in dirty places. Rats, mice, and other pests like dirty places too.
  - ✓ Take away and burn or compost all dust, old pieces of grain, dirt, straw, and chaff from the storage place.
  - ✓ There should be no cracks and holes in the floor, ceiling, or walls. Insects and rodents use these holes to get in.
  - ✓ Fill and seal all cracks and holes.
  - ✓ Seal large holes in wooden storage places with sheet metal, flattened tin cans, or pieces of wood.
  - ✓ Concrete and plaster make good sealing material for plaster, brick, and concrete buildings.
  - ✓ Put paint or whitewash on the walls and floors of the storage area. This paint helps close up very small holes. Insects like these small holes.
  - ✓ Do not use any poison until you talk to your extension worker.
  - ✓ Put mesh wire over large openings and windows. This will keep out rats, chickens, and birds.
  - ✓ The roof must keep rain from coming in. The grain must be kept dry.
  - ✓ Mend all holes and openings in the roof.
  - ✓ Clean the outside area around the storage place.
  - ✓ Clean out the containers that you put the grain in.

- ✓ Bags or sacks for storing grain must be shaken.
- ✓ Bags or sacks should be boiled in hot water and dried in the sun. Mend any holes you find in the bags.
- ✓ Check with an extension worker for information on poisons to kill insects and rodents.
- ✓ The extension worker will know what poison to use. He will know how to use the poison.
- ✓ Always remember that many poisons can kill animals and people.
- ✓ Use insecticide on the inside and outside of your storage area.
- ✓ Put insecticide on all cracks and small places where insects like to live.
- ✓ Put out traps for rodents.
- ✓ A good storage place is free of insects and rodents. It is clean and dry.

2.2. Kinds of grain storage facilities

- **On the ground**

(Note: Grain should be piled on the ground only after harvest and in the absence of available storage space or available transport equipment to move it to a safer place.

- **Underground**

Farmers store grain in underground pits (holes) in many parts of the world. Pits are used for storing threshed sorghum and maize. They also are used for wheat, peas, and beans. In areas where pit storage is used, it has served farmers well as a way of avoiding theft of the grain (because the pits are hidden). Also, because the pits are dug deep into the earth, they keep the grain cool. In addition, some pits are relatively airtight. However, pit storage is generally not a storage method to encourage a farmer to adopt. If a farmer is looking for a storage method, he is more likely to get airtight storage by using oil drums, plastic sacks, etc.

Low-cost but makeshift underground storage has a place in some farming systems but a good natural site is essential and grain recovery will present some challenges. This system is appropriate mainly for long-term storage as a drought reserve. Grain left in properly designed underground stores will last for several years without any deterioration. It has even been delivered to bulk store after four years underground. Insect activity releases moisture and heat into the spaces between the grains. Moisture builds up faster

and to higher levels from insects than from grain respiration alone. Moisture carried into the silo headspace may condense on a cold roof and fall back as free water. This will sometimes cause a ring of grain to germinate against the silo wall. When the grain contains insects in large numbers, increased moisture can cause a damp moldy layer across the top of the grain which can be difficult to out load.

Water entering through structural damage will increase grain moisture content to the point where mold growth occurs. This moisture may also migrate to other areas. Insects will develop more rapidly in this high moisture zone.

- **Bagged and stored in buildings**

(Note: Bags can be transported and handled without special equipment. But both bags and bag storage space become expensive where manpower costs are high.) Putting grain in sacks (bags) is a very old method of storing. Storage sacks are made of woven jute, hemp, sisal, local grasses, and cotton whatever material is available in the area. Sacks are relatively expensive as they do not often last for more than two seasons. Sacks do not give a lot of natural protection against insects, rodents, and moisture. But sack storage has some advantages for the small farmer, and there are things farmers can do to protect their sacked grain.

Thea advantages of sack storage for farmers:

Grain stored in sacks made of fibers can have a little higher moisture content than grain put into airtight storage. If the sacks are properly stacked, air can move through the sacks to dry and cool the grain.

Sacks are easy to label. Farmers can label old grain sacks and new grain sacks to keep them separate. Seed grain can be marked and kept separately from the other grains. Sacks are easy to move around. And sacks or parts of sacks can be used as they are needed.

Sacks can be stored in a farmer's house no special buildings or containers are needed. Farmers in a village may decide to build a shed to hold the grain belonging to all the village's

farmers. It is easy to mark sacks so that each farmer's grain can be found simply. Grain stored in fiber sacks is easily attacked by insects, rodents, and molds. Often these attacks are worse because a farmer has no all he can to protect his grain sacks.

- **Farm bins**

(Note: Farm storage may consist of any available space that will hold grain and keep out moisture ranging from wooden enclosures round steel bins to silo type or Quonset hut bins.)

- **Bin sites**

✓ Storing grain in metal bins

Metal bins are being tried for small-scale use in many parts of the world. In some areas, farmers can buy metal bins in different sizes. They are sometimes expensive, and they rust in moist areas. Often a farmer needs to be a member of a credit program to get the money to buy this type of metal silo or bin. Then he repays the money for the cost of the bin. Hopefully, the bin pays for itself by reducing losses to the stored grain due to attacks by insects and rodents. Metal bins can also be built quite easily: but the farmer must know how to weld and work with metal. Or someone with these skills must be able to help.

- **Characteristics of metal bins**

✓ Built above the ground either on platforms or on cement bases when kept outside. The metal bottoms will rust because of contact with ground water if the bins are on the ground.

✓ Rounded in shape to hold the pressure of the grain better a square bin would have more seams and be more likely to break open.

✓ Painted white or stored out of the sun because metal conducts (passes on) heat very well.

- **Advantages of Metal Bins**

✓ Good control of insects, molds, and rodents if bins are well-made, well-sealed, kept off the ground, and out of the sun.

✓ Small metal bins are lightweight and may be moved easily.

✓ A metal bin may pay for itself out of the farmer's increased profit. This is true (for all improved storage methods) only where initial costs are not too high or a good credit program is available.

- **Disadvantages of Metal Bins**

- ✓ Metal sheets for building the silo are more expensive than most locally available materials, or, in some areas, cement.
- ✓ Construction of a bin requires special equipment to cut and weld the metal and people trained in working with metal.
- ✓ Metal rusts quickly in hot, wet places. Sheet metal for bins must be galvanized or painted regularly to protect the metal from rusting.

This is another cost to the farmer. Blacksmiths and people with metal-working experience, who might be interested in making bins to fit local needs, should be encouraged to try to do so. Experimenting with various designs will give information which can help you decide what kind of metal bin will work best in your area.
The following information on various metal bins is provided to give some idea of what types of bins are available. Wherever possible, an address is included so that you may write for further information.(Note: In recent years, much of the surplus grain owned by the U.S. government has been stored in farm-type bins in large numbers, called bin sites.)

- **Country elevators**

(Note: Country elevators receive grain directly from producers.
Their principle function is to accumulate grain from nearby farms, to reload it into trucks railroad cars or barges send it to market. In addition, they offer storage space and other services

- **Terminal elevators**

(Note: Terminal elevators are usually located in transportation terminals and larger markets. They receive grain from country elevators and transfer it to storage or into other transportation equipment such as barges or other vessels.)

Self-check 2	**Written test**

Name…… ID…… Date…….

Directions: Short Answer Questions.

Test I: Description

1. List down Cleaning and repairing your storage place (15 point)

2. Write the Kinds of grain storage facilities explain each kinds (15point)

Test II: true or false

1. Terminal elevators are usually located in transportation terminals and larger markets.
2. Country elevators receive grain directly from producers.
3. Metal sheets for building the silo are more expensive than most locally available materials.
4. Construction of a bin requires special equipment.
5. Good control of insects, molds, and rodents if bins are well-made, well-sealed, kept off the ground, and out of the sun.
6. Grain stored in sacks made of fibers can have a little higher moisture content than grain put into airtight storage.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 30 points Unsatisfactory - below 30 points

Information Sheet 3- Applying treatments for grain storage facilities

3.1 Grain treatments in storage

It is not recommended to use synthetic insecticides with grain that is for consumption. Only chemicals registered for direct application to grain should be used and these should be applied according to the label

Treating storage facilities: depending on the commodity to be stored, storage facilities may additionally be sprayed or dusted, if needed, with a recommended insecticide before storing grain in the bin (e.g. Malathion, diatomaceous earth or cyfluthrin refer to product labels for details). some commodities, such as canola, flax and sunflowers, should not be stored in facilities recently treated with.

- **Malathion**

Storage containers, structures and equipment can be treated with:

- ✓ Malathion (50EC) at 5ml/20l of water @20ml/m^2
- ✓ Fenitrothion (50EC) at 5ml/l water @20ml/m^2
- ✓ Deltamethrin (2.5% WP) at 1.5g/l water @20ml/m^2

Malathion is a widely used chemical and is toxic to insects if it comes into direct contact with the pest. Malathion is considered one of the safest organophosphate insecticides as it is not highly toxic to humans or pets/tame animal/, and breaks down fast under tropical conditions. Malathion will not penetrate piles of grain. Although it is not usually recommended, it is still legal to treat grain with Malathion at 8 parts per million concentrations. As a grain treatment Malathion is applied at the time grain is stored. Treated grain should not be sold for at least 7 days nor eaten within 60 days of treatment. Safety precautions must be observed when applying Malathion or any other chemical.

Fumigation

Fumigants are effective against storage pests because as gases they can reach the pests in the most remote hiding place. The range of safe fumigant chemicals that can be used is now restricted to phosphine and carbon dioxide.

Phosphine fumigation

Phosphine fumigation is undertaken using tablets and pellets. These tablets and pellets release phosphine gas when they come into contact with humid air. Phosphine is toxic to all insects. When insects are exposed to fumigation in a sealed environment all stages of development from the eggs, larvae, pupae to adults are killed. Phosphine does not impair the grain nor leave residues that could be hazardous to the consumer when correctly applied and the grain aerated. Care must be taken when using phosphine as a gas as it is very toxic to humans. Fumigation must take place in an enclosure that can be tightly sealed. Once the exposure time is ended, the grain must be aerated and the bin checked for residual phosphine gas before entry.

> Example: At 25^{o}C, the minimum exposure time for tablets and/or pellets is 3 days.Table 2

Temperature(in ^{o} Celsius)	Tablets (days)	Pellets (days)
5-10	10	8
11-15	5	4
16-25	4	3
Over 25	3	3
5-10	10	8

Carbon dioxide fumigation

Insects need oxygen for respiration. With carbon dioxide fumigation, much of the oxygen in the storage bin is replaced by carbon dioxide that suffocates, dehydrates and also produces toxic chemicals in the blood of the insects. To be effective, elevated carbon dioxide levels must be maintained until all insects die. The required exposure time depends on the percentage of carbon dioxide and the temperature of the grain. The cost of CO2 fumigation is high. Guidelines for Carbon Dioxide Application Table.3

Grain temperature(in ° Celsius)	Minimum CO2 Levels (%)	Days for control
25-30	80	8.5
25-30	60	11
25-30	40	17
25-30	20	Weeks to months

Infected seeds can be treated by either physical or chemical treatments, or a combination of both methods. Seed borne bacteria can be treated by dry heat at 65°C for 6 days or dipping in hot water treatment at 52-55°C. Seeds can also be treatment with fungicides such as Dithane M-45 and Benlate at the rate of 3 grams kg-1.

The most effective method of treating mycotoxin problems is avoidance. This is possible by drying the grain to safe moisture content before storage, reducing physical damage to the grain during harvesting and storage and ensuring clean, dry insect-proof storage conditions.

Top five practices for successful storage:

1. **Aeration**: Correctly designed and managed, aeration provides cool grain temperatures and uniform grain moisture conditions. Aeration cooling reduces storage problems such as molds and insect pests, plus helps maintain grain quality attributes such as seed color and germination. Aim for grain temperatures of less than 23°C in summer and below 15°C in winter.
2. **Hygiene**: A good standard of storage hygiene is crucial in keeping storage pest numbers to a minimum. Good hygiene for silos, augers and trucks also reduces the risk of seed contamination. The use of diatomaceous earth (e.g. Dryacide™) in empty

storage following the grain residues clean out helps to control any remaining insect pests.

3. **Monitoring**: To prevent serious damage, undertake monthly checking of grain in storage for insect pests (sieving / trapping) as well as checking grain quality and temperature. Keep monthly storage records, including any grain treatments applied.
4. **Fumigation**: In Australia, only fumigant gases (e.g. phosphine) are registered to deal with live insect pest infestations in stored grain. To achieve effective fumigations, the storage/silo must be sealable/gas-tight to hold the gas concentration for the required time. For example, a minimum phosphine gas concentration of 200ppm is required for 10 days to control all life stages (egg, larvae, pupae, adult) of storage pests. Check labels for details.
5. **Grain protectants**: Grain protectant insecticide sprays provide another line of defence against storage pests. Before use, always check with potential grain buyers as there are a growing number of markets where grain is required to be pesticide free. Treated planting seed retained on-farm is common. Treat at harvest time, while augering into storage. Always use a registered grain protectant according to label directions.

   Warning: Grain protectant notes do not apply to the grains industry in Western Australia where their use is restricted. In all cases, product labels are to be used to determine correct use patterns.

Minimize Damage

Little can be done to prevent or reduce the invasion of crops in the field by fungi. However, the following recommendations should help prevent storage fungi problems or minimize damage from storage fungi in stored grains.

1. Harvest as soon as the moisture content allows for minimum grain damage.
2. Adjust the harvesting equipment for minimum kernel or seed damage and maximum cleaning.
3. Clean all grain harvesting and handling equipment thoroughly before beginning to harvest. Clean bins or storage facilities thoroughly to remove dirt, dust and other foreign material, crop debris, chaff and grain debris.
4. Clean grain going into storage to remove lightweight and broken kernels or seeds as well as foreign material and fines.

5. Moisture content is by far the most important factor affecting the growth of fungi in stored grain. After harvest, grain should be dried to safe moisture contents as quickly as possible.
6. Aerate grain to safe and equalized temperatures through the grain mass.
7. Protect grain from insect and mite damage.
8. Check stored grain on a regular basis and aerate as needed to maintain low moisture and proper temperature.

Self-check 3	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What is Malathion test? (2point)

_____

_____

2. What is Fumigation test? (3)

_____

_____

3. Write the treating storage facilities? (5 point)

_____

_____

Test II: true or false

1. Aerate grain to safe and equalized temperatures through the grain mass.
2. Protect grain from insect and mite damage.
3. Check stored grain on a regular basis and aerate as needed to maintain low moisture and proper temperature.
4. Harvest as soon as the moisture content allows for minimum grain damage.
5. Adjust the harvesting equipment for minimum kernel or seed damage and maximum cleaning.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 20 points Unsatisfactory - below 20 points

Information Sheet 4- Recording grain storage application treatments

4.1 Records in grain storage program

Failing to monitor grain conditions throughout the entire storage period is a mistake that many producers make. Regular inspections are essential if mold and insect activities are to be detected early. A small area that starts to heat or otherwise go out of condition can quickly get out of control and spread within the bin.

How often you need to check the grain in storage will vary with the time of year, the initial condition of the grain and how often the grain is aerated. Generally, grain should be inspected at least once a month during the winter and every two weeks during the spring, summer and fall. Grain checking is extremely important during the summer, because grain is being held at higher temperatures and aeration conditions are less favorable than during the rest of the year.

Grain temperatures should be checked and recorded during each inspection. Without temperature records, it is difficult to tell whether evaluated grain temperatures are caused by normally occurring outside temperatures or by heating due to mold activity. Use a deep bin probe to obtain samples at different locations in the bin to determine the moisture content, the amount of trash and fines and the general condition of the grain. An accurate moisture tester is required to determine actual moisture contents. You can check the accuracy of your tester by checking readings with your local elevator.

- **When checking your bins, look for;**

✓ Condensation on the grain surface, crusting, wet areas, molds and insects.

✓ Leaks or condensation on the bin roof.

✓ Non-uniform temperatures in the grain mass, pockets or layers of high-moisture grain, molds and insects.

✓ Musty or sour odors, spoiled grain gives off a detectable odor, but in most cases, the spoiling grain must be near the surface of the grain and the grain must have under gone considerable spoilage before you can detect any odor. Generally, if you can smell a musty odor, a problem is already under way.

Any problems that found n to be evaluated and corrected as soon as possible. This may include cooling with aeration, further drying or fumigation for insect control.

- **Clean in and around storage facilities**. Grain storage facilities, and the area around storage facilities, should be cleaned thoroughly prior to storing grain.
- **Clean equipment used to move grain**. Grain left in equipment throughout the summer months can result in new grain being placed into storage becoming infested. Combines, truck beds, grain wagons, augers and other equipment used to move grain should be clean before moving grain. Other potential sources of grain infesting insects include livestock feeds, old seed bags, spilled grain, etc.
- **Inspect grain storage facilities** for signs of deterioration, especially for leaks or holes through which insects or rodents can gain access to the stored grain.
- **Dry and Cool Grain**. If possible, grain should be dry before being put into storage, and cooled as quickly as possible. For long-term storage, lower the grain temperature below 15°C as soon as possible after the grain is placed in storage. At 15°C the stored product insects stop laying eggs and development stops. Aeration systems used during the night immediately after harvest should have the grain below 15°C in about 2 weeks. Once the grain mass is cooled to the desired temperature, fans should be sealed to prevent unwanted air migration through the mass that could result in early grain mass warm-up. Cold grain has a longer storage life than warm grain

Self-check 4	**Written test**

Name…… ID…… Date…….

Directions: answer the following question. Pay attention in each activity and try to answer to the point

1. Define the following terms /2point each/

A. Grain C .grain monitoring

B .grain inspection D. grain maintaining

2. How to maintain grain hygiene in storage /5point/
3. List the type of storage facilities and justify them /5point
4. List five important measures to prevent introduction of pathogen in field /5points

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 20 points Unsatisfactory - below 20 points

LG #75	LO# 2 Monitor grain from arrival to dispatch

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Taking grain samples for testing
- Taking grain Samples for purity testing
- Checking grain quality for dispatch
- Taking , preparing and forwarding samples for analysis
- Creating *records* of grain movements in and out of storage
- Making recommendations adopt new technology, systems or practice
- Undertaking activities for grain storage facilities

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Take grain *samples* for testing
- Take grain Samples for purity testing
- Check grain quality for dispatch
- Take , preparing and forwarding samples for analysis
- Create *records* of grain movements in and out of storage
- Make recommendations adopt new technology, systems or practice
- Undertake activities for grain storage facilities

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “learning guide.

Information Sheet 1- Taking grain samples for testing

1.1 Taking grain sample before storage to ensure quality

Sampling is defined as the process of removing an appropriate quantity for testing from a larger bulk, in such a way that the proportion and distribution of the factors being tested are the same in both the whole (lot) and the part removed (sample).

Distribution of constituents, such as broken kernels or foreign material, is generally not uniform throughout the load. As grain is loaded into a container (truck, wagon, railcar, or storage), constituents of the grain mass stratify and segregate.

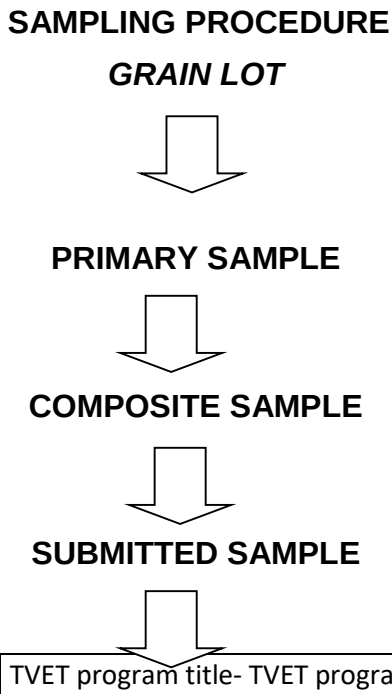
The constituents separate depending on size, density, and shape. Fine particles tend to concentrate in a region near the center of the container and coarse particles in the outer

perimeter. This causes variations in the physical characteristics within the load. As the amount of foreign material in a lot of grain increases, so does the segregation of the foreign material. This makes the method of sampling extremely important to ensure that the sample is truly representative of the whole grain mass.

People collecting grain samples can influence how well the sample represents the lot of grain by sampling only a portion of the grain stream. Seed testing includes those tests necessary to properly evaluate the quality of the planting seed to be used by the cultivator. The international seed testing association (ISTA) lays down the procedures and methods for seed testing. The most important seed tests are moisture content, purity physical (mixture), germination and vigor health genetic composition.

1.2 Sampling and working procedures

Seed sampling is one of the most important factors in seed quality control activities. The objective of seed sampling is to draw a representative sample from the seed lot for seed testing purpose. The value of test results depends to a large extent on the degree to which the seeds tested represent the total seed lot. Poor sampling may cause misleading results. Random samples are taken from a seed lot and combined to obtain a sample that is representative for the entire seed lot. The samples are mixed and from this composite sample the desired quantity for the sub-samples can be taken.



WORKING SAMPLE

- **Important terminologies in sampling**

✓ **Grain lot**: is a specified quantity of homogenous seed.

✓ **Grain sampling**: is a method by which a representative sample is taken from a seed lot to be sent to a laboratory for analysis.

✓ **Grain sample**: is a very small quantity of seed, which represents the overall quality of the lot.

✓ **Primary sample**: a number of single samples drawn from different bags or from different locations of the seed lot in containers or stored in bulk.

✓ **Composite sample**: a mixture of all primary samples from a seed lot.

✓ **Submitted sample**: part of the composite sample reduced as necessary and submitted to a testing Station.

✓ **Working sample**: a reduced sample taken from the submitted sample in the laboratory given for a given quality test.

3.2 sampling requirements

The seed for sampling should fulfill the following requirements:

- The lot to be sampled should not have volume larger than specified subject to a 5% tolerance.
- The bags or containers should be easily accessible for the sampler.
- The lot should be in properly sealed or sealable bags or containers and loose seeds should not be sampled.
- All containers must bear a lot identification number.
- The sealed lot should be uniform or homologous.

3.3 Sampling equipment's and methods

1. Bin or bag samplers

- **Automatic samplers**. They are attached to a stationary processing plant and are not flexible which are used to take samples from the whole cross section of the seed stream while cleaning and packing. Triers are most common and efficient sampling instruments especially for sampling seed in bags or small containers. The common triers are:

- ✓ **Hand triers**: They are smaller in size used to take samples from different positions of bags and sacks.
- ✓ **Stick triers**: stick or sleeve trier consists of two metal tubes with slots in which one is fitted inside the other. The outer fixed part has a pointed end were as the inner tube is fitted with handle, which can be used to rotate it for closing and opening the slots.
- ✓ **Noble trier**. (Dynamic spear): it is a modified trier used for greater accuracy. It consists of one tube with a pointed end and at the end a hole through which the seeds will enter. The tube should be long enough to reach the centre of the bag to be sampled.

- **Hand samplers**:

They are used only for chaffy noon-free flowering species which are not suitable to insert triers

5. Laboratory samplers

The working sample from the submitted should be taken by repeatedly dividing on fiat surface4 into smaller portion.

1.5. **Sample size**

The quantity of sample to be sent to the seed-testing laboratory should be large enough to represent any variability that exists within the seed lot. The sample weight to seed lot ratio for most cereals and legumes is 1:10000 or 20 00 for moisture content determination. Approximately 100g for species that has to be ground and 50g for others should be submitted.

Self-check 1	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test II: Short Answer Questions

1. Which one is a specified quantity of homogenous seed.
   a) Seed lot
   b) Seed sample
   c) Seed sampling
2. ----------is a method by which a representative sample is taken from a seed lot to be sent to a laboratory for analysis.
   a) Seed lot
   b) Seed sample
   c) Seed sampling
   d) All
3. --------is a very small quantity of seed, which represents the overall quality of the lot.

a) Primary sample
b) Seed lot
c) Seed sample
d) Seed sampling

Part 2 .Fill the black space

4. ---------- a number of single samples drawn from different bags or from different locations of the seed lot in containers or stored in bulk.

5. ---------- a mixture of all primary samples from a seed lot.

6. ---------- part of the composite sample reduced as necessary and submitted to a testing Station.

7. ---------- a reduced sample taken from the submitted sample in the laboratory given for a given quality test

You can ask you teacher for the copy of the correct answers.

Note*:* Satisfactory rating - 14 points Unsatisfactory - below 14points

Information Sheet 2- Taking grain Samples for purity testing

2.1. Introduction

Grain purity test: purity test provide the actual % of varietal purity from the nominated grain variety. Grain variety: grain comes in money variety. There are more than 40,000 variety of wheat alone in the world and each has genetic difference. Growers take advantage of this difference and choose the specific varieties that best the requirement and condition of their farm and the market.

Identifying the need for varietal testing market force are increasingly demanding pure variety of grain for specific purpose. e.g. a maltster require a pure variety of malt barely in order to ensure optimum grain processing and to produce a quality consumer products .this means varietal testing must become standard practice in order to guarantee the sale of grain.

Test available; the purity test provides the actual %of varietal purity from the nominated grain variety. This provides better assurance of crop purity .the test is particularly useful

prior to seeding to identify the purity of seed grain. By conducting the test prior to seeding, it can potentially identify the purity of the crop before it is grown.

The sample composite grist /multiple grain ground up together / and 20 individual grains are compared to standard using page .single grain testing against a standard gives a far more accurate result than simply using a composite grist ,as a clear representation of the sample can be seen . The purity is based on the nominated variety only which means that any contaminants cannot be identified without further testing against comparable standard. Purity test extension; the purity extension test also uses a composite grist.

Grain purity includes the phenotypical characteristic of the seeds (grain size (its length expressed as extra-long, long, short) , shape (length-width ratio which can be expressed as slender, medium, bold, round) , color, 1000 grain weight and the genetically characteristics that describe the genetic makeup of the variety to express the phenotype as well as the chemical composition.

Quality seeds has to meet the minimum seed certification standards and quality attributes viz., physical purity, germination per cent, moisture content, seed health and genetic purity. The genuineness of the variety is one of the most important characteristics of good quality seed. Genetic purity test is done to verify any deviation from genuineness of the variety during multiplication stages. For certification genetic purity test is compulsory for all foundation and certified hybrid seeds.

Higher genetic purity is an essential requirement for the commercialization of any seed. Besides for the success of any hybrid technology depends on the quality of the seed supplied in time.

The genetic purity during multiplication stage plot is prone to contamination from presence of pollen shedders, out crossing with foreign pollen and physical admixtures due to careless handling during harvesting, threshing, processing and bagging. Using low genetically pure seeds will proportionately reduce the commercial yield. It is estimated that for every 1% impurity in the hybrid seed the yield reduction is 100 kg per hectare (Mao *et al*., 1996). Maintenance of parental line purity is a prerequisite to ensure high genetic purity of hybrid seeds.

A certification standard of genetic purity for foundation is 99 per cent. While, for certified hybrids it is 95 per cent except cotton (90 %) and castor (85%).

Methods to assess genetic purity

Genetic purity of a given grain lot can be assessed by using one of the following methods

1. Conventional grow out test
2. Chemical test
3. Electrophoresis method

a. Biochemical markers (Proteins and Isozymes)

b. Molecular markers (DNA): Molecular markers, in contrast, being based on DNA sequence variation, provide an unbiased means of identifying crop varieties. The Biochemical and Molecular Techniques group of the International Union for the Protection of New Varieties of Plants (UPOV) is evaluating different DNA marker parameters prior to its routine use in establishing distinctness, uniformity and stability (DUS) of plant varieties.

Self-check 2	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. Grain purity test what are the most important? (5 point)

_____

_____

2. What are genetic purity of a given grain lot (5 point)

_____

_____

Test II: true or false

1. A certification standard of genetic purity for foundation is 99 per cent.

2. Grain purity includes the phenotypical characteristic of the seeds
3. Purity test provide the actual % of varietal purity from the nominated grain variety.
4. The genuineness of the variety is one of the most important characteristics of good quality seed.
5. Higher genetic purity is an essential requirement for the commercialization of any seed.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 20 points Unsatisfactory - below 20 points

Information sheet 3- Checking grain quality for dispatch

3.1 Dispatch

The following are some of the standard procedures when dispatching supplies from the storage site products should spend as little time as possible in storage; hence the rotation of the stocks on the basis of "first in, first out". The items that have been in the warehouse longest should be placed in the front rows of the stowage racks so they can be distributed first, and the items that come in later are to be placed at the back, rotating them to the front as deliveries are made;

The same principle applies to products with an expiry date: the first to be dispatched are those nearest their expiry date.

A dispatch can only be carried out with an official authorization document that has been signed by the person authorized to do so;

The same procedure of physical and documentary verification that was carried out when goods entered the warehouse must be carried out when they leave the warehouse, to make sure that the supplies that are being delivered correspond to the packing list or other identification documents;

Every dispatch must be recorded so it can be withdrawn from the inventory records. The following are some of the standard procedures when dispatching supplies from the storage site:

Products should spend as little time as possible in storage; hence the rotation of the stocks on the basis of "first in, first out". The items that have been in the warehouse longest should be placed in the front rows of the stowage racks so they can be distributed first, and the items that come in later are to be placed at the back, rotating them to the front as deliveries are made;

The same principle applies to products with an expiry date: the first to be dispatched are those nearest their expiry date.

The following are some of the standard procedures that should be applied when supplies arrive at the warehouse: Every load that arrives should be checked to see if the quantity, weight, and quality correspond to the information contained in the shipping papers, by carrying out a physical examination of the load; Once verification is made, goods should be recorded in the warehouse inventory. It is important to write down any special information about the supply. Sometimes all or part of some consignments may be returned to the warehouse, because they could not be distributed or were not needed. These should be recorded as returns, not as new arrivals;

- By engaging in a physical examination of the load, it should be possible to identify:
  - ✓ Bundles, crates, boxes, or sacks that are torn or wet;
  - ✓ Packages that show evidence of having been rifled;

Self-check 4	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. Define engaging in a physical examination of the load? (5 point)

_____

_____

2. Define Dispatch for grain quality (10 point)

_____

_____

_____

_____

Test II: true or false

1. Products should spend as little time as possible in storage
2. A dispatch can only be carried out with an official authorization document that has been signed by the person authorized to do so.
3. The same principle applies to products with an expiry date.
4. The items that have been in the warehouse longest should be placed in the front rows of the stowage racks.

Note: Satisfactory rating - 15 points Unsatisfactory - below 15 points

You can ask you teacher for the copy of the correct answers.

Information Sheet 4- Taking, preparing and forwarding samples for analysis

4.1. Introduction

Sampling grain bin to take a representative sample at the farm a grain bin, you will need four identical pails that holds a minimum of 20 liters .two of these pail should be labeled A and 2 pails labeled B.

PROCEDURES as the grain streams out of the bin ,take grain sample at consistence and regular to ensure the sample is representative .the length of the interval should be determined at the beginning of the process and should take in to account .- amount of grain that is moved , type of equipment you are using ,how much sample you need The larger the auger the smaller the load of, the shorter the interval.

when taking grain sample alternate b/n the sides in pail 'A', ensuring stream .place all the sample for each bin pail 'A' ,ensuring that you have at least enough sample to fill the pail to three quarter full .mix the content of pail A thoroughly by hand .place the 2 empty pails labeled 'B', side by side and touching a level surface .pour the content of

pail' A' at the point where that each pail revives about half the sample . Return pails of sample to pail 'A'. The content of the other pail can be poured back in to the bin. Repeat this process with the remaining sample until you have approximately 2 kg of sample left. Place the final sample in to the remaining pails labeled 'A'. Place the final sample in sealed containers and label each container to show the bin it represent .keep in mind that for most purpose, you will need 1kg sample.

4.2 Sampling at out loading

Best practice, to which the industry should aspire, is to take and retain samples from each lorry load before it leaves the farm. These samples will not be contractual for the purposes of the determination of quality or condition at the delivery point but they may help if problems arise.

The quality and quantity of grain leaving the farm represent the result of a year's work and this is the best opportunity for the grower's assessment and the purchaser's assessment of delivered quality to match. Taking and retaining samples is also a requirement of some assurance schemes.

The sampling method depends on the equipment used for loading the lorry. In all cases, sampling should follow standard protocols to maximize the validity of retained out loading samples. For a 30 tons lorry-load of grain, take at least 10 samples of 200g as the grain is loaded. This provides a 2kg aggregate sample.

4.3 Sampling safety

- Do not attempt to climb on top of lorries, unless there is special provision
- Be aware of risks around loading equipment and vehicles at outloading
- Wear hi-vis clothing at all times when working around loading lorries

4.4 Labelling the samples

All samples must be labelled with basic information, including:

- Farm name
- Store name/number
- Bin number
- Variety
- Date

- Time
- Vehicle registration and trailer number

4.5 Sample storage

Samples should be stored in airtight containers (for example, polythene bags or plastic boxes) in a cool, dry place safe from rodent attack. These samples should be retained until payment has been received for the loads to which the samples relate.

4.6 Sampling from the loading bucket

Sampling from the loading bucket is the best method to obtain a representative sample but manual sampling ideally requires a second person. A safer method would be to use an automatic bucket sampler.

- Scoop samples from the grain in each bucket loaded
- Combine these incremental samples into a single 2kg aggregate sample in a bucket
- Mix the aggregate sample and divide into two 1kg representative samples

4.7 Sampling from spout loading

For grain being loaded into a lorry from a conveying system, it is best that grain is sampled at a point close to the loading location, where samples may be drawn safely. In some cases, an 'interrupter' plate can be inserted into conveying tubes.

- Collect at least ten 200g samples
- Combine these incremental samples into a single 2kg aggregate sample in a bucket
- Mix the aggregate sample and divide into two 1kg representative samples

4.8 Sampling from a grain heap

When loading bulk/on-floor stored grain, the grain needed for the next lorry could be pre-positioned into a separate heap. This can be sampled with a conventional grain spear preferably multi-aperture).

- Take at least ten 200g samples
- Combine these incremental samples into a single 2kg aggregate sample in a bucket

- Mix the aggregate sample and divide into two 1kg representative samples

.

Self-check 4	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: choose the best answer

1. Without the proper machinery and equipment, farmers would not be efficient enough to provide the food, clothing, and shelter that we need? (5 point)

A. True B. False

2. Which one of the following is tools and equipment is used for soil health?

A. GPS B. GIS C. machinery D. all

Test II: Short Answer Questions

3. Write the equipment's and machinery required during soil amending? (5 point)

_____

_____

Test III: true or false

1. Sampling from the loading bucket is the best method to obtain a representative sample.
2. Samples should be stored in airtight containers
3. Do not attempt to climb on top of lorries, unless there is special provision
4. Be aware of risks around loading equipment and vehicles at out loading
5. Wear hi-vis clothing at all times when working around loading lorries

Note: Satisfactory rating - 5 points Unsatisfactory - below 5 points

You can ask you teacher for the copy of the correct answers.

Information Sheet 5- Creating *records* of grain movements in and out of storage

5.1. Introduction

It is part of the responsibility of warehouse managers to ensure that supplies are used by those who really need them, and prevent their loss or diversion. Pilferage or theft should be kept to a minimum. Similarly, the storage conditions must be such that they allow for the optimum conservation of the supplies.

5.2 Security of the Supplies

Only the authorized staff should have free access to the warehouse facilities. The presence of third parties should be discouraged as much as possible, and their access regulated and only allowed when in the company of an authorized official.

The storage area must be secured against break-ins and theft by means of locks, fences, external perimeter lighting, and so on. Whenever possible, the most valuable goods and items must be kept under lock and key. The use of the keys to the warehouse must also be strictly controlled.

Finally, guards must be available around the clock, seven days a week.

5.3 Rotation of the Supplies

Minimum and maximum stock levels must be determined, as well as the point at which new supplies must be requested. The size of the stockpiles may differ depending on the type of supply and its rotation cycle.

The "first in, first out" principle must be applied strictly, which in turn requires an up-to-date list of the dates of arrival and expiry dates of the goods.

5.4 Control and Monitoring

Clear and strict procedures must be in place to control the arrival and delivery of the supplies. Each new arrival must be recorded in the inventory. Even those products that arrive in poor or unusable condition must be recorded as such. A stock control card must be available for every type of product stored in the warehouse. On the card, the dates and quantities that have arrived must be recorded; spaces must also be available on the card to register information about the delivery of the supplies. The current level of stocks of the same product must be recorded, as well as the sector of the warehouse where the product is kept. Regular inventories should be performed; control cards, printed inventories, and the computer database (if one is in place) should be kept up to date. Inventories and delivery documents should correspond to the information recorded on the stock control cards.

Clear and up-to-date controls and records of losses and certification of expired or spoiled items must be kept. Normally, the destruction or discarding of expired or spoiled medicines must be carried out under the supervision of a specialist. Individual forms are needed to record all warehouse activities, such as arrivals, deliveries, and requisitions. These forms should be numbered consecutively and must include the date and basic information about the people involved in the process.

Self-check 5	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What is Control and Monitoring? (5 point)

_____

_____

2. Control and Monitoring approaches to Grain storage were (5)?

_____

_____

Test II: true or false

1. Clear and up-to-date controls and records of losses and certification of expired or spoiled items must be kept.
2. Minimum and maximum stock levels must be determined
3. Guards must be available around the clock, seven days a week.
4. The use of the keys to the warehouse must also be strictly controlled.

Note: Satisfactory rating – 20 points Unsatisfactory - below 20 points

You can ask you teacher for the copy of the correct answers.

Information Sheet 6- Making recommendations adopt new technology, systems or practice

6.1. Introduction

Proper drying is considered the biggest single factor in determining whether grain will be effectively stored without damage. Usually grain is dried while it stands in the fields, or it is spread out on concrete surfaces, roads, baskets, plastic sheets, or the ground itself.

The standard alternative to such methods has been the fuel-burning artificial dryer. In these units, large quantities of grain can be dried with greater speed and greater control over drying rate and product quality.

There is a major section on grain dryers which includes complete production and operating instructions for 3 different solar dryers, pit & above ground oil barrel dryers, and improved traditional units such as the maize (corn) drying and storage crib (made of bamboo).

“The majority of the farmers do not adopt any pest controlling practices because according to them, the damage due to insect attack is negligible if clean dry paddy is stored in the structure .A main defect of this structure is that it has no facilities for aeration to bring down temperature rises.” Some minor changes are proposed.

A good example of successful, low-cost traditional grain storage bin that could be relevant in many other countries.

- **Simple Grain Drier**

“Local availability of drying facilities not only can reduce spoilage losses in storage but can also promote increased production through strengthening the practicality of double cropping in irrigated areas where the offseason crop is harvested in humid weather.”

The dryer is made mostly of sheet metal, and is of simple design. It is easy to build and requires no special skills to operate. It can be disassembled for easy transport and storage. The stirring blade is attached to the smoke stack base with a wooden bearing. A durable thermometer is needed, but the operator can estimate temperatures from the smell and feel of the grain.

Aeration to maintain grain temperatures as uniform as possible and as low as practical by managing aeration fans in temporary storages should aim at keeping grain temperatures below 40°F. Operate the fans intermittently during cold weather periods (preferably with an automatic fan controller) to keep the grain fresh and minimize condensation on the grain surfaces. Smell the exhaust air for any odors that might indicate grain spoilage. Fans should always be sealed whenever they are turned off to prevent premature rearming due to the chimney effect and pest infiltration. If the grain is in good condition, it should not be rearmed in the early spring. Instead, the fans should be kept sealed and the grain moved out of temporary storage as soon as possible.

Monitoring grain in temporary storages should occur weekly. The use of thermocouple cables is generally not feasible. However, special thermometers attached to long probes can be used to spot check even outdoor piles.

Vacuum-assisted probes are also available to remove samples from depths that are impossible to reach with hand probes. Samples should be checked for temperature, moisture, signs of self-heating, molding, and insects. Grain in temporary storage should not be stored into warmer weather that would require the application of insecticidal protect ants. In case of insect infestation, fumigation of existing buildings and outdoor piles is generally impractical, expensive and often ineffective. Infested grain should be moved into permanent storage structures that permit proper sealing to assure a successful

fumigation before marketing the grain. When deteriorating grain conditions are observed, temporary storage should be discontinued and the grain moved as quickly as possible. **Technologies can help them** suggests the use of enclosed solar dryers, black plastic sheets for direct drying, and improved grain storage units

Self-check 6	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What are the most important to Simple Grain Drier? (5 point)

_____

_____

2. Write Technologies can help them? (3 point)

_____

_____

Test II: true or false

3. Technologies can help them suggests the use of enclosed solar dryers
4. Monitoring grain in temporary storages should occur weekly.
5. Smell the exhaust air for any odors that might indicate grain spoilage.
6. The dryer is made mostly of sheet metal, and is of simple design.
7. Aeration to maintain grain temperatures as uniform as possible and as low as practical by managing aeration fans in temporary storages

8. Operate the fans intermittently during cold weather periods

You can ask you teacher for the copy of the correct answers.

Note*:* Satisfactory rating – 30 points Unsatisfactory - below 30 points

Information Sheet 7- Undertaking activities for grain storage facilities

7.1. Guide lines for grain storage facility

In response to the rising number of workers entrapped and killed in grain storage facilities.

When workers enter storage bins, employers must (among other things):

- ✓ Turn off and lock out all powered equipment associated with the bin, including augers used to help move the grain, so that the grain is not being emptied or moving out or into the bin. Standing on moving grain is deadly; the grain can act like "quicksand" and bury a worker in seconds. Moving grain out of a bin while a worker is in the bin creates a suction that can pull the workers into the grain in seconds.
- ✓ Prohibit walking down grain and similar practices where an employee walks on grain to make it flow.
- ✓ Provide all employees a body harness with a lifeline, or a boatswain's chair, and ensure that it is secured prior to the employee entering the bin.
- ✓ Provide an observer stationed outside the bin or silo being entered by an employee. Ensure the observer is equipped to provide assistance and that their only task is to continuously track the employee in the bin. Prohibit workers from

entry into bins or silos underneath a bridging condition, or where a build-up of grain products on the sides could fall and bury them.

- ✓ Train all workers for the specific hazardous work operations they are to perform when entering and working inside of grain bins.
- ✓ Test the air within a bin or silo prior to entry for the presence of combustible and toxic gases, and to determine if there is sufficient oxygen.
- ✓ If detected by testing, vent hazardous atmospheres to ensure that combustible and toxic gas levels are reduced to non hazardous levels, and that sufficient oxygen levels are maintained.
- ✓ Ensure a permit is issued for each instance a worker enters a bin or silo, certifying that the precautions listed above have been implemented.

Self-check 7	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

1. List the problems to be considered during pesticide application ./5point/
2. What are the precaution measure to treat plant disease and pests?/5p0ints/
3. Define pesticide and mention its import ant's /5points/
4. ----------is the process of removing an appropriate quantity for testing from a large bulk /2point/

Test II: true or false

1. Train all workers for the specific hazardous work operations they are to perform when entering and working inside of grain bins.
2. Test the air within a bin or silo prior to entry for the presence of combustible and toxic gases, and to determine if there is sufficient oxygen.
3. Turn off and lock out all powered equipment associated with the bin

Note: Satisfactory rating – 20 points Unsatisfactory - below 20 points

You can ask you teacher for the copy of the correct answers.

Operation Sheet -1	Taking grain sample for analysis

Material required

- Grain seed

Procedures

Sampling grain bin to take a representative sample at the farm a grain bin ,you will need four identical pails that holds a minimum of 20 liters .two of these pail should be labeled A and 2pails labeled B.

- ✓ As the grain streams out of the bin ,take grain sample at consistence and regular to ensure the sample is representative .
- ✓ The length of the interval should be determined at the beginning of the process and should take in to account. Amount of grain that is moved, type of equipment you are using, how much sample you need.
- ✓ The larger the auger the smaller the load of, the shorter the interval.
- ✓ When taking grain sample alternate b/n the sides in pail 'A', ensuring stream.
- ✓ Place all the sample for each bin pail 'A', ensuring that you have at least enough sample to fill the pail to three – quarter full .

- ✓ Mix the content of pail A thoroughly by hand .place the 2 empty pails labeled 'B' side by side and touching a level surface .pour the content of pail' A' at the point where that each pail revives about half the sample .
- ✓ Return pails of sample to pail 'A'. The content of the other pail can be poured back in to the bin
- ✓ Repeat this process with the remaining sample until you have approximately 2 kg of sample left .
- ✓ Place the final sample in to the remaining pails labeled 'A'.
- ✓ Place the final sample in sealed containers and label each container to show the bin it represents.
- ✓ Keep in mind that for most purpose, you will need 1kg sample.

LAP TEST	Performance Test

Name……ID…… Date……

Time started: _____ Time finished: _____

Instructions: Given necessary templates, tools and materials you are required to perform the following tasks within 4hrs . The project is expected from each student to do it.

Task – 1 Perform taking grain sample

You can ask you teacher for the copy of the correct answers

LG #72	**LO # 3- Monitor and maintain grain condition in storage**

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Conducting regular checks of grain in storage
- Conducting periodical checks of grain in long-term storage
- Taking samples of the grain
- Taking , preparing , and forwarding samples
- keeping records of grain tests and inspections
- Monitoring the *condition of storage facilities*
- Taking corrective action for grain storage facilities
- Undertaking activities around the grain storage facilities

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Conducting regular checks of grain in storage
- Conduct periodical checks of grain in long-term storage
- Take samples of the grain
- Take , preparing , and forwarding samples
- Create, maintaining and keeping records of grain tests and inspections

- Monitor the *condition of storage facilities*
- Take corrective action for grain storage facilities
- Undertake activities around the grain storage facilities

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6. If you earned a satisfactory evaluation proceed to “learning guide.

Information Sheet 1- Conducting regular checks of grain in storage

1.1. Contaminants or factors causing deterioration of stored grain

Include molds, moisture, mite's insects or fungal disease.

Insects are a major source of grain losses worldwide. They cause lose by eating the grain there by reducing the total weight. in addition they lower the quality of grain particularly by affecting germination and general contamination which greatly lowers its monetary value .insects which attack grain in store are ; beetles ,weevils moths ,and cockroaches .insect do not breed successfully where the humidity is maintained below 40 %and the temperature below 10 degree centigrade .

Weevils are frequently the most important storage pests particularly the maize weevil, rice weevil the granary weevil. The maize and rice weevil are 2,5to 5 cm long, the rice weevil being slightly smaller. Both species can fly and thus can attack cereal in the field some week before harvest .several and distinct kinds of damage may be cause by weevils.

Beetle , moth and cockroach ; are other insects of stored grain which is a worldwide pest of cereals cereal products and dried fruit .unlike some weevil infestations does not take place in the field . Beetle infestation leads to arise in the temperature with subsequent mold development and spoilage .a variety of moth and cockroach also attack stored grain and especially foods. three main cockroach species are found in storage buildings ,processing , rooms and warehouse .these are the German cockroach the oriental cockroach and the American cockroach .they are frequently found as scavengers of food stuff remains and packaging . Mites; are very small sized insects which belongs to the spider family .they are extremely difficult to see and are only usually detected when

present in large number appearing adjust. They have shiny translucent body with yellowish to reddish brown legs and mouth parts .mites multiply rapidly in grain or food stuff with high moisture content . They are most serious in temperate region but may be a problem in tropical areas.

Birds and rodents can cause considerable weight losses before harvest and after harvests, including storage bird control is a complex issue including ecological aspects shooting and scaring with various device are the established control methods.

Rodents / rats and mice / may be serious pests of grain .however, modern methods of control, principally the use of poisoned baits are adequate for most situation.

Fungi ;the major types of losses caused by fungi in stored grain are :-weight loss, reduce germ inability ,increased respiration , discoloration , physiological change and production of toxins which may be injuries to human and animals .

The main grain storage fungi are;

1. Penicilium
2. Various species of aspergillus.

The main source of storage fungi are relatively low infestation on harvested seeds and probably more important the atmosphere in which grain is transported , handled and stored .in general the critical factor in grain storage are :

1. Moisture content
2. Temperature
3. Insect and mites
4. Fungi and bacteria

- **Effective grain preservation can be achieved by:**

✓ Reducing moisture content of grain; the moisture content of most cereal grain should not exceed 15% and preferably 13-14%.some grains especially those with high oil content should be dried down to 8-9% moisture.

✓ Keeping grain at low temperature; cooling grain and keeping it at a low temperature can prevent spoilage and losses .however, this is seldom a realistic long –term storage option.

✓ Removing oxygen from the storage atmosphere; removing oxygen or eliminating respiration of grain and microorganisms. This can be achieved in sealed air tight silos.

- ✓ Chemical treatment grain can be preserved by sterilization with acid or alkali .acid preservation is widely used in some countries for preservation of moist grain which is used for feeding to animals .stored grain should be checked regularly to defect spoilage look out for . Heating/hotspots/ , mold, insect or mites and moist or caked grain.

Self-check 1	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Choose the best answer (5 point)

1. Detailed plan, objectives, specifications Reducing moisture content of grain are established based on program requirements**.**

A. True B. False C. A&B

Test II: Short Answer Questions

2. Write the critical factor in grain storage

_____

_____

Test III: true or false

1. Reducing moisture content of grain
2. Keeping grain at low temperature
3. Rodents / rats and mice / may be serious pests of grain
4. Removing oxygen from the storage atmosphere
5. Weevils are frequently the most important storage pests
6. Chemical treatment grain can be preserved by sterilization with acid or alkali

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 20 points Unsatisfactory - below 20 point

Information Sheet 2- Conducting periodical checks of grain in long-term storage

2.1 Introduction

Checking grain in long term storage, long term grain storage management practices following the management procedure outlined below will help assure that basic aeration requirements are met.

2.2. Aeration Phases

- **Phase 1: Fall Cool Down**
  - ✓ Lower grain temperatures stepwise
  - ✓ October – 40-45oF
  - ✓ November – 35-40oF
  - ✓ December – 28-35oF

Move at least one (preferably two) cooling zone(s) through the grain to remove field or dryer heat and help equalize moisture contents. Thereafter, move one cooling zone per month through the grain until it is cooled to between 35^{o} and 40^{o} F and to equalize grain mass temperatures. Check the grain temperature and condition every two weeks and as needed to monitor cooling zone progress.

The initial cooling is important, so do not skimp on fan operation. Turn the fans on as soon as grain covers the perforated floor or aeration ducts, and operate continuously until the grain has been cooled to the prevailing outside temperature. Since cooling is the primary concern, especially if the grain has come from a dryer, do not turn the fans off during rainy or humid weather. Failing to properly cool the grain can cause more problems than the small amount of rewetting that occurs from running the fan on a humid day.

- **Phase 2: Winter maintenance**
  - ✓ Check the grain temperature and condition at least once a month.
  - ✓ Maintain low temperatures with intermittent aeration: January, February- 28-35oF

- ✓ Aerate as needed to maintain grain temperatures between 35 and 40^{o} F.
- ✓ During the winter, the aeration system needs to be operated only on a maintenance schedule to control localized temperature increases.

In fact, it may not be necessary to run the fan at all during the winter if the grain remains dry and in good condition, and if grain mass temperatures are stable. One aeration strategy is to operate the fan for a few hours as part of a bi-weekly or monthly grain checking program. This allows the operator to check the exhaust air for off-odors, an indication that the grain requires immediate attention.

Avoid operating the fan on warm days. When air temperatures are warmer than grain temperatures, fan operation can result in moisture condensing and possibly freezing on the cold grain. This condensation problem can be prevented by operating the fan only when air temperatures are the same as or cooler than grain temperatures.

Freezing grain is not recommended because of the increased likelihood of condensation problems if the grain is not properly warmed in the spring. However, freezing the grain becomes a secondary concern if the grain begins to heat or go out of condition. If a problem occurs, operate the aeration fan continuously, regardless of weather conditions, until the problem is corrected.

- **Phase 3: Spring Holding**

Keep grain cold from winter aeration, Seal fans &Ventilate only headspace intermittently

If the grain is frozen, thaw by moving a warming zone completely through the grain as soon as outside air temperatures remain above freezing.

If the grain is not frozen and will be fed or sold by June, aerate only as needed to control "hot spots" and heating problems.

If the grain will be held into or through the summer, move one warming zone per month completely through the grain until the grain mass is uniformly warmed to about 60^{o} F.

Check the grain temperature and condition at least every two weeks and as needed to monitor warming zone progress.

It may seem counterproductive to warm grain in the spring after cooling it down in the fall. If fact, there is little reason to warm the grain if it is to be marketed or fed by summer. One exception is that frozen grain should always be thawed before being handled in warm

weather. Operate aeration fans continuously when thawing frozen grain to prevent freezing of condensed moisture on the grain.

Since average outside air temperatures change at the rate of 2.5 to 3º F per week, move one warming zone per month through the grain to maintain uniform grain temperatures and to warm the grain to 60º F in preparation for summer storage. This temperature is cool enough to slow insect activity, yet warm enough to minimize condensation if the aeration fans need to be operated to control localized heating in the bin. Fans should be operated continuously for each successive warming zone.

- **Phase 4: Summer**

Check the grain at least once every two weeks to monitor temperature, moisture, and insect activity.

Consider operating the fan one cool night per week through June to help maintain grain temperatures at 60º F.

Cover fan openings during June, July, and early August.

Grain checking is very important during the summer because grain is being held at higher temperatures and aeration conditions are less favorable than during the rest of the year. Grain temperatures need to be checked and recorded on a regular basis.

Storage capacity

Different grains and components of grain have different weights. The following Table gives the approximate weight and volume for paddy rice and its milled components.

	Bulk (kg/m3)	**Bag (bags/ton)**	**Weight per bag**
Paddy or rough rice	600-650	13-20	50-80 kg
White rice	850-900	20-25	40-50kg
Bran or meal	550-600	20	50kg
Husk	120-140		

To determine the storage capacity for different types of storages the following equations may help

- Square or rectangular bin:

Volume = (length x width x height) x bulk density (kg/m2)

- Tower silo with flat bottom

  Volume = (22/7 x radius x height) x bulk density (kg/m2)

- Tower silo with cone bottom:

  Volume cylinder= (22/7 x radius x height) + volume of cone = (1/3 (22/7 x height)) x bulk density (kg/m2)

- Grain pile on a pad

  Volume (length x width x 0.73 (grain coefficient))

In many storage devices allowances must be made for the angle of repose of grain (angle on the top of the grain stack). The angle of repose for rice, which is allowed to freely fall into a pile, is approximately 36 degrees.

Self-check 2	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: short Answers (4 points).

1. List down of Aeration Phases

2. ----------Keep grain cold from winter aeration, Seal fans &Ventilate only headspace intermittently 2pts

3. -------- And ----------^{o} F Aerate as needed to maintain grain temperatures 2pts

Test II: true or false

1. Grain pile on a pad
2. temperature is cool enough to slow insect activity
3. Keep grain cold from winter aeration
4. Move at least one (preferably two) cooling zone(s) through the grain
5. Cover fan openings during June, July, and early August.

Note: Satisfactory rating – 20 points Unsatisfactory - below 20 point

Information Sheet 3 Taking samples of the grain

3.1 The need for sampling

Batches of grain are rarely uniform in quality even when regarded as acceptable. Pests usually occur non-randomly in stored grain. Consequently the only sure way of obtaining complete and accurate information about the grain is to carry out a total examination. This may be possible if the quantity to be examined is small, but is usually neither practical nor economical when a large quantity is involved. The choice is either not to examine the consignment at all or to take samples to obtain some information, acknowledging that anything less than a total examination is bound to affect the accuracy of the results.

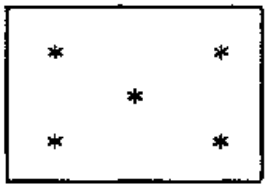
3.2 Principles of representative sampling

The results of sample analyses can be expressed in precise terms. However, precise analytical results may be of little practical value, and may be misleading if the samples are obtained without taking into account the non-random or aggregated distributions of foreign matter, damaged grains, insects, etc.

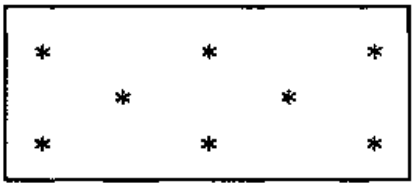
Certain principles of representative sampling must be observed:

- The consignment should be divided into primary units of equal size or status, which may be sampled. For bagged grain, each bag may be regarded as a primary unit. For bulk grain, the primary unit may be expressed in terms of weight, if the grain is being moved, or volume, when it is static - as in a truck or bin.
- All primary units should have an equal opportunity of being sampled. This is possible only during the construction or dismantling of a stack, the loading or off-loading of a truck, or when bulk grain is being moved.
- The method should select, without bias, a representative number of primary units from the consignment.

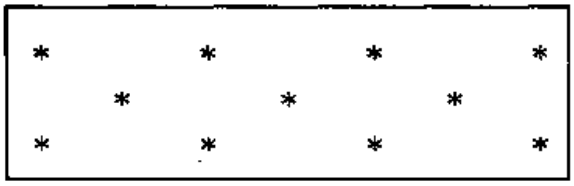
Many countries adopt the recommendations of ISO 950 "Cereals - Sampling (as grain)"



Truck containing up to 15 tonnes: five sampling points (middle and approximately 50 cm from sides).



Truck containing 15 to 30 tonnes: eight sampling points.



Truck containing 30 to 50 tonnes: eleven sampling points.

3.3 Working sample size

In practice, it is necessary to compromise between what is theoretically attainable and the natural desire to obtain results of analyses as quickly as possible. Providing the associated margins of error are recognized and accepted, it is generally suggested that working samples of between 500 and 1000 grains should be used for the determination of common defects such as insect damage, broken grains and discolored grains.

Equivalent minimum working sample weights are:

Maize (small grain)	200g
Maize (large grain)	250g
Sorghum	25g
Black-eyed cowpeas	150g
Wheat	25g
Bulrush millet	10g
Paddy	15g

Samples of these sizes can be analyzed in 10 to 20 minutes, depending upon the skill of the inspector and available equipment.

- **Selection of bags for sampling**

Number of bags in consignment	**Number of bags to be sampled**
Up to 10	Every bag
11 to 100	10, drawn at random
More than 100	Square root (approximately) of the total number of bags drawn random according to a suitable scheme.

In the USA, minimum working sample weights of 250g and 1000g are required for the determination of ergot and garlic respectively in wheat, while 250g samples are recommended for the determination of smut in both wheat and sorghum. Such 10 to 40 fold increases on the basic working sample weight illustrate what is meant by 'large' and 'small' sample sizes.

There is a need for sampling awareness when dealing with grain contaminated with mycotoxins. As analytical techniques improve, so detectable and tolerance levels are being lowered. To emphasize the link between the standard test method and specification conclude, "When aflatoxin levels are controlled by legislation it is important that sampling procedures and sample sizes are specified."

For the determination of foreign matter and live infestation, samples should be as large as possible. If bagged grain is being tested, the best results are obtained by passing the entire contents of sample bags over a suitable sieve.

Self-check 3	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: True or false (4 points).

1. Maintenance Regular inspections should be carried out to determine the condition of the building, particularly its electrical installations, locks, roof,
2. Hygiene Keep the store absolutely clean! Remove any spilt grain immediately as it attracts rodents!
3. The inspection should cover all sides of the stowage piles
4. There is a need for sampling awareness when dealing with grain contaminated with mycotoxins.
5. To emphasize the link between the standard test method and specification conclude, "When aflatoxin levels are controlled by legislation
6. Many countries adopt the recommendations of ISO 950 "Cereals - Sampling (as grain)"
7. The results of sample analyses can be expressed in precise terms
8. All primary units should have an equal opportunity of being sampled.

Note: Satisfactory rating - 25 points Unsatisfactory - below 25 point

Information Sheet 4 Taking, preparing, and forwarding samples

4.1. Introduction

Understanding the quality and condition of grain is crucial. Accurate sampling at each stage of the grain chain is required to develop that understanding. It should help to reduce waste and minimize charges, claims and rejections.

For many years, sampling grain has been important in measuring key quality parameters in combinable crops (e.g. Hagberg Falling Number, nitrogen content and specific weight). In recent years, however, other challenges (including mycotoxins) have emerged, requiring the industry to demonstrate due diligence; samples of grain traded are part of that evidence. Grain sampling is, therefore, even more important and must be undertaken using appropriate methods at the most relevant points along the grain chain.

During storage, grain is still a living crop respiring and susceptible to infection by molds and infestation by pests. Monitoring temperature and moisture content provides early warning of any change that may threaten crop quality

4.2. Samples for moisture

When grain is dried ‘in situ’ (i.e. on-floor or in-bin), this is generally achieved by passing a high volume airflow up through the grain. This effectively 'pushes' a drying front up from lower layers towards the surface a process that takes up to two weeks.

Moisture sampling monitors progress of the drying front. This can be achieved by sampling and testing grain near the top of the bulk/bin or with an automatic sensor inserted into the grain. The information gathered confirms when the drying front has completed its movement and drying equipment can be turned off.

Monitor for moisture content at several locations (the same each time). An increase in moisture content in a localized area of 2% or more in a week may indicate condensation, leaks, hot spots or insects. Record moisture content at least once each month during winter.

4.3. Samples for temperature

Monitor every few days until the target temperature is reached and then every week.

Always record at the same location. Measurements must be taken where cooling takes longest, e.g. furthest from the fan in blowing systems, usually 0.5m beneath the surface and centrally between ducts.

In larger stores, consider permanent temperature probes installed in a grid pattern across the bulk. Modern installations enable constant remote monitoring, including via smartphone. Electronically recorded data also allows trends to be observed over time.

Any temperature rise over 1˚C should be investigated, as it could indicate the presence of fungi, sprouting, and development of pests or a leaking roof.

4.4. Samples for pests

While pests in stored grain can be detected by examining physical samples of grain drawn from a bulk or bin, it is a very laborious process. Traps have been shown to be more than ten times as effective as sampling at detecting low level populations of insects and mites. Some traps are designed for use in the store, others for use within the grain bulk.

Positioning traps both on the grain surface and approximately 5–10 cm below (approximately 4–5 meters apart) will provide the greatest likelihood of detecting all species of stored product insects and mites at the earliest opportunity.

Monitor for pests weekly until grain reaches the target temperature and then monthly, providing it remains at the target temperature, until spring when temperatures rise and insects become more active. Then revert to weekly monitoring. Traps should be accounted for each time they are examined and a permanent record of the contents should be kept**.**

4.5. Samples for mycotoxins

If grain has been harvested 'dry', or has been dried quickly, storage mycotoxins (such as ochratoxin A) should not be a risk, unless water has contacted the grain from the store structure. Legally, all producers should know whether grain for human consumption meets the food safety standards for the presence of the fusarium mycotoxins, DON, ZON, T2 and HT2 (see page 16). Many processors will require this information, especially at the start of each new harvest year. Samples taken in store may be used to provide this information.

Self-check 4	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: True or false (4 points).

1. Understanding the quality and condition of grain is crucial.
2. grain has been harvested 'dry', or has been dried quickly
3. Monitor for pests weekly until grain reaches the target temperature.
4. Monitor for moisture content at several locations
5. Pests in stored grain can be detected by examining physical samples of grain.
6. For many years, sampling grain has been important in measuring key quality parameters.
7. Always record temperature samples at the same location.
8. Traps have been shown to be more than ten times as effective as sampling at detecting low level populations of insects and mites.

Note: Satisfactory rating - 20 points Unsatisfactory - below 20 point

Information Sheet 5- Creating, maintaining and keeping records of grain tests and inspections

5.1. Maintenance and Sanitation Measures

- **Maintenance**

Regular inspections should be carried out to determine the condition of the building, particularly its electrical installations, locks, roof, and structural integrity in general. Any necessary repairs must be carried out as soon as possible to prevent the damage from getting worse.

- **Hygiene**

The warehouse and its environs should remain clean at all times. The uncontrolled accumulation of waste products such as empty cardboard boxes should be discouraged. It is important to get rid of stagnant water, overgrown weeds, or any other feature in the vicinity that may encourage the proliferation of insects and rodents.

A warehouse cleaning plan must be implemented, including both daily and periodic cleaning sessions. An inspection of the state of cleanliness of the stowage racks, corners, and sectors of the building must be carried out regularly. Similarly, a plan must be in place for managing and disposing of solid waste, whether spoiled supplies, packing material, or empty containers. Warehouse inspections should be carried out at least once a week, in order to detect problems. These inspections must include, as a minimum, the following tasks

- ✓ Checking for and eliminating from the food piles insects, spider webs, or cocoons;
- ✓ Detecting damage caused by rodents, birds or insects, or the careless extraction of samples from the grain and cereal sacks;
- ✓ Looking for damage caused by water or humidity, such as mold, stains, discoloration, or hardening of the packages, bales and bundles;
- ✓ Detecting leaks in containers and the loss of supplies due to tears in the packages;
- ✓ Detecting tinned food cans that are bulging, leaking, or rusty;
- ✓ Detecting signs of fermentation in cereals. Several layers of the stowage piles should be sampled, particularly the ones in the middle.

The inspection should cover all sides of the stowage piles. All corners and dark areas of the warehouse should be inspected to locate potential rodents' nests or an accumulation of dust or waste. The most useful measure that can be taken to get rid of insect or rodent infestations is to prevent them in the first place.

5.2. Inspect grain frequently during storage

Stored grain should be inspected frequently. Insect or mould activity gives a distinct odour to air moved through the grain. By operating the aeration system and smelling the air coming through the grain, storage problems can be detected. Any 'hot spots' should be cooled as soon as possible by aeration. If the problem is due to insect activity, the grain should be fumigated

Self-check 5	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: True or false (4 points).

1. Stored grain should be inspected frequently.
2. Insect or mould activity gives a distinct odour to air moved through the grain.
3. If the problem is due to insect activity, the grain should be fumigated
4. By operating the aeration system and smelling the air coming through the grain, storage problems can be detected.
5. If the problem is due to insect activity, the grain should be burnt.
6. The inspection should cover all sides of the stowage piles.
7. Regular inspections should be carried out to determine the condition of the building,
8. The warehouse and its environs should remain clean at all times.
9. Checking for and eliminating from the food piles insects, spider webs, or cocoons
10. Detecting leaks in containers and the loss of supplies due to tears in the packages;
11. Detecting tinned food cans that are bulging, leaking, or rusty

Note: Satisfactory rating – 30 points Unsatisfactory - below 30 point

Information Sheet 6- Monitoring the condition of storage facilities

6.1. Monitoring Conditions of a safe storage facility

- Maintain quality and quantity
- Protect from pests
- Protect from moisture
- Protect from destructively high or low temperatures
- Protect from objectionable odors and contamination
- Protect against unauthorized distribution

(Note: A safe storage place must be provided for the greater part of crops produced until they are needed for consumption, since crop production is seasonal, and consumption is continuous.)

Once the last grain has been agreed into the bin and the hatches closed, there is often a tendency to forget about what is needed to maintain the grain at a high level of quality. However, without proper management, that grain can rapidly deteriorate, becoming a worthless mass.

Grain spoilage is usually the cumulative result of several different handling and management operations and decisions. Thus, the better the overall management program, the better the chance for maintaining grain quality.

Four factors which greatly affect grain storability are

1. Grain moisture content;
2. Grain temperature;
3. Initial condition of the grain; and
4. Insects and molds. These factors are all interrelated

- **Grain moisture Content**

If grain moisture content is too high, even the best aeration equipment and monitoring management will not keep the grain from spoiling - it only delays the inevitable. Recommended moisture contents are given in Table 1. These recommendations assume the grain is high quality and aerated to control temperatures and moisture migration. Reduce the recommended moisture contents by 1 percentage point when storing low quality grain. This includes immature grain, severely cracked and damaged grain, and grain subject to previous insect or mold activity.

Also reduce the recommended moisture contents by at least 1 percentage point for grain in temporary or emergency storage.

Table 1. Maximum recommended moisture contents for properly managed, high quality, aerated grain.

Storage Period	Corn and Sorghum	Soybeans
Fed by April	18%	13%
Marketed by June	15.5%	13%
Up to one year	14%	12%
Over one year	13%	11%

- **Grain Temperature**

Whether holding wet grain for a short period of time or storing dry grain for longer periods, it is important that grain temperatures be controlled by moving air through the grain mass. Because both wet grain and molds respire and give off heat, aeration is needed to keep the grain cool and to slow mold growth. Properly aerated grain can generally be safely held about four times longer than non-aerated grain.

Aeration is needed, even if grain is dry and cool when placed in storage, to keep the grain mass at the desired temperature and to keep temperatures equalized. Differences in grain temperatures create convection currents which can move and concentrate moisture in the top center of the bin. Problems caused by this moisture movement, or moisture migration, often become obvious in the spring when outside air temperatures begin to warm.

Moisture also moves by vapor diffusion from warmer to cooler areas in the bin. If grain is not properly cooled for winter storage, there is a tendency for moisture to move to the cool grain along the bin sidewall, causing spoilage. Moisture movement problems can be

prevented or minimized by keeping grain mass temperatures equalized and within 10 to 15^{o} F of the average outside air temperature.

Aeration can also be used effectively to control insect activity by keeping grain temperatures at or below 60^{o} F. Aeration is especially critical early in the fall to cool grain from warmer harvest or summer storage temperatures. Waiting until late in the fall to cool grain invites insect activity. Cooling the grain in the fall and keeping grain temperatures below 60^{o} F as long as possible into the summer will help control insects and increase the chances of getting through the summer without having to fumigate the grain.

When grain from a dryer is cooled in a storage bin, it is critical that cooling be completed within 4 to 6 hours. Do not turn the fan off until all the grain has been cooled, regardless of weather conditions. Holding warm grain in a bin for even a few days is a needless risk to take.

- **Initial Grain Condition**

Grain quality will not improve during storage. At best, initial quality can only be maintained. To help assure that only high quality grain goes into storage, the following is recommended:

- ✓ Clean around the bin site. Remove any old grain, grass, weeds, and other debris.
- ✓ Remove all traces of old grain from the bin and harvesting and handling equipment.
- ✓ Properly adjust the combine to minimize grain damage.
- ✓ Clean the grain as it is put into the bin, preferably using a rotating grain cleaner.
- ✓ Cool the grain to the prevailing outside air temperature as soon as it is put

- **Insect and Mold Control**

Insects are generally not a problem in grain stored for less than 10 months or a year. However, if grain is to be stored for longer than this, or if a bin has had an insect problem in the past, special precautions should be taken. These include:

Spray the inside of the bin with protective insecticides 2 to 3 weeks before new grain is added.

Treat the grain with an approved insecticide as the bin is filled.

Top-dress the grain with an approved insecticide after the bin has been filled and the grain

Left untreated, an insect infestation will eventually lead to other storage problems. Insects give off moisture which can cause grain moisture contents to increase enough to create a mold problem. Mold activity will in turn raise temperatures and result in an increased rate of insect reproduction. Greater numbers of insects create more moisture, and the cycle is repeated at an ever increasing rate.

Self-check 6	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. What is Insect and Mold Control? (5 point)

_____

2. Write the grain temperature? (3 point)

_____

_____

Teat II choice 2pts

1. Monitoring Conditions of a safe storage facility
   a) Maintain quality and quantity
   b) Protect from pests
   c) Protect from moisture
   d) Protect from destructively high or low temperatures
   e) All the above
2. The factors which greatly affect grain storability are
   a) Grain moisture content
   b) Grain temperature
   c) Initial condition of the grain
   d) Insects and molds.
   e) All the above

Test III: True or false (4 points).

1. Insects are generally a problem in grain stored for less than 10 months or a year.
2. Grain quality will not improve during storage.
3. Cool grain along the bin sidewall, causing spoilage.
4. When grain from a dryer is cooled in a storage bin, it is critical that cooling be completed within 4 to 6 hours.

Note: Satisfactory rating – 25 points Unsatisfactory - below 25 point

Information Sheet 7- Taking corrective action for grain storage facilities

7.1 Taking corrective action

Corrective action maintenance activities such as inspection for structural problems repair of physical damage, sealing of inlets and outlets to maintain gas tightness, pressure testing of sealed storages to recommended levels, location and repair of leaks in sealed storages, maintenance of pressure relief valves, and painting and upkeep of heat reflecting coating.

Corrective action might also include the operation of installed equipment where it exists. For example, refrigeration may be used on storage facilities holding malt quality barley or sorghum, or where high moisture content is jeopardizing grain quality.

Matching the cooling load with equipment selection may involve site-specific data and calculations, combined with the use of manufacturer's data.

Additionally, aeration might assist to reduce grain temperature and grain moisture levels to client and organizations requirements Corrective action might also include the operation of installed equipment where it exists. for example refrigeration may be used on storage facilities holding malt quality barely or sorghum or where high moisture content is jeopardize grain quality. matching the cooling load with equipment selection may involves site specific data and calculation , combined with the use of manufacturer data . Additionally, aeration might asset tom reduce grain temperature and grain moisture levels to client and organization requirements

.

Self-check 7	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: True or false (4 points).

1. aeration might asset tom reduce grain temperature and grain moisture levels
2. matching the cooling load with equipment selection may involves site specific data and calculation
3. fumigation might assist to reduce grain temperature and grain moisture levels
4. Corrective action might include the operation of installed equipment where it exists
5. High moisture content is jeopardizing grain quality.

Note: Satisfactory rating – 30 points Unsatisfactory - below 30 point

Information Sheet 8- Undertaking activities around the grain storage facilities

8.1 OHS guide lines for grain storage facility

Condition of storage facilities to eliminate or minimize OHS risks; the range of actions are both systemic and at an operational level .these are listed below. Systems should be in place to ensure the safe operation and maintenance of machinery and equipment. Precaution should also be in place to minimize exposure to noise and organic and other dusts. systems and procedures for handling and storing grain ,as well as working with and around electricity should also be in place .fixture should be in place in all silos and storage sheds , including appropriate access ladder ,hand rails and ladder cages . personal protective equipment should be selected ,used and maintained .environmental conditions should be controlled .for example ; keeping moisture levels within prescribed industry standards will reduce the like hood of fire and silo collapse . procedures should be in place and used for working on top of stored grain , working with grain mass movement and stability , working with in confined working space , moving vehicles and working at height .

- **Conditions of storage facilities**

When workers enter storage bins, employers must (among other things):

- ✓ Turn off and lock out all powered equipment associated with the bin, including augers used to help move the grain, so that the grain is not being emptied or moving out or into the bin. Standing on moving grain is deadly; the grain acts like 'quicksand' and can bury a worker in seconds. Moving grain out of a bin while a worker is in the bin creates a suction that can pull the workers into the grain in seconds.
- ✓ Prohibit walking down grain and similar practices where an employee walks on grain to make it flow.
- ✓ Provide all employees a body harness with a lifeline, or a boatswain's chair, and ensure that it is secured prior to the employee entering the bin.
- ✓ Provide an observer stationed outside the bin or silo being entered by an employee. Ensure the observer is equipped to provide assistance and that their only task is to continuously track the employee in the bin

- ✓ Prohibit workers from entry into bins or silos underneath a bridging condition, or where a build-up of grain products on the sides could fall and bury them.
- ✓ Test the air within a bin or silo prior to entry for the presence of combustible and toxic gases, and to determine if there is sufficient oxygen.
- ✓ Ensure a permit is issued for each instance a worker enters a bin or silo, certifying that the precautions listed above have been implemented.

As an employer of workers facing these hazards, you have the legal obligation to protect and train your workers. OSHA will not tolerate non-compliance with the Grain Handling Facilities standard. OSHA has investigated several cases involving worker entry into grain storage bins where we have found that the employer was aware of the hazards and of OSHA's standards, but failed to train or protect the workers entering the bin. OSHA has aggressively pursued these cases and we will continue to use our enforcement authority to the fullest extent possible. Just in the last 10 months, OSHA has issued three large penalty citations to grain elevator operators for these very hazards

Self-check 8	**Written test**

Name…… ID…… Date…….

Test I: Short Answer Questions

1. What are OSHA's standards? (5 point)

_____

2. Write the key reasons for Conditions of storage facilities? (3 point)

_____

_____

_____

Test II: true or false

1. Turn off and lock out all powered equipment associated with the bin
2. Condition of storage facilities to eliminate or minimize OHS risks; the range of actions are both systemic and at an operational level
3. OSHA has investigated several cases involving worker entry into grain storage bins
4. Test the air within a bin or silo prior to entry for the presence of combustible and toxic gases.

You can ask you teacher for the copy of the correct answers.

Note*:* Satisfactory rating – 10 points **Unsatisfactory - below 10 points**

LG #77	**LO# 4- Control pests in storage area**

Instruction sheet

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Monitoring grain
- Taking samples of the grain test.
- Preparing and forwarding the sample for analysis.
- Controlling pests in storage
- Fumigating enclosed grain storage area
- Identifying sources grain storage infestations
- Undertaking grain storage pest control activities
- Creating, maintaining and keeping records

This guide will also assist you to attain the learning outcomes stated in the cover page. Specifically, upon completion of this learning guide, you will be able to:

- Monitoring grain
- Taking samples of the grain test.
- Preparing and forwarding the sample for analysis.
- Controlling pests in storage
- Fumigating enclosed grain storage area
- Identifying sources grain storage infestations
- Undertaking grain storage pest control activities
- Creating, maintaining and keeping records

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below.
3. Read the information written in the “Information Sheets”. Try to understand what are being discussed. Ask your trainer for assistance if you have hard time understanding them.
4. Accomplish the “Self-checks” which are placed following all information sheets.
5. Ask from your trainer the key to correction (key answers) or you can request your trainer to correct your work. (You are to get the key answer only after you finished answering the Self-checks).
6.If you earned a satisfactory evaluation proceed to “learning guide.

Information Sheet 1- Monitoring grain

1.1 introduction

Stored-product insects cause significant losses of stored grains, processed foods, fibers and animal products. In general, losses can be minimized when infestations are quickly identified and appropriate control measures implemented. Numerous methods for detecting stored-product insects have been developed or are being investigated. The most promising technique that has been developed, and continues to be refined, is monitoring populations with insect pheromones and/or food attractants. The incorporation of monitoring methods into existing stored-product pest management programs can lead to earlier detection of low level infestations and pinpointing location of infestations.

Monitoring information can be used to justify reduction in pesticide use or the need for intensified surveillance and pest management procedures. Monitoring results also can serve as an indicator of how well integrated pest management (IPM) program components are functioning.

1.2 Monitoring Methods

Current monitoring methods for insect infestation vary and depend on the type of insect, commodity and/or storage. They include:

1. Bulk commodity storage

- Observation of the commodity surface and over space for insects and/or evidence of their presence, i.e. webbing, cast skins, dust, odor, etc.
- Examination of commodity samples obtained by various means, i.e. probe sampling, turning of the commodity, etc.
- Probe (pitfall) traps inserted into the surface of grain masses and left for varying lengths of time have proven useful as a means of early detection of live, free-living insects.
- Temperature monitoring in grain masses may detect localized increases in temperature which can indicate the presence of an insect infestation.

2. Pheromone/food attractant monitoring

Pheromones have been identified for many of the stored-product insects. Some synthesized lures have been commercially developed and a variety of trap designs are available. Traps have been very effective for monitoring commodities that have few species of stored-product pests, e.g., tobacco.

3. Pheromone and food attractant lures

Pheromone lures have been developed for several stored-product insects. Lures developed for species with short-lived adults have proven more effective. The lure for the lesser grain borer (Rhyzopertha dominica) also has produced good results. Food attractant lures for stored-product insects (predominantly an oil lure consisting of oat oil, wheat germ oil extracts and mineral oil) are used for species having long-lived adults and

some larvae. These lures may be used with or without pheromones. In general, food attractant lures have a smaller effective range than pheromone lures. They can be used to enhance the effectiveness of pheromone traps for flour beetles (Tribolium) and to attract Trogoderma, Attagenus, and Anthrenus larvae.

4. Pheromone and food attractant traps

There are a variety of traps used to deploy pheromones and/or food attractants. Bulk grain is most effectively monitored with perforated plastic probe (pitfall) traps. Traps are usually placed in the grain near the surface at cardinal points and in the center. They take advantage of the normal movement and activity of grain-infesting insects and may include a pheromone or food attractant lure. Traps for flying insects (wing-, delta-, and diamond-traps) suspended at various locations throughout grain elevators or warehouses are an effective way to monitor for moth adults and certain beetles. Lures containing pheromones for either Indianmeal moth or lesser grain borer placed in the center of glue coated surface within the trap attracts these species and traps them on the sticky surface.

Self-check 1	**Written test**

Name…… ID…… Date…….

Test I: Short Answer Questions

1. What is monitoring? (5 point)

_____

2. Write the key reasons for monitoring? (3 point)

_____

_____

_____

Teat II choice

1. Monitoring of bulk commodity storage for insects may include such techniques as:
   a. Observation of surface and over space
   b. Probe traps inserted into the surface
   c. Temperature read-outs in the grain mass
   d. All the above
2. These pheromones are used in warehouse storage of processed commodities and they attract both sexes of the species.
   a. Repelling
   b. Sex
   c. Aggregation
   d. Reproduction
3. Pheromone and food attractant traps may include:
   a. Perforated plastic probes
   b. Multi-layered corrugated paper
   c. Wing-, delta-, and diamond traps
   d. All the above

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating – 20 points Unsatisfactory - below 20 points

Information Sheet 2- Taking samples of the grain test.

2.1. Introduction

Sampling is one of the basic tools used in the SLAM method and should be used to check for insects in grain bins. It is referred to as “Monitoring” in the SLAM method, and uses a specialized pan with 1/12-inch holes and a bottom pan without holes to catch insects that fall into the bottom pan.

SLAM is an acronym for Sanitation, Loading, Aeration and Monitoring. Monitoring can be used to detect insects after the bin has been filled. In addition to sampling for insects, producers should take temperature and moisture measurements too, as insects like high moisture and relatively high temperatures

2.2. Taking samples

Grain should be sampled at weekly intervals to detect any moisture, temperature, insect or mold problems. The grain may be sampled less frequently during the winter months. However, if warm periods during the winter months continue for a week or longer, samples should be taken during that time

- **Storage Problems**

Outside the bin, signs of storage problems can be easily detected. These problems may include leaking grain, bulging walls, standing water, insects, cracked walls and weeds. Inside the bin, look for crusting of the upper level of the grain (bridged grain). Also look for moldy grain and insects. Note any large amounts of cracked kernels and insect-damaged kernels. These areas should be sampled because they are most likely to contain insects or molds.

- **Safety Precautions**

Bridged grain may result in a cave-in and subsequent suffocation of the workers. Bridged grain is caused when grain mats together, forming a false floor in the upper level of the grain mass. Persons falling through this bridged area are subject to suffocation.

- **Sampling Devices**

The deep cup (torpedo) grain probe is the most commonly used sampler available commercially. The deep cup grain probe consists of a separate brass or plastic cup about 8 to 12 inches long with a connected top, which separates upon removal from the grain, allowing a specified amount of grain to enter the cup. A separate handle and extension rod connect to the top of the cup, providing up to 12 or more feet of extension.

- **How to Sample**

While standing on the grain mass surface, push the probe into the grain mass at a slight angle. The top of the cup will open as the probe is pulled up and out of the grain, allowing grain to fill the cup. It is best to divide the grain surface into quarters and take at least three probes per quarter section of grain mass. This will provide a good representative

sample of the grain to allow inspection for the presence of insects, molds or excessively moist grain.

- **Sampling Difficulties**

Overfilled grain bins are difficult to sample for insects or molds. Sometimes the only access points are through the bin wall, door or roof. Sample in the center of the grain mass as deeply as possible. Reach the bin wall if possible at two to three depths.

- **Examining the Sample**

Place the grain sample in a specially designed weevil sieve (1½-inch diameter holes) if available and shake side to side at least 30 times to loosen any insects that may be in the grain. If a sieve is not available, place samples on a white piece of cloth for examination. Inspect the sample carefully for insects. It may be necessary to use a magnifying glass to see some of the smaller insects.

- **Equipment Needed for Sampling**
  - ✓ Deep bin compartment probe
  - ✓ Deep cup probe
  - ✓ Grain sieve with 1/12- or 3/16-inch round holes
  - ✓ Sample vials
  - ✓ Bin inspection forms
  - ✓ Temperature probe

Self-check 2	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. SLAM is an acronym for:

   S _____

   L _____

   A _____

   M _____

2. Manton Equipment Needed for grain Sampling

_____

_____

_____

_____

_____

_____

Test II true or false

1. The deep cup (torpedo) grain probe is the most commonly used sampler available commercially
2. If a sieve is not available, place samples on a white piece of cloth for examination.
3. Place the grain sample in a specially designed weevil sieve.
4. Outside the bin, signs of storage problems can be easily detected.

You can ask you teacher for the copy of the correct answers.

Note: Satisfactory rating - 20 points Unsatisfactory - below 20 points

Information Sheet 3- Preparing and forwarding the sample for analysis

3.1 Introduction

The quality of the food grains is analyzed by taking the samples of the grains and testing it for its physical characteristics such as its size and weight, for pesticide residue, and mycotoxin contamination. The food grains are usually analyzed in order to monitor its quality, time of storage, procurement, and distribution.

3.2 sample grain

If taken and stored correctly, grain samples provide a powerful record of grain quality. Central to success is the segregation of different grain qualities, and the extraction of representative samples with the appropriate equipment.

The best approach to grain sampling depends on the sampling point (e.g. at harvest, in store, out loading and intake). However, there are three broad sampling stages used to build a final sample, suitable for a wide range of analyses.

Note: Mycotoxin tests require a particularly demanding sampling regime especially for the storage mycotoxin, (10 kg sample required).

Stage1. Take incremental samples

An incremental sample is any single, relatively small sample that is combined with others. This sample may be taken by spear, jug or other means. They are taken at one point in the grain chain, from grain with similar qualities.

Stage2. Create an aggregate sample

Incremental samples, taken in Step 1, are combined to form a large aggregate sample. These should be held in a clean dustbin or similar container.

Aggregate samples include grains of various sizes and quality. It is important that all grains have an equal chance of being included in any subsample drawn from it – so that it is truly 'representative'. This requires a thorough pre-mixing of the sample, with a drum mixer or by hand.

How to mix aggregate samples with a drum mixer

- Do not fill drum mixers more than half full
- Secure contents with a tight-fitting lid
- Roll the drum along its axis
- Invert drum at least five times

How to mix aggregate samples by hand

- Tip the aggregate onto a clean floor area
- Mix thoroughly with a shovel/scoop

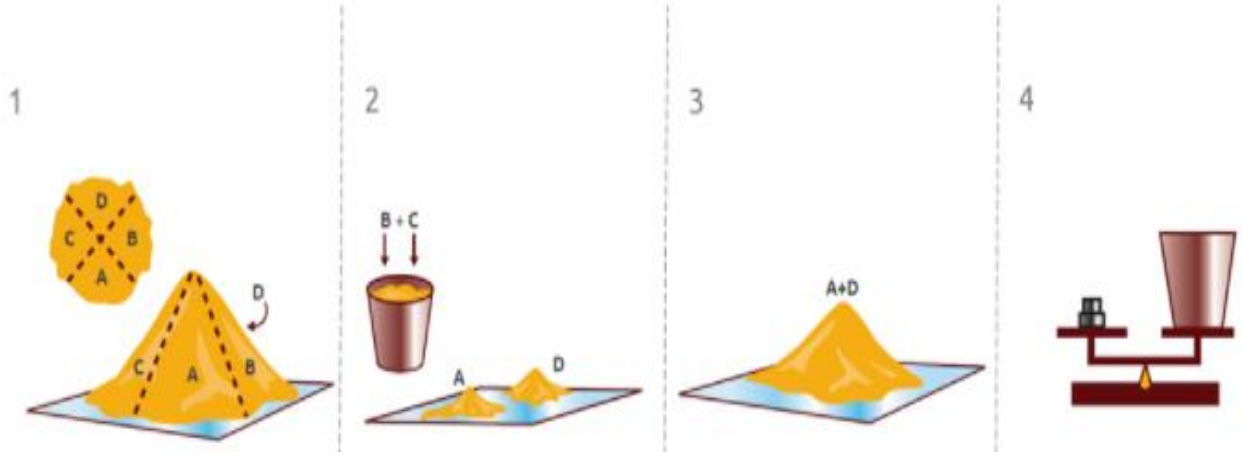
Stage3. Make representative samples

A thoroughly pre-mixed aggregate sample can be used as the source for representative subsamples. Such samples are most suitable for laboratory analysis. The extraction of

subsamples requires further mixing of the grain. There are several methods (of varying complexity) that produce optimally mixed grain. A simple method is coning and quartering.

2. Coning and quartering method

1. A heap of tipped grain will take the rough form of a cone – it can be described as having four quarters (e.g. A, B, C and D).
2. Select two opposite corners (e.g. A+D). Remove the other two quarters (e.g. B+C) and return them to the original aggregate container.
3. Mix the selected samples (e.g. A+D) again to form a new cone of grain.
4. Repeat until the size of one of the quarters is the equivalent weight of the final sample required (e.g. 1 kg).



3. Grain sampling equipment

Ahead of harvest, ensure that all equipment is maintained (e.g. serviced and calibrated), clean and ready for use.

- Sampling equipment includes:
- Sampling spears*
- Measuring jugs
- Weighing devices
- Sealable** plastic sample bags (1 kg grain capacity)
- Sealable** containers (5–10 kg grain capacity)

- Suitable labels (to apply to bags*** and containers)
- Indelible pens (ballpoint ink may fade in a matter of months)
- Moisture meters
- Record sheets
- Temperature probes (consider using automated systems)
- Insect traps

4. Labelling the samples

- Farm name
- Store name/number
- Bin number
- Variety
- Date
- Time
- Vehicle registration and trailer number

5. Sample storage

Samples should be stored in airtight containers (for example, polythene bags or plastic boxes) in a cool, dry place safe from rodent attack.

These samples should be retained until payment has been received for the loads to which the samples relate.

Self-Check – 3	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. Write equipment's used in grain sampling.
2. List containers used for grain sample storage.

Test II: true or false

1. Samples should be stored in airtight containers

2. Samples should be retained until payment has been received for the loads to which the samples relate.
3. Aggregate samples include grains of various sizes and quality
4. Mycotoxin tests require a particularly demanding sampling regime especially for the storage mycotoxin.
5. Pre-mixed aggregate sample can be used as the source for representative subsamples.

Note*:* Satisfactory rating - 5 points Unsatisfactory - below 5 points

You can ask you teacher for the copy of the correct answers.

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Information Sheet 4- Controlling pests in storage

4.1. Introduction

The ‘pesticide revolution’, following the end of World War II, promised a reduction in the loss of food during growth and storage due to insects and mites. Despite initial successes, the promise was not delivered, as it was subsequently discovered that many of the compounds used were damaging to the environment and/or had serious toxicity issues with humans. In addition, insects soon developed resistance to the various types of insecticides being used, requiring higher concentrations to maintain the level of

protection. The consequence of this approach has been the desire of consumers to avoid foods with any traces of pesticides, and many countries have a zero tolerance of some pesticides in all food imports. Nevertheless, it is necessary to employ some means of control to ensure that damage due to insects is prevented. For stored grain, fumigation with gaseous toxins is the preferred way in which this is done; although in the past liquids have also been applied. Liquids may comprise solids in a carrier solvent, or substances such as carbon disulfide which can be applied directly or in a diluted form with another solvent.

4.2. Controlling pests

Grain production, along with other plant-production industries, often employs a range of pest-management techniques as a multi-faceted approach to controlling the most economically threatening pests. Chemical control of pests is highly regulated in many countries through a national registration system, which requires that chemicals used are registered, effective and used in accordance with label requirements to avoid residue problems. Other pest-management practices used in the grain industry to manage quality include cultural and mechanical control as well as stored-product pestmanagement practices, including fumigation, controlled atmosphere and other technologies**.**

A wide variety of substances have been used organochlorines, organophosphates, carbamates and pyrethroids being the main classes. Many of these are not volatile so that residues may remain in the grain after treatment. The organophosphates have relatively short half-lives, particularly in humid conditions while organochlorines tend to be persistent as they are not broken down quickly. Maximum residue levels (MRL) are set for each of the substances that are permitted for use in The main gaseous fumigants are methyl bromide, carbon dioxide, phosphine and very volatile liquids such as carbon-disulfide and ethylformate. The latter are usually applied as a solution in another solvent. Phosphine may be introduced directly as a gas, or it may be applied to the grain as aluminum phosphide cereals.

Table .2 Common Pesticides (Fumigants and Insecticides) in Common Use on Grain

Aldrin	Fenitrothion
Carbaryl	Malathion

Carbon disulfide	Methyl bromide
Chlordane	Phosphine
DDT	Pirimiphos-methyl
Dichlorvos	Pyrethrin
Endosulfan	Endosulfan Sulfuryl fluoride

Modified atmospheres (MA), including the use of carbon dioxide, are commonly used in grain storage. Nitrogen is also used with the primary goal of reducing the oxygen content of the gases in the storage facility, and thus either kill or inactivate any insects present. This approach is widely used in many countries on many different cereals, but it requires good containment.

Finally, one form of insect control is simple hygiene on the farm. Many pieces of equipment, such as harvesters and augers, and storage facilities have various corners, crevices, and other dead spaces where grain can collect and remain when the facility is not in use. Grain left undisturbed becomes a perfect breeding ground for insects and, if the space is accessible, rodents and birds. Removal of all grain or fumigation of the equipment or store before use in following seasons will ensure that the next season's harvest does not become contaminated almost immediately. The recommended procedure is to clean and treat the equipment or storage bin immediately after use, and then again before use the following season.

Self-Check – 4	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. List all pest control chemicals

_____

_____

_____

_____

_____

2. Write all storage pest control methods

_____

_____

_____

_____

Test II: true or false

1. Chemical control of pests is highly regulated in many countries through a national registration system.
2. Grain left undisturbed becomes a perfect breeding ground for stored grain insects.
3. One form of insect control is simple hygiene on the farm.
4. Grain production, along with other plant-production industries.
5. A wide variety of substances have been used organochlorines, organophosphates, carbamates and pyrethroids.
6. Modified atmospheres (MA), including the use of carbon dioxide, are commonly used in grain storage.
7. Nitrogen is used with the primary goal of reducing the oxygen content of the gases in the storage facility.

Note*:* Satisfactory rating - 4 points Unsatisfactory - below 4 points

You can ask you teacher for the copy of the correct answers.

Information Sheet 5- Fumigating enclosed grain storage area

5.1 Introduction

Fumigants are gases that penetrate the grain mass to kill insects. The term fumigation is sometimes used for smokes, mists or aerosols and even the fumes from "pest strips." These are fine solid or liquid particles that are suspended in the air but, unlike the true fumigant gases, they cannot penetrate surfaces. It is the ability to penetrate that gives fumigants their big advantage in controlling stored grain insects. This same ability creates the greatest problems with their use: bins must be sealed tightly enough to hold a toxic concentration of the gas for the time that it takes to kill the insects, and the gases that escape from the bin during fumigation are lethal to humans, livestock and other animals.

Every step in the use of fumigants must be done properly if the fumigation is to be effective and safe.

Because all fumigants are highly toxic and hazardous to use, they are classified by the EPA as restricted use pesticides. This means that they should only be applied by or under the direct supervision of persons trained to properly use them. Due to the large size of many on-farm grain bins and the specialized equipment and training necessary to conduct a successful and safe fumigation job, it is often safer, less expensive, and more effective for farmers to have their stored grain fumigated by a licensed and certified professional fumigator. The most important factor to consider when deciding whether to hire a professional to do a fumigation job is the personal risk involved in the handling and application of these highly toxic chemicals. A professional fumigator will have the knowledge and experience required to conduct effective treatment and will also have the special equipment needed to apply fumigants properly. In addition, professionals will have safety equipment such as gas masks or other respiratory protection which is expensive but necessary when applying any fumigant.

5.2 Types of fumigants

- **Liquids**

For many years there were four general formulas for liquid fumigant mixtures:

1) Those in which carbon tetrachloride was the major constituent,

2) Those in which ethylene dichloride was the predominant compound, and

3) The group containing ethylene dibromide (EDB). As of this writing (late 1990), carbon tetrachloride, ethylene dichloride and ethylene dibromide have all been phased out by EPA. The compound in the last group

4) is chloropicrin, and this chemical is the only liquid grain fumigant with continuing registration for use in grain bins (empty bin treatment only).

Table1. Some common fumigants registered for use in stored grains.

Fumigant**	State	Trade names	Common uses
aluminum phosphide*	Solid	Fumitoxin Phostoxin Phostek	Wheat, barley, rye, oats, corn, sorghum, safflower, sunflower, soybeans, millet.
chloropicrin*	Liquid	Chlor-O-Pic	Perforated floors in empty grain bins.

methyl bromide*	Gas	Meth-O-Gas Brom-O-Gas	Wheat (similar small grains), shelled corn, milo (grain Sorghum). May affect seed germination at high moisture levels and high dosages.
*EPA has classified this fumigant as a restricted use pesticide. **Dosage rates for the fumigants listed will vary depending upon the commodity and type of storage structure to be treated. Read and follow label directions.			

Most chemicals used in liquid fumigant mixtures are strongly absorbed by the grain, so they sometimes were preferred over other fumigants by commercial applicators for the treatment of small lots of grain, grain that is moldy or "out of condition," and grain stored in loosely constructed bins. Longer periods of ventilation or "airing" are required to remove the fumigant vapors after treatment than are required with less sorptive fumigants. This is especially true if the grain temperature is 60° or lower.

NOTE: Chloropicrin is no longer registered for direct application to stored grain. However, the fumigant can still be used for treating the perforated floors in empty bins in order to control insects in the sub-floor area prior to bin filling.

- **Solid**

Phosphine producing fumigants have become one of the predominant fumigants used for the treatment of bulk-stored grain throughout the world. They are available in solid formulations of aluminum phosphide or magnesium phosphide.

Phosphine has no adverse effects on germination of seeds when applied at normal dosage rates and is the choice of fumigants for seeds or malting barley. It is also widely used in the fumigation of processed foods since excessive fumigant residues have not been a problem with phosphine.

Hydrogen phosphide is a colorless gas with an odor that is perceived differently by different individuals. Its odor is often described as similar to garlic, commercial carbide, or decaying fish. Although the odor of hydrogen phosphide gas can be very distinctive, fumigators must not rely only on their sense of smell to detect potentially harmful gas concentrations. Gas detector tubes should be used throughout all stages of a fumigation to monitor gas concentrators.

- **Gas**

Methyl bromide is a colorless, odorless, tasteless, gaseous fumigant marketed as compressed, liquefied gas packed in special 1 or 1.5 pound cans or in cylinders of 50, 100 or 200-pound capacity. As with other fumigants, the cost is lower when purchased in larger containers. However, farmers should not try to store fumigants but should buy only enough fumigant for each fumigation. Compressed liquid methyl bromide readily changes into a gas when the container is opened at temperatures above 39°F. The gas is odorless at fumigation concentrations and has no irritating qualities to indicate its presence. For fumigation, methyl bromide is formulated as either 100 percent methyl bromide or with a mixture with ½ to 2 percent chloropicrin that serves as a warning agent.

Self-Check – 5	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: True or False

1. Phosphine producing fumigants have become one of the predominant fumigants used for the treatment of bulk-stored grain throughout the world.
2. Fumigators must not rely only on their sense of smell to detect potentially harmful gas concentrations.
3. Most chemicals used in liquid fumigant mixtures are strongly absorbed by the grain,
4. Chloropicrin is no longer registered for direct application to stored grain.
5. Methyl bromide is formulated as either 100 percent methyl bromide or with a mixture with ½ to 2 percent chloropicrin.

6. Hydrogen phosphide is a colorless gas with an odor that is perceived differently by different individuals.
7. the odor of hydrogen phosphide gas can be very distinctive
8. Most chemicals used in liquid fumigant mixtures are strongly absorbed by the grain

Test II: short answer

1. Write all chemical fumigants used in stored gain.
2. Compressed liquid methyl bromide readily changes into a gas when the container is opened at temperatures above 39°F.
3. Write the characters of methyl bromide.

Note*:* Satisfactory rating - 4 points Unsatisfactory - below 4 points

You can ask you teacher for the copy of the correct answers.

Information Sheet 6- Identifying sources grain storage infestations

6.1 Introduction

Infestation is presence of a large number of pest organisms in an area or field, on the surface of a host or anything that might contact a host, or in the soil.

Stored grain is subject to insect infestation and deterioration from molds and bacteria. High grain temperatures and moisture, along with dockage and broken kernels, provide conditions that accelerate mold and insect development. Many grain insects are good fliers and move to newly stored grain from fields and from infested grain bins. Infestation refers to the state of being invaded or overrun by pests or parasites.

6.2 Sources of infestation

Some of the stored grain insects can fly and begin their infestation in maturing grain in the field. While field infestation may occasionally occur in Wyoming, it is a negligible source of infestation. The insects can be virtually everywhere and may easily be carried

onto the farm in infested lots of grain or feed or they may fly in from infested grains or bins on adjacent farms.

Without question, the greatest source of infestation is old grain, seed, feed, spills, debris and accumulated grain dust in and around storage areas.

Stored grain insect infestations rarely begin in the field. Most develop from small numbers of pests already present in or around farm storage bins.

Stored grain is subject to insect infestation and deterioration from molds and bacteria. High grain temperatures and moisture, along with dockage and broken kernels, provide conditions that accelerate mold and insect development. Many grain insects are good fliers and move to newly stored grain from fields and from infested grain bins. Insects can reach a high population size in unchecked grain bins, in subfloors or aeration ducts in bins, in equipment used to move grain, or in discarded refuse grain. These areas must be kept free of insects to reduce migration to newly harvested grain.

Grain insects move within the grain mass at a rate that is determined by the grain temperature. During the summer and fall, insect infestations are usually on the surface of the grain. In cold weather, insects congregate at the center and lower portions of the grain and may escape detection until high population numbers are reached.

Self-Check – 6	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: Short Answer Questions

1. Mention causes for stored grain infection.
2. Explain how moisture and temperature affect stored grain decoration.

Test II: true or false

1. Some of the stored grain insects can fly and begin their infestation in maturing grain in the field.
2. Grain insects move within the grain mass at a rate that is determined by the grain temperature.

3. Stored grain is subject to insect infestation and deterioration from molds and bacteria.
4. During the summer and fall, insect infestations are usually on the surface of the grain.
5. High grain temperatures and moisture, along with dockage and broken kernels, provide conditions that accelerate mold and insect development.
6. Infestation refers to the state of being invaded or overrun by pests or parasites.

Note: Satisfactory rating - 4 points Unsatisfactory - below 4 points

You can ask you teacher for the copy of the correct answers.

Information Sheet 7- Undertaking grain storage pest control activities

7.1 Introduction

In dry conditions, some cereals can be stored indefinitely without chemical or microbiological decay, provided the water activity is below that at which storage fungi can develop. Dry grain is, however, susceptible to attack by storage insects, and the temperature of grain harvested in Australia is suited to the rapid development of several insect species.

The development of insects produces water and heat which, if unchecked, lead to mold and formation of mycotoxins in bulk grain. This can be a very dangerous situation in bulk storage, as heating and caking may occur and the silo may become blocked with heating grain.

All markets have a nil-tolerance standard for live insects. This means that insects should not be detectable. Keeping a low nil-tolerance standard depends on improving the

sampling rate, the sensitivity of the detection method and the effectiveness of the pest control method.

7.2 Control methods of stored produce pests

The control methods of stored produce pests can be categorized into preventive and curative measures.

- Preventive measures
  - ✓ Brush the cracks, crevices and corners to remove all debris in the go down.
  - ✓ Clean and maintain the threshing floor/yard free from insect infection and away from the vicinity of villages.
  - ✓ Clean the machines like harvester and thresher before their use.
  - ✓ Made the trucks, trolleys or bullock carts free from infestation.
  - ✓ Clean the go downs/ storage structures before storing the newly harvested crop to eliminate various bio stages of pest hiding.
  - ✓ Provide a metal sheet upto a height of 25 cm at the bottom of the wood in doors to arrest the entry of rats. Fix up wire meshes to windows, ventilators, gutters, drains etc., to prevent entry of rats, birds and squirrels.
  - ✓ Remove and destroy dirt, rubbish, sweepings and webbings etc from the stores.
  - ✓ Close all the rat burrows found in go down with a mixture of broken glass pieces and mud plastered with mud/ cement.
  - ✓ Plaster the cracks, crevices, holes found on walls, and floors with mud or cement and white wash the stores before storing of grains.
  - ✓ Provide dunnage leaving gangway or alleyway of 0.75 to 1 m all around to maintain good storage condition.
  - ✓ Store the food grains in rat and moisture proof storage structures.
  - ✓ Disinfest the storage structures receptacles by spraying Malathion 50 EC @ 3 lit 100 m before their use.
- Curative measures

i) Ecological methods

  - ✓ Manipulate the ecological factors like temperature, moisture content and oxygen through design and construction of storage structures/ go down and storage to create ecological conditions unfavorable for attack by insects.

- ✓ Temperature above 42 ^{0}C and below 15 ^{0}C retards reproduction and development of insect while prolonged temperature above 45 ^{0}C and below 10 ^{0}C may kill the insects.
- ✓ Dry the produce to have moisture content below 10% to prevent the buildup of pests
- ✓ Kill the pests bio stages harbored in the storage bags, bins etc., by drying in the sun light.
- ✓ Store the grains at around 10 % moisture content to escape from the insects attack.
- ✓ Manipulate and reduce oxygen level by 1% to increase the CO2 level automatically, which will be lethal to all the stages of insects.

ii) Physical methods

- ✓ Provide a super heating system by infrared heaters in the floor mills and food processing plants to obtain effective control of pests since mostly the stored produce insects die at 55 –600 C in 10 – 20 minutes.
- ✓ Modify the storage atmosphere to generate low oxygen (2.4% and to develop high carbon di oxide (9.0 – 9.5) by adding CO2 to control the insects.
- ✓ Seed purpose: Mix 1 kg of activated kaolin (or) lindane 1.3 D (or) malathion 5 D for every 100 kg of seed and store/pack in gunny or polythene lined bags.
- ✓ Grain purpose: Mix 1 kg activated kaolin for every 100 kg of grain and store. To protect the pulse grains, mix activated kaolin at the above dosage or any one of the edible oils at 1 kg for every 100 kg of grain or mix 1 kg of neem seed kernel for every 100 kg of cereal / pulse and store.
- ✓ Do not mix synthetic insecticides with grains meant for consumption.

iii) Cultural methods

- ✓ Split and store pulses to escape from the attack by pulse beetle since it prefers to attack whole pulses and not split ones.
- ✓ Store the food grains in air tight sealed structures to prevent the infestation by insects.

IV) Mechanical methods

- ✓ Sieve and remove all broken grains to eliminate the condition which favor storage pests.

- ✓ Stitch all torn out bags before filling the grains.

v) Chemical methods

- ✓ Treat the walls, dunnage materials and ceilings of empty go down with Malathion 50 EC 10 ml/L (or) DDVP 76 WSC 7 ml/L1 at 3 Ll spray solution/10 sq.m.
- ✓ Treat the alleyways and gangways with Malathion 50 EC 10 ml/L or DDVP 76 WSC 7 ml/ L (1 L of spray fluid/270 m3).
- ✓ Spray Malathion 50 EC 10 ml/ L with @ 3 L of spray fluid / 100 m2 over the bags.
- ✓ Do not spray the insecticides directly on food grains.
- ✓ Use knock down chemicals like lindane smoke generator or fumigant strips pyrethrum spray to kill the flying insects and insects on surfaces, cracks and crevices.
- ✓ Use seed protectants like pyrethrum dust, carbaryl dust to mix with grains meant for seed purposes only. Decide the need for shed fumigation based on the intensity of infestation
- ✓ Check the black polythene sheets or rubberized aluminum covers for holes and get them ready for fumigation.
- ✓ Use EDB ampoules (available in different sizes 3 ml, 6 ml, 10 ml, 15 ml and 30 ml) at 3 ml/quintal for wheat and pulses and 5 ml/ quintal for rice and paddy (Do not recommend EDB for fumigation of flour oil seeds and moist grains)
- ✓ Use EDCT (available in tin containers of 500 ml, 1 liter and 5 liters) at 30 – 40 liters/ 100 cubic meter in large scale storage and 55 ml/quintal in small scale storage

Self-Check – 7	Written test

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: True or False

1. Temperature above 42 ^{0}C and below 15 ^{0}C retards reproduction and development of stored grain insect.
2. Do not mix synthetic insecticides with grains meant for consumption.
3. All markets have a nil-tolerance standard for live insects.
4. Store the food grains in rat and moisture proof storage structures.
5. Check the black polythene sheets or rubberized aluminum covers for holes and get them ready for fumigation.
6. Treat the walls, dunnage materials and ceilings of empty go down with Malathion.
7. Do not spray the insecticides directly on food grains.
8. Split and store pulses to escape from the attack by pulse beetle.
9. All markets have a nil-tolerance standard for dead insects.

10. Use knock down chemicals like lindane smoke generator or fumigant strips pyrethrum spray to kill the flying insects and insects on surfaces, cracks and crevices

Test II: short answer

1. Write all grain storage pest control activities.
2. List at least three chemicals used in grain storage pests.

Note: Satisfactory rating - 4 points Unsatisfactory - below 4 points

You can ask you teacher for the copy of the correct answers.

Information Sheet 8 - Creating, maintaining and keeping records

8.1 Introduction

While pests in stored grain can be detected by examining physical samples of grain drawn from a bulk or bin, it is a very laborious process. Traps have been shown to be more than ten times as effective as sampling at detecting low level populations of insects and mites. Some traps are designed for use in the store, others for use within the grain bulk. Positioning traps both on the grain surface and approximately 5–10 cm below (approximately 4–5 meters apart) will provide the greatest likelihood of detecting all species of stored product insects and mites at the earliest opportunity. Monitor for pests weekly until grain reaches the target temperature and then monthly, providing it remains at the target temperature, until spring when temperatures rise and insects become more active. Then revert to weekly monitoring. Traps should be accounted for each time they are examined and a permanent record of the contents should be kept.

8.2 Keeping records

Keeping a record of each monitoring activity both provides evidence of due diligence and allows trends, particularly in temperature and moisture, to be spotted. Electronic systems provide a simple way to record all measurements and assessments made during storage. As an alternative to time-consuming probing or sampling grain, fixed probes/sensors can be installed in stores to monitor conditions in store constantly (eg moisture and temperature).

- **Moisture**

When grain is dried 'in situ' (i.e. on-floor or in-bin), this is generally achieved by passing a high volume airflow up through the grain. This effectively 'pushes' a drying front up from lower layers towards the surface a process that takes up to two weeks.

Moisture sampling monitors progress of the drying front. This can be achieved by sampling and testing grain near the top of the bulk/bin or with an automatic sensor inserted into the grain. The information gathered confirms when the drying front has completed its movement and drying equipment can be turned off.

Monitor for moisture content at several locations (the same each time). An increase in moisture content in a localized area of 2% or more in a week may indicate condensation, leaks, hot spots or insects, record moisture content at least once each month during winter.

Annual calibration of moisture meters is essential. Errors are frequently +/- 0.5% and can be greater in very wet, very dry or freshly harvested grain. Take as many samples as possible and determine moisture content without delay. Keep samples in a watertight container with minimum free air space and at a steady air temperature. Mix each sample thoroughly before testing.

- **Temperature**

Monitor every few days until the target temperature is reached and then every week. Always record at the same location, measurements must be taken where cooling takes longest, e. g furthest from the fan in blowing systems, usually 0.5m beneath the surface and centrally between ducts.

In larger stores, consider permanent temperature probes installed in a grid pattern across the bulk. Modern installations enable constant remote monitoring, including via smartphone. Electronically recorded data also allows trends to be observed over time. Any temperature rise over 1˚C should be investigated, as it could indicate the presence of fungi, sprouting, and development of pests or a leaking roof.

Self-Check – 8	**Written test**

Name…… ID…… Date…….

Directions: Answer all the questions listed below.

Test I: True or False

1. Moisture sampling monitors progress of the drying front.
2. Monitor every few days until the target temperature is reached and then every week.
3. In larger stores, consider permanent temperature probes installed in a grid pattern across the bulk.
4. Record all measurements and assessments made during storage.
5. Modern installations enable constant remote monitoring.
6. Hot spots or insects, record moisture content at least once each month during winter.
7. Any temperature rise over 1˚C should be investigated, as it could indicate the presence of fungi.

8. Take as many samples as possible and determine moisture content without delay.
9. Keep samples in a watertight container with minimum free air space and at a steady air temperature.
10. Mix each sample thoroughly before testing.

Test II: short answer

1. Write importance of grain storage recordkeeping.
2. List all information gathering during grain storage record keeping.

Note: Satisfactory rating – 20 points Unsatisfactory - below 20 points

You can ask you teacher for the copy of the correct answers.

Operation sheet 1– Coning and quartering

Tools and equipment's

- Sampling equipment includes:
- Sampling spears*
- Measuring jugs
- Weighing devices
- Sealable** plastic sample bags (1 kg grain capacity)
- Sealable** containers (5–10 kg grain capacity)
- Suitable labels (to apply to bags*** and containers)
- Indelible pens (ballpoint ink may fade in a matter of months)
- Moisture meters
- Record sheets
- Temperature probes (consider using automated systems)
- Insect traps.

Procedures:

1. A heap of tipped grain will take the rough form of a cone – it can be described as having four quarters (e.g. A, B, C and D).
2. Select two opposite corners (e.g. A+D). Remove the other two quarters (e.g. B+C) and return them to the original aggregate container.
3. Mix the selected samples (e.g. A+D) again to form a new cone of grain.
4. Repeat until the size of one of the quarters is the equivalent weight of the final sample required (e.g. 1 kg).

Lap Test	Demonstration

Name……. ID……..

Date…….

Time started: _____ Time finished: _____

Instructions: conduct coning and quartering

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Acknowledgement

We wish to extend thanks and appreciation to the many representatives of TVET instructors and respective industry experts who donated their time and expertise to the development of this Teaching, Training and Learning Materials (TTLM).

We would like also to express our appreciation to the TVET instructors and respective industry experts of Regional TVET Bereau, TVET College/ Institutes, Holeta Polytechnic College, East Africa Skills for Transformation and Regional Integration Project (EASTRIP) who facilitate the development of this Teaching, Training and Learning Materials (TTLM) with required standards and quality possible.

This Teaching, Training and Learning Materials (TTLM) was developed on September, 2021 at Adama, Pan- Africa Hotel

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