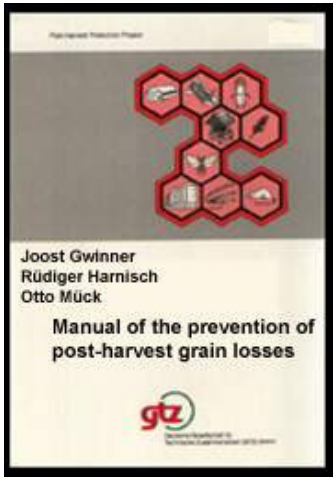


Manual on the Prevention of Post-harvest Grain Losses (GTZ)

5. Central storage

As a result of extensive social and economic changes (e.g. expansion of trade with basic foodstuffs, supplies of food aid, increase in urbanisation), central stores have grown both in number and importance in all countries. These stores have

usually been run under state control by cereal offices. Structural adjustments in many countries led to substantial retrenchments of food quantities stored for emergencies, but still storage in medium- and large-scale facilities plays a vital part in the provision of the population with staple foods.

5.1 Storage facilities

It is quite apparent that a number of the storage facilities set up in tropical and sub-tropical countries are unsuitable for storing goods without a reduction in quality and considerable losses.

Although appropriate warehouse designs have been provided as far as suitable construction material, ventilation facilities and favourable constructional properties are concerned, little use is made of these. This can be observed even in recently-built stores.

The storage structures described in the following paragraphs can frequently be found in hot climates. The potential for the use of each type and their main shortcomings are highlighted in the text.

- Corrugated iron halls

Easy-to-erect corrugated iron halls made of prefabricated parts may be justifiable for short-term storage in case of emergencies. Buildings of this kind are unsuitable for long-term storage due to the poor control of climatic conditions and condensation problems.

- Flexible plastic silos

Under arid climate conditions, instant erection flexible plastic silos can be used for bag storage of locally produced grain as a pan of maintaining security reserves. To avoid condensation problems it is a precondition that the produce is absolutely dry (about 10% moisture content) at the moment of storage.

In the case of supplies of foodstuffs coming from temperate areas or produce with higher moisture content, flexible plastic silos can only be used as emergency stores for a short period as the same problems may be anticipated as for corrugated iron halls. Fumigation can easily be performed in silos of this kind. Flexible plastic silos are not suitable as transit stores due to the longer filling procedure and their fragility.

- Bag storage in warehouses

Assuming that the basic storage requirements are adhered to, the system of bag storage in well-designed warehouses is most suitable in tropical or sub tropical areas. This system is easy to manage, cheap, and efficient and well adapted to the existing infrastructure in most countries. It involves little risk in particular as far as long-term storage of security reserves is concerned.

- Bulk storage

Bulk storage in warehouses and silos is a system whose strengths lie particularly in rapid and labour-saving turnover of produce. The system enables relatively simple and efficient pest control measures and may considerably simplify transport tasks. The transit silos found in ports are typical of this usage. The relatively sophisticated bulk storage system demands, however, a high degree of management qualities, in particular with respect to loss prevention as a result of moist grain and condensation problems.

Successful bulk storage in silos requires adequate funds being

made available for the relatively high overheads (maintenance, service, energy). in general operating costs are higher for bulk storage than for bag storage. Setting up silo units demands also considerably higher investments and capital costs than for the comparable warehouse capacity for bag storage. A minimum annual turnover is necessary to justify these investments, thus making silos uneconomical for long-term storage. In the Federal Republic of Germany, for example, the rough figure for the economic operation of a silo plant is an annual turnover of 13 times.

In developing countries the bulk storage system may gain importance in the long term if the conditions in terms of infrastructure and management permit the introduction of such a system.

- Open-air storage

Open-air storage is a short-term emergency measure. The produce must always be stored on pallets in order to avoid any ground moisture being absorbed. Tarpaulins spread on the

ground, or concrete platforms, afford also protection, and must be present in any case for fumigation. The stacks also have to be covered with tarpaulins against adverse weather conditions.

A decision in favour of one system or the other must take into account all the pros and cons of the systems and the framework conditions in the country in question. Moreover, storage must be seen only as one element in the entire chain of food supply from the producer to the consumer, and any particular storage system must become an integrated, well adapted part of the existing structures.

5.1.1 Instructions for the Construction of Warehouses

As many serious mistakes are made in the construction of medium-sized and large warehouses, instructions are given here for the basic design of stores which provide optimum conditions for the storage of grains and other foodstuff

5.1.1.1 Siting and Orientation

· A raised site and good drainage ensure that there is no stagnant

water in the vicinity of stores.
· Setting up the store with its longitudinal side on an East-West axis (less sun radiation on the building) or exposed to the main wind direction creates balanced temperature conditions, thus reducing the danger of condensation.
· Firm soil and good road connections enable easy delivery and transportation of produce.

5.1.1 2 General Constructional Features

· Not more than four corners and a simple and effective spatial design without any more angles, pillars, beams, windows or doors than necessary make work and especially cleaning easier and make it more difficult for pests to enter or find a hiding place.
· Offices and sanitary facilities which are separate from the warehouse enable fumigation and pest control measures to take place without any danger to staff.
· Pesticides, fertilizers and other material which are stored separately prevent any damaging effect on the stored produce and improve storage hygiene.

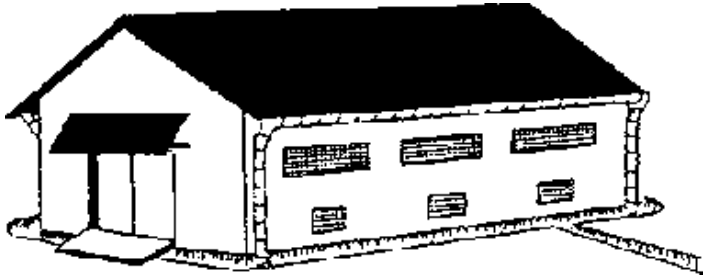


Figure 39

5.1.1.3 Flooring

· A floor at a height of I m above the ground with a ramp prevents ground moisture to penetrate the store, protects the walls and doors from being damaged by vehicles and simplifies loading and unloading of trucks,
· A vapour barrier stops ground moisture from rising. A suitable method is to insert polyethylene foil of at least 0.2 mm thickness, or a 5 cm layer of bitumen in the floor and in the first 25 cm of the walls.
· A concrete floor hard enough to bear the load expected prevents cracks.
· A smooth surface without any cracks or holes is easy to clean

and does not afford insects any place to hide.

5.1.1.4 Walls

· Roof - bearing pillars integrated into the walls facilitate storage hygiene.
· A smooth surface without any cracks ether inside or out affords no hiding-places for pests. Even the smallest of holes must be filled in.
· A white, water-resistant and, if possible, plastifying outer coat of paint reflects the sun radiation and prevents penetration by moisture.
· Corrugated iron walls are unsuitable due to temperature variations inside the store.

5.1.1.5 Roofing

· Eaves overhanging the walls by at least 1 metre ensure that the store is kept in the shade and its walls are protected against rain.
· Eaves overhanging by at least 2-3 metres at the doors enable vehicles to be loaded and unloaded when it is raining.

· Properly sealed connections from roof to walls prevent any insects or birds from entering.
· Insulation under the roof in case of corrugated iron sheets reduces the effect of the sun radiation and creates better storage temperatures. Insulating material does, however, have the danger of being an ideal hiding place for pests and also makes it more difficult to maintain good storage hygiene.
· Aluminium sheets or fibre concrete roofing do not become as hot as corrugated iron and create better storage temperatures.
· Gutters linked to a drainage system prevent the outer walls and the foundation becoming wet in case of rain.

5.1.1.6 Doors

· One door at each gable end is normally sufficient.
· Tight-sealing hinged doors prevent rodents from entering. Sliding doors always leave a gap between door and wall, A gap of 6 mm is sufficient to enable a mouse to enter. Roll-up doors rust and often become defect when older.
· Metal doors are most resistant against any damage by rodents. Wooden doors should be fitted at the bottom with a panel of

sheet steel of half a metre in height.

5.1.1.7 Ventilation Openings

· Ventilation openings with flaps which can be regulated enable controlled ventilation and the evacuation of heat from the store.

Ventilation openings should have a size of:

0.5 m²/100 m² storage area for incoming air (lower ventilation openings) and 1.5 m²/100 m² storage area for outgoing air (upper ventilation openings).

The lower ventilation openings should be situated approx. ½ metre above the floor, the upper ones approx. ½ metre below the roof on both sides of the store.

· Tightly-sealing ventilation openings permit fogging with insecticides.
· Wire gauze and grilles in the ventilation openings prevent insects, rodents and birds from entering.

Roofing over the ventilation openings prevents any penetration by rainwater.

5.2 Store management

The proper management of the store should be assigned to one person, the storekeeper. The responsibility for the several tasks listed in the following section must be clearly defined in a written job description. For the job description of a storekeeper see section 5.2.3.2.

5.2.1 The Storekeeper's Job

The storekeeper is responsible:

- for the maintenance of the warehouse (small repairs) and its equipment (fumigation sheets, spraying equipment, etc.)
- for the correct handling and storage of the commodities and the products for pest control
- for the performance of any measures necessary to maintain the quality of the stored produce (hygiene measures, application of insecticides, fumigation, rodent control, controlled ventilation)

- for the correct use of chemical products and the safety of the staff
- for regular controls of the storage facilities and the stored produce for keeping correct records of all movements of stored produce and of all activities in the store including stack cards
- for giving support and guidance to the staff under his supervision
- for writing regular reports for his superiors.

5.2.2 Storage Hygiene

Preventive measures with regard to storage hygiene are of decisive importance in maintaining the quality of the stored produce and avoiding losses. By the term storage hygiene, we mean the use of all technical measures with the exception of the application of chemicals. Perfect storage hygiene is the basic prerequisite for successful storage and for the effectiveness of all on-going measures, such as the use of insecticides or fumigants.

All hygiene measures are very simple, particularly effective and cheap, and can thus be performed by any storekeeper with little

effort.

Hygiene requires knowledge, attentiveness, diligence, surveillance, responsibility and thoroughness on the part of the storekeeper.

A few basic principles determine the success of storage:

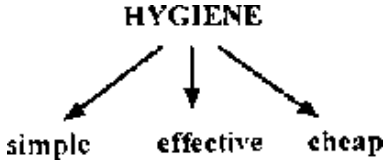


Figure 40

- Always keep the store and its surroundings clean: the broom is the most effective and economic instrument in storage!
- Always keep grain cool and dry!
- Always keep the store in good condition!

5.2.3 Measures to Maintain the Quality of the Stored Produce

5.2.3.1 Influence on the Part of the Storekeeper

From the delivery of the produce to the end of the storage period, the storekeeper has to make decisions and initiate actions with the aim of keeping the produce in good condition.

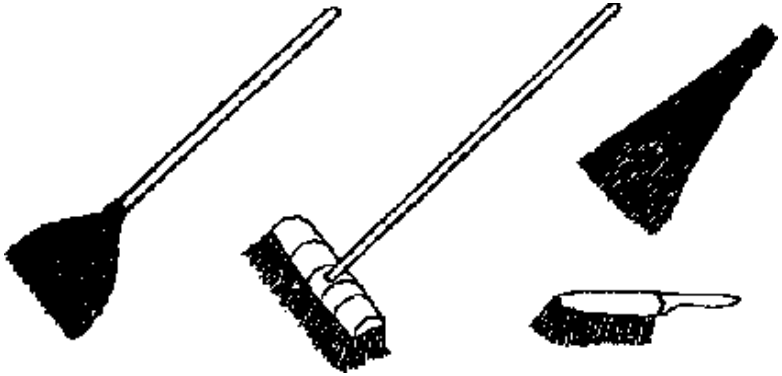


Figure 41

5.2.3.2 Activities to Prevent Losses in Storage

Note before storage:

- Check the storage conditions using the store check list provided in section 5.2.5.4 and deal with any faults you discover!
- Ensure that any damage to the warehouse is repaired (root

leaks; walls and floor: cracks and crevices; doors: gaps; ventilation openings damaged gauze and grilles, broken glass)!
- Thoroughly clean the store's floors, walls, roof, doors and ventilation openings!
- Clean the area surrounding the store and remove any left-overs of grain, rubbish, birds' nests, grass and bushes within a minimum of 5 m around the store so as not to give pests any shelter or the chance to develop!
- Collect rubbish in a bin (e.g. old oil drum)! Dispose of it immediately by burning or, in case of non-inflammable material, by burying!
- Repair any damaged pallets (pay particular attention to nails sticking out)!
- Treat the empty store, if necessary, and al! pallets with a contact insecticide (see chapter 8)!
- Draw up a storage plan for each store!

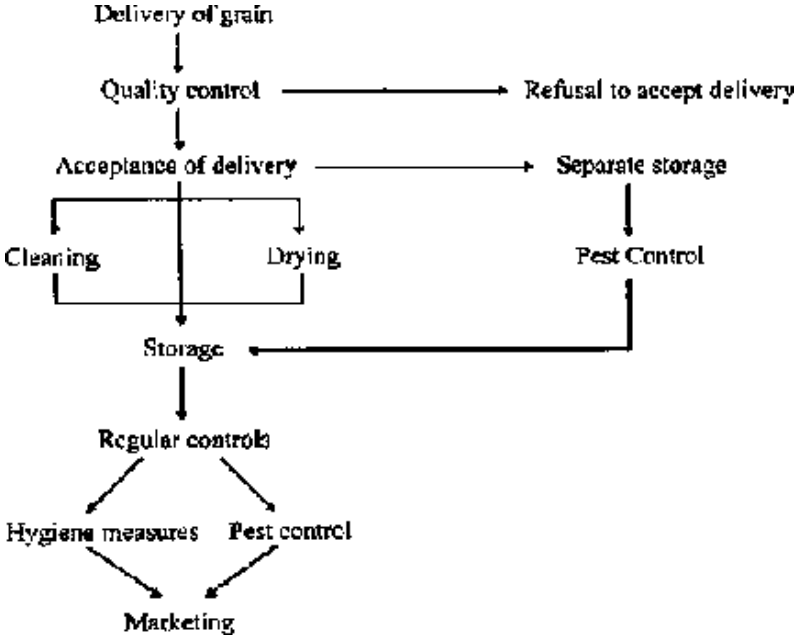

Delivery of grain
Quality control
Refusal to accept delivery
Acceptance of delivery
Separate storage
Cleaning
Drying
Pest Control
Storage
Regular controls
Hygiene measures
Pest control
Marketing

Figure 42

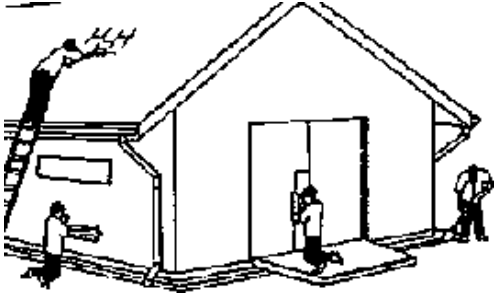


Figure 43

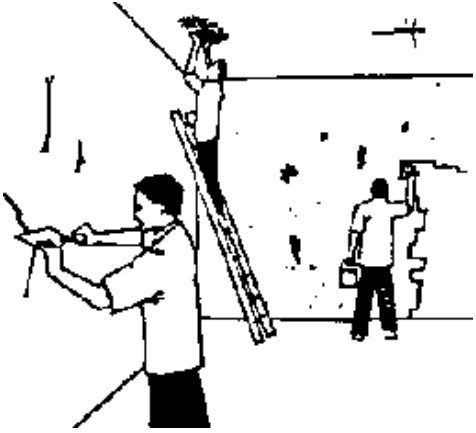


Figure 44

Figure 45

Note before accepting delivery:

- Carry out quality control! Take representative samples following the instructions in section 5.2.4.3!
- Check the smell and the appearance of the produce delivered!
- Measure the moisture content of the produce from individual bags of any particular vehicle (see section 5.2.4.3)!

Figure 46

Figure 47

If the moisture content is too high, ensure further drying or refuse to accept delivery!

- Check whether the produce is infested by taking samples (see section 5.2.4.3)1 Pay particular attention to cracks and gaps in vehicles where insects may hide!

If the produce is infested, ensure it is stored separately (quarantine) and treated in order to prevent the pests infesting

uncontaminated produce. In case of heavy infestation refuse to accept delivery!

- Check the degree of impurity!

If the degree of impurity is too high according to the respective standards, have the produce cleaned or refuse to accept delivery!

Note when storing:

- Avoid infested produce coming into contact with uncontaminated produce!
- Handle the bags carefully in order to avoid any damage! Do not use bag hooks!
- Make sure that any damaged bags are replaced and/or repaired!
- Make sure that the bags are stacked correctly and safely on pallets (see section 5 2.4 1)!

Figure 48

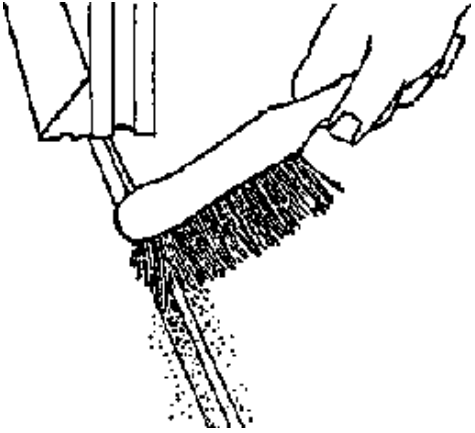


Figure 49

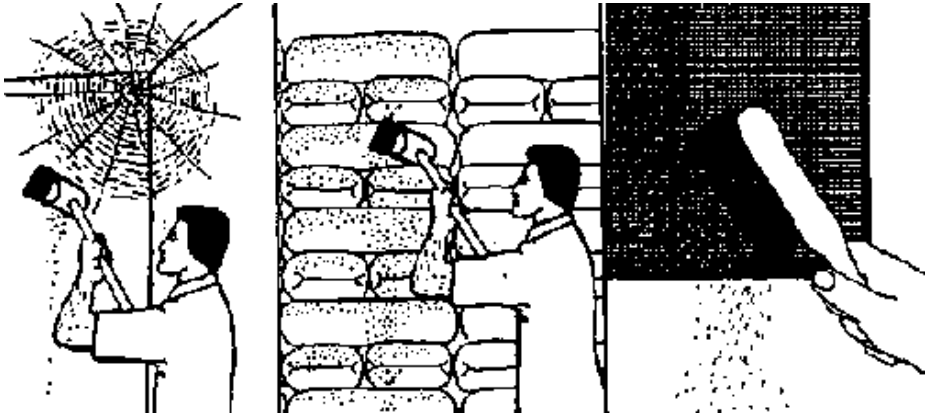


Figure 50

Note during storage:

Daily:

- Sweep the floor of the store! Pay particular attention to corners and edges where dirt and pests may gather!
- Clear the walls, the ventilation openings including the gauze and grilles and the stacks of bags!
- Brush the roof beams as insects may hide and survive there!

- Clean equipment after use in order to remove grain left over in inaccessible places I
- Dispose of any waste immediately after cleaning by burning or burying it!
- Check the store for damage and ensure reparation immediately!
- Look for the presence of any flying or crawling insects!
- Check for traces of rodents or birds!
- Carry out controlled ventilation (see section 5 2.4.2)!
- Make sure that the store records ate kept up-to-date!

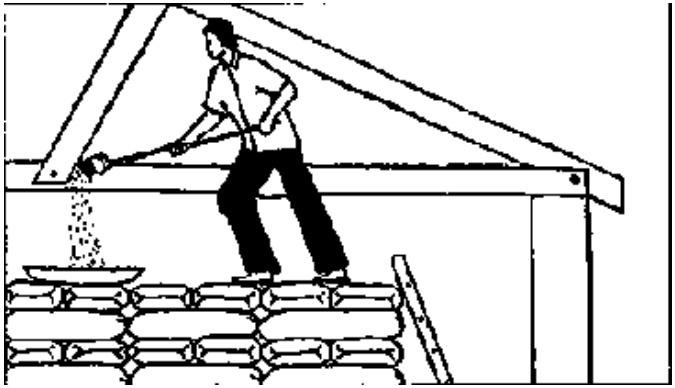


Figure 51

Figure 52

Weekly:

-Take samples of every lot and check:

- the moisture content of the produce
- the presence of pests in the stored produce by sieving the samples!

-Check the temperature of the stored produce in the stacks of bags using a grain thermometer!

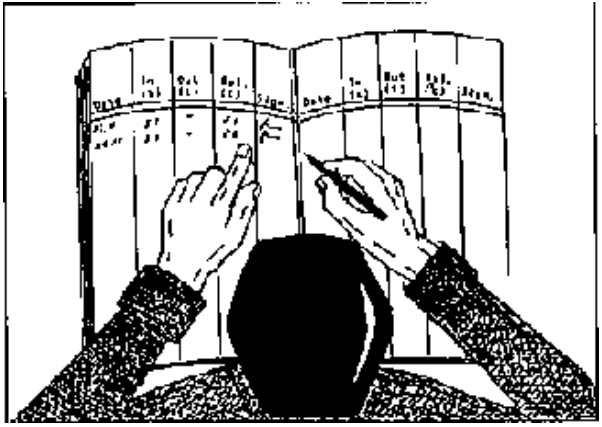


Figure 53

Monthly:

-Clean the area surrounding the store and remove any herbs!
- Draw up a monthly report and send it to your superiors!

General Principles of Storage

- Only accept delivery of sufficiently dry, uninfested and well cleaned produce!

- For foodstuffs:
Ensure for rotation of the produce in store according to the "first in - first out" principle in order to prevent overstorage!

- For seeds:
Remove any lots which ate below the prescribed standard of germination capacity and make other use of them!

If the germination ability is in accordance with the prescribed standard, first supply the lot with the lowest germination ability! The higher the germination ability of any lot, the longer it can be stored as seed.

- Remove any waste from processing (by-products such as from cleaning seeds) immediately! If by-products have to remain in the store, treat them as any other stored produce. Otherwise they risk to be a constant source of infestation.
- Stack empty bags on pallets with a distance of I m to walls. Fumigate empty bags after use!
- Stack unused pallets tidily and treat them with insecticide before and after use!

- Store equipment and chemicals in separate stores!
- Remove any junk from stores!

A job description, such as in the form of a poster, in the storekeeper's office reminds him of his tasks and duties. It should be signed by him in order to prove that he has taken cognisance of his responsibilities.

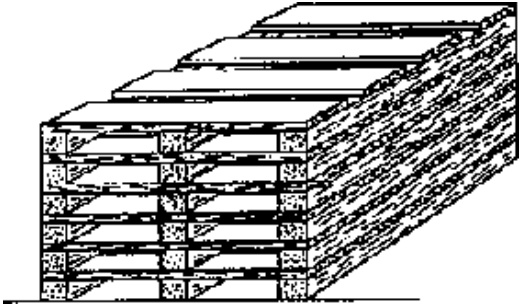


Figure 54

5.2.4 Storage Techniques

5.2.4.1 Stacking Bags

- Pallets

Always stack bags on pallets! Place the pallets in a way that enables a free current of air under the stack!

The pallets should be 10 cm high in order to facilitate aeration from below. As an additional advantage rodent infestation can easily be determined. The following illustration shows a model with three base beams and cross beams of a thickness of at least 2.5 cm.

The surface area of the supporting bars should not be less than approx. 40% of the overall surface area of the pallet in order to prevent the bottom bags being damaged as a result of too much pressure

Figure 55

- Stacking the bags

The objective when stacking bags is to build up safe stacks which will not collapse. In practice, three or five bags units, depending on their size, have proved most effective whereby overlapping the bags in the different layers is essential.

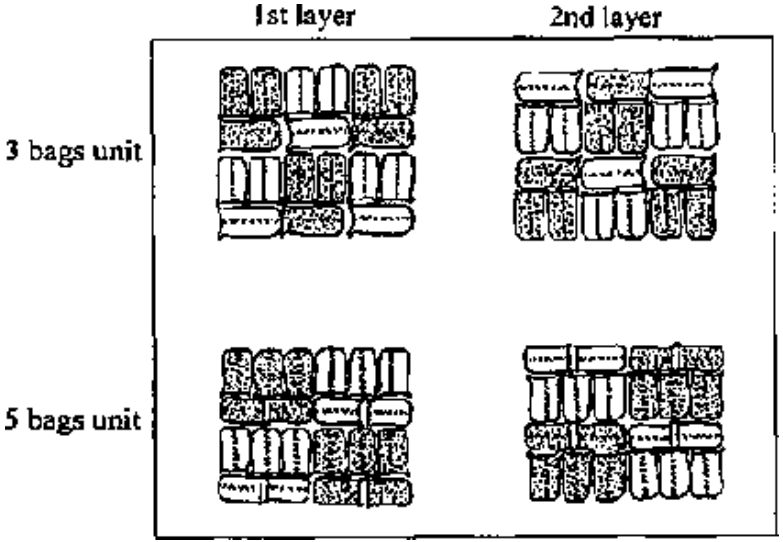


Figure 56

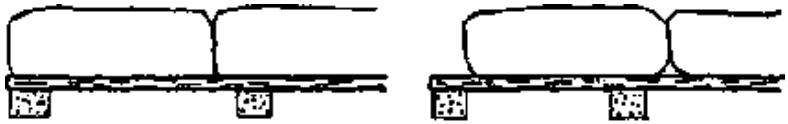


Figure 57

Attention must be paid to the following:

- Start exactly at the edge of the pallet:
- Ears of bags (side where the bag is sewn) should be pointing inwards the stack in order to prevent grain spilling.
- Stack the bottom layers with larger intervals than the top ones in order to obtain a slightly conical form of the stack which provides stability.
- On every layer, work inwards from all four sides. If this results in gaps occurring in the middle of the upper layers, the stability of the stack will not be affected.

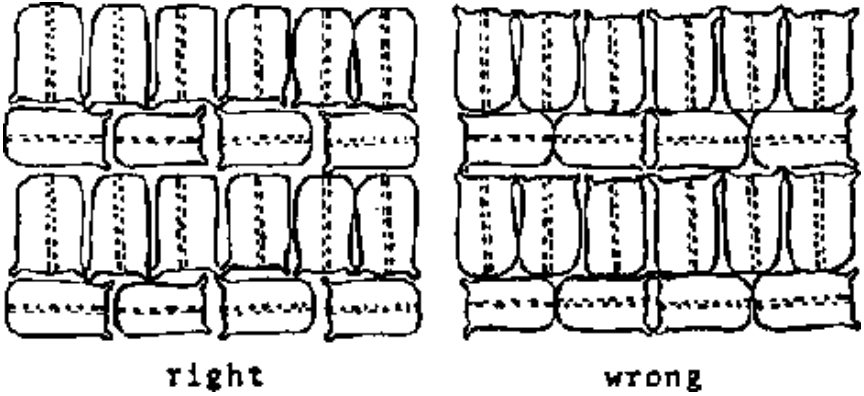


Figure 58

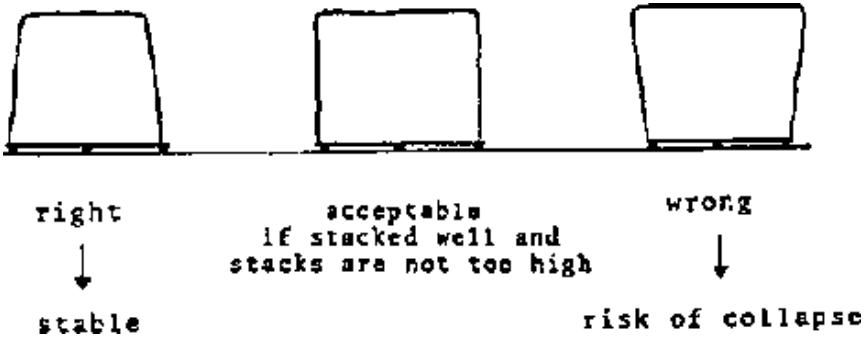


Figure 59

- Size of stacks

For the purpose of stability, jute bags should not be stacked any higher than 4 m and plastic bags no higher than 3 m! Plastic bags are more slippery and the stacks thus less stable.

When determining the size of stacks, take into account the store's capacity, the ratio of its length to its breadth and its height, the position of the doors and the size of the fumigation sheets available! Set the dimensions of the stacks to facilitate sealing with a single fumigation sheet! if the stacks are too large, they can no longer be effectively controlled, and if they are too small, space is wasted. Do not exceed stack sizes of approximately 250 t!

Leave a space between the top of the stacks and the roof of a least 1.5 metres in order to be able to carry out control measures.

Standardized stack sizes should be prescribed for all stores. This has the following advantages:

- It enables optimum use of space.
- It permits standardized procedures for treatments and

fumigation as well as for taking samples.
- It simplifies controls.
- It enables the purchase of perfectly-sized fumigation sheets.

- Positioning of stacks

All stacks of bags must be freely accessible at all times order to carry out controls, surface treatment and fumigation Leave a minimum space *of I m* between stacks and between the stacks and the walls!

Mark the positions of the stacks by painting a line on the warehouse floor (Drawing at in the following figure)! if the sizes of the stacks are not fixed, paint a line at a distance *of* 1 m from the walls all around the floor (b)!

Provide a site plan before storage!

- Marking the stacks

Book-keeping and routine work is made considerably easier if the individual stacks are marked with numbers or letters for easy

identification These markings may be made on the walls, the floor or the roof pillars, as long as they are always clearly visible. They should also be entered on the stack card.

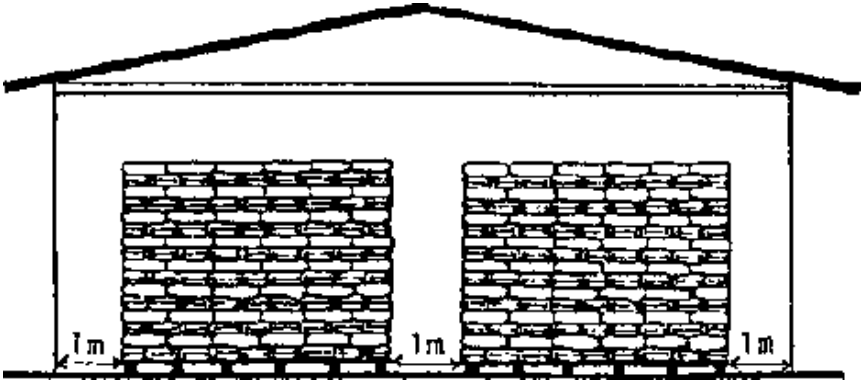


Figure 60

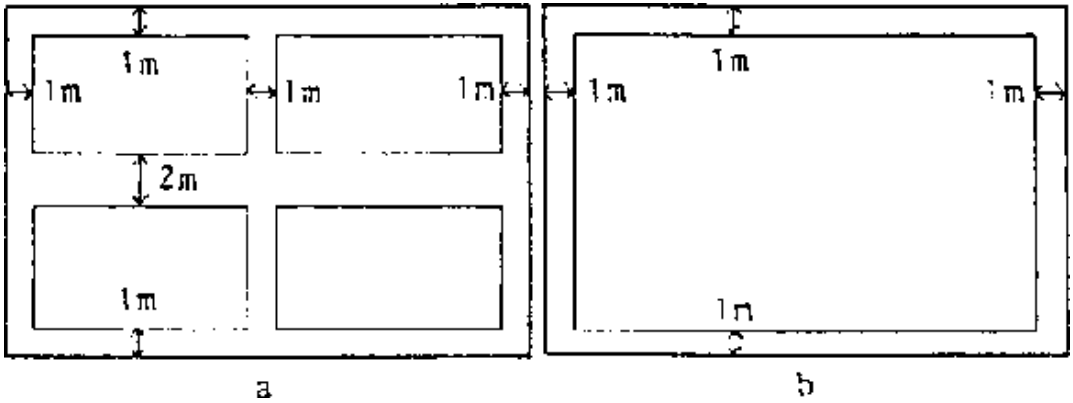


Figure 61

- Stack cards

Attach a stack card (sometimes referred to as a "bin card") in a clearly visible position to every stack of bags, containing the most important information. All controls and treatments should also be entered on the card. You will find a model of a stack card in the section on book-keeping (5.2.4.4).

Summary of Bag Stacking:

RIGHT

- A space of I m is left between stack and wall.
- The stacks are on pallets.
- The pallets are set up allowing an optimum air flow beneath the stacks.
- The bags are stacked in units of three

WRONG
- The bags are touching the wall.
- The bags are on the floor.
- No aeration of the stacks is possible.
- The bags are stacked irregularly.

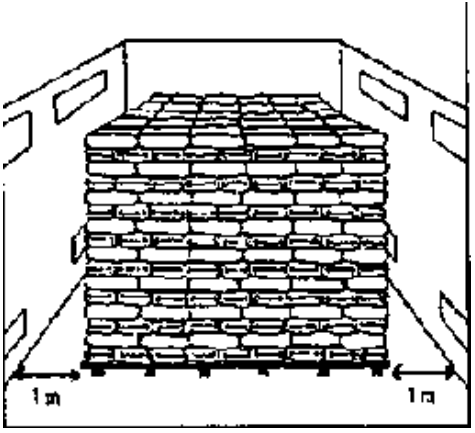


Figure 62

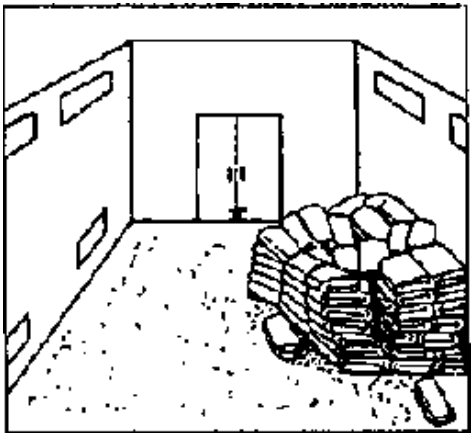


Figure 63

Consequences:

- The stack is free of rodents.
- The stack is well aerated.
- The stack is stable.
- The stack can be controlled, treated and fumigated at any time.
- The stack is a nesting place for rodents.
- No aeration takes place.

- The stack may collapse.
- The stack cannot be controlled, treated or fumigated.

5.2.4.2 Controlled Ventilation

Controlled ventilation has a positive effect on the moisture content of the stored produce and the temperature in the store,

Humid air can remoisten whereas dry air further dries the stored produce until the relevant equilibrium moisture content has been reached (see section 2.2.4). This means that the ventilation openings should be kept closed if the relative humidity is high and opened if the relative humidity is low.

Further drying of the stored produce is only possible, however, if this method is consistently practised over a certain period of thee, as the exchange of moisture in stacked produce takes place relatively slowly.

The equilibrium moisture content of the stored produce does not only depend on the relative humidity of the atmosphere, but also on the temperature, which influences the ability of the air to

absorb water, The change in the equilibrium moisture contents is, however only slight within temperature ranges of approximately 10°C, so that simplifications can be made in practice.

Both of the following tables thus contain average values for the temperature ranges from 20 - 30°C and 30 - 40°C which have been calculated on the basis of various publications. The equilibrium moisture contents stated are to be regarded as guidelines. Using these tables, a thermometer a hygrometer (or a combined thermo-hygrometer) and a grain moisture meter are needed in order to determine whether ventilation is favourable or not.

Tables of Equilibrium Moisture Contents

· Equilibrium moisture contents of selected commodities at 20 - 30°C (in %)

	Equilibrium moisture content at a relative humidity of the air of:					
Commodity	40%	50%	60%	70%	80%	90%

White maize	9.3	10.6	12.1	13.8	16.1	19.6
Yellow maize	8.4	9.7	11.3	13.1	15.5	19.2
Sorghum	9.8	11.0	12.1	13.8	15.8	18.9
Wheat	10.0	11.1	12.7	142	16.4	20.3
Paddy	9.2	10.4	11.6	13.0	14.8	17.6
Rice	9.0	10.4	11.7	13.0	14.6	16.7
Groundnuts	5.4	6.8	7.7	9.1	11.6	16.0

· Equilibrium moisture contents of selected commodities at 30 - 40°C (ill %)

	Equilibrium moisture content at a relative humidity of tile air of:					
Commodity	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**
Yellow maize	9.0	9.9	11.7	13.3	14.9	18.2
Sorghum	10.0	11.6	12.1	13.0	14.7	

Sorghum	10.0	11.6	12.1	13.0	14.7	
Wheat		11.8	12.9	14.7		
Paddy	10.1	11.4	12.6	13.5	14.9	19.1
Rice			11.1	12.7	14.5	16.8

Procedure:

1. Measure the relative humidity and the temperature of the outside air using a thermometer and a hygrometer! Both instruments must be fixed outdoors and protected from rain and direct sunlight.
2. Measure the moisture content of the stored produce using a moisture meter!
3. Determine the equilibrium moisture content of the stored produce for the determined relative humidity:

- Select the appropriate table on the basis of the temperature reading!
- Find the point where the row of the produce in storage meets the column of the relative humidity reading!

4. Compare the moisture content reading with the equilibrium moisture content determined!

- Ventilate if the moisture content of the stored produce is higher than the equilibrium moisture content shown in the table! Further drying will take place.
- Close the ventilation flaps if the moisture content of the stored produce is lower than the equilibrium moisture content shown in the table! Otherwise it is to be expected that the stored produce will become more moist.

Example 1:

- outside temperature: 27°C
- relative humidity of outside air: 60%
- moisture content of stored sorghum: 13.5%

In this case, the appropriate table is the one showing the temperature range from 20 - 30°C. The equilibrium moisture content for sorghum at a relative humidity of 60% is 12. 1%. The actual moisture content of the produce at 13.5% is higher than

the equilibrium moisture content.

Therefore: Ventilate!

Example 2:

- outside temperature: 34°C
- relative humidity of outside air: 80%
- moisture content of stored wheat: 13%

In this case, the appropriate table is the one showing the temperature range from 30 -40°C. The equilibrium moisture content for wheat at a relative humidity of 80% is 14.8%. The actual moisture content of the produce at 13% is lower than the equilibrium moisture content.

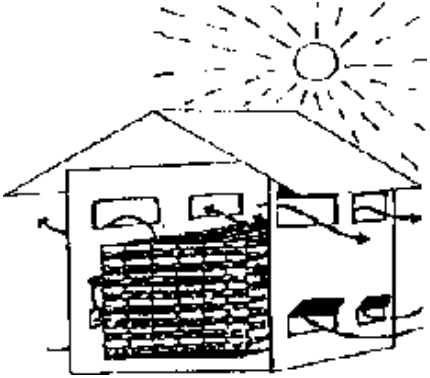


Figure 64

Therefore: Keep the ventilation Raps closed!

Controlled ventilation is particularly necessary where the moisture content of the stored grain is close to the permissible maximum values for long-term storage (see section 2.2.6). This is generally the case in humid regions and often also in arid regions with imported grain.

If the moisture content is well below the maximum value, which is generally the case with local grain in arid regions, ventilation need only take place if condensation occurs in the store or if the

inside temperature is too high.

If no thermometers and hygrometers are available, the following rules of thumb apply:

· Ventilate the store only during the daytime, using the hours of sunlight when experience has shown that the relative humidity is comparatively low! This is the period from 11 a.m. to 3 p.m., or longer in dry regions.
· if it rains, keep the store closed for a number of hours or for the entire day following the end of the rainfall.

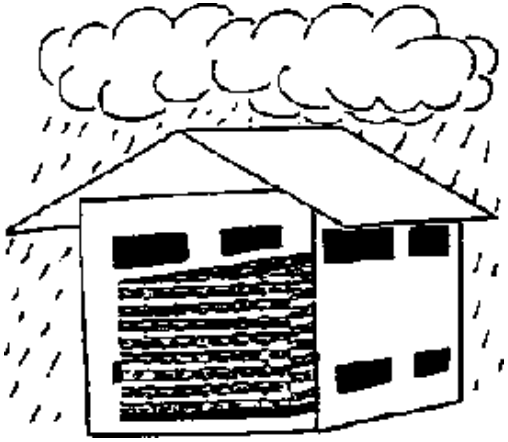


Figure 65

5.2.4.3 Monitoring. Sampling and Quality Control

Monitoring is a constant process of control with the aim of maintaining the quality of the stored produce. A brief visual inspection is by no means sufficient, rather it is important that a systematic search for possible sources of damage is performed. Should such sources be identified, measures must be taken (see section 3.3) and the success of these measures then examined.

Monitoring comprises regular inspection of the store as well as continuously sampling of the stored produce.

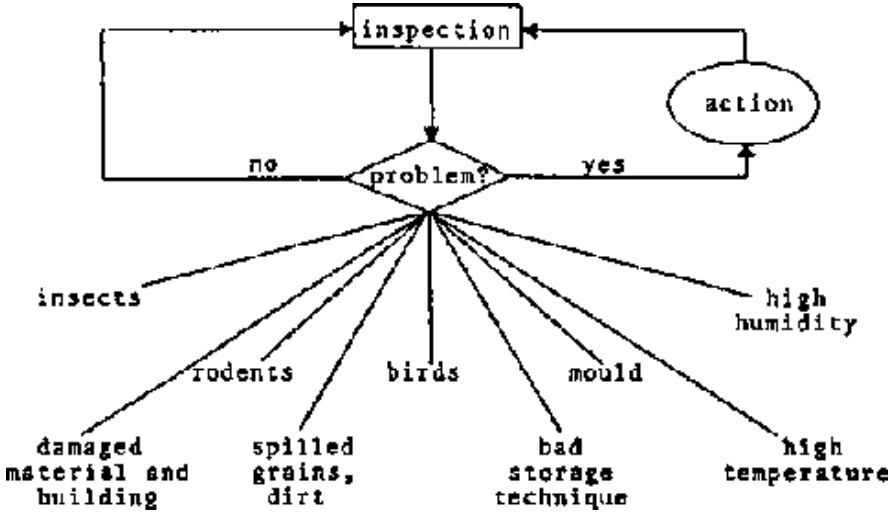


Figure 66

Inspecting the Store

Inspect the store daily!

- Damage to the store

Losses in the quality of the stored produce are in many cases caused by damage to the store building.

Pay particular attention to damage to the roof to the junctions of roof and walls, cracks and holes in the walls and the floor, damage to doors, windows, ventilation openings and their gauzes and grilles! Take immediate action if you notice any damage on walls or the floor or leaks in the roof!

Keep the rainwater drainage system and gutters in good function!

- Presence of rodents and birds

Rodents betray their presence in the store by leaving various traces. Pay particular attention to droppings, footprints in the dust, holes in bags, spilled grain, damaged material and grain left-overs (see chapter 11)!

Birds also leave excrements, food prints and damage to bags.

- Presence of insect pests

Look for insect pests at dusk, as they then have an active flying phase and ate more easily detected!

Moths are generally noticeable when their population density is already considerable.

Traps using pheromones or attractants can be of great service for identifying a low population in the store (see section 10.2). Pheromone traps are available for monitoring the most important species of moths as well as the beetle species *Trogoderma granarium, Tribolium spp., Rhizopertha dominica* and *Prostephanus truncatus* (see section 10.2).

Food attractants are less specific in their function to monitor infestation (see section 10.2)!

Brush stacks of bags with a stick or a broom to disturb and discover resting moths! Lift bags in order to detect moth cocoons along the line where the bags touch one another.

When looking for beetles pay particular attention to cracks, bag seams and ears where they often hide!

Empty individual bags in a thin layer onto a sheet and examine the contents for beetles and larvae! This should be done in the

shade so that the insects do not flee immediately. It is, however, more effective to sieve out ally insects present using a box sieve with a mesh of 1 - 2 mm.

Higher infestation can be noticed by an increase in the temperature of the stored produce as a result of the metabolic activity of the insects, or in certain cases by a characteristic smell (e.g. *Tribolium* spp.). Very important infestation can be noticed by feeding noise produced in the stack.

Identify the insects found as far as possible in order to perform the correct treatment.

- Mould

Pay attention to the mouldy smell which is noticeable in the case of fungi infestation even before any visual changes can be seen to the products!

- Moisture damage

Attention has to be made to water marks on the bags which can

still be seen after the bags have dried!

Taking samples

The most reliable method to establish moisture damage, insect or fungus infestation is by examining the stored produce itself. In order to do so, it is essential to take samples. The method of taking samples presented below serves for use in routine controls:

- **for infestation by pests**
- **of the moisture content**
- **for other changes to the stored produce.**

The controls should be made regularly by the storekeeper during the storage period. Regulations for laboratory examinations of samples, e.g. of seeds, remain unaffected.

Take samples of every lot in a weekly to fortnightly rhythm! Draw up a schedule for regular sampling.

Sampler

The samples are taken by means of a sampler, of which there are two different kinds:

· Bag sampler

It reaches to the centre of the bag and is quick and easy to use:

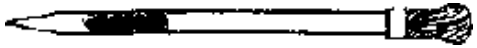


Figure 67

Use the sampler to pierce the bag from below (1), turn it in the bag so that the produce can fall into the opening and run into the recipient (2). Withdraw the sampler (3) and close the hole with its tip (4).

The right diameter of a bag sampler depends on the type of produce being sampled. The following rough values apply:

- for small seeds: 12 mm
- for cereals: 15 mm
- for grain legumes: 20 mm
- for rough produce: 25 mm

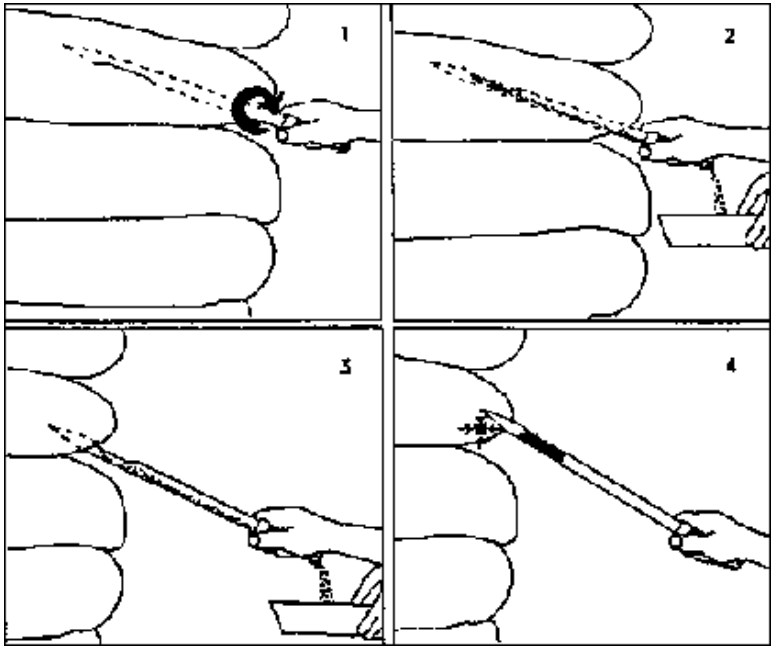


Figure 68

· Grain sampler

It is longer than the bag sampler and is able to cover the entire cross-section of the bag. its use is more complicated and slower. The grain sampler consists of two parts; an outer and an inner

tube. Turning the inner tube opens and closes the sampler.

Grain samplers are available as entirely hollow constructions or with intermediary sections. The latter enable the produce to be examined layer by layer. Grain samplers are available in various sizes. Larger ones are mostly used for taking samples from bulk produce.

Grain samplers are used as follows:

Pierce the bag with the closed grain sampler. Turn the inner tube to open and till the sampler. Then reclose it by turning the inner tube again. Shake the sampler as you do so to avoid any broken grain! Draw out the sampler and empty the sample into a recipient or on a sheet!

Representative sampling

A single sample only consists of a tiny portion of the overall amount of grain contained in a lot. Sampling must therefore be done according to certain rules and with the greatest care in order to obtain a sample which is representative of the entire

stack.

Figure 69

In order to ensure this

- a sufficient number of primary samples must be taken
- the points from which the samples are taken must be evenly distributed throughout the entire lot
- the primary samples are put together to form a composite sample (with the exception of those samples which serve to determine the presence of moisture!)
- the composite sample is reduced to a standard sample which will be thoroughly analysed.

The three types of samples involved in this procedure are defined as follows:

· Primary Sample

A primary sample is a single sample out of one bag with an approximate volume of 100 ml. In order to obtain a representative sample for the whole stack a sufficient number of primary samples must be taken following the rules given below.

· Composite Sample

The composite sample consists of the merged primary samples and should have a minimum volume of 2 l.

· Standard Sample

The standard sample has a volume of exactly 1 l of grain. It is obtained by reducing the composite sample to it volume of 1 I with it sample divider. The standard sample is the basic unit tot-pest infestation analysis

· Number of primary samples

The minimum number of primary samples depends on the size of the bag stacks. Proportionately mot-e samples have to be taken from smaller stacks than from larger ones, as in the former more

hags arc placed on the outside and thus exposed to damaging influences. The number of primary samples depends solely on the number of hags, regardless of their weight.

There are several systems how to determine the number of primary samples necessary to obtain a representative sample. The following system is simple to apply:

Number of bags	Number of primary samples required
up to 10	one sample per hag
11 to 100	10 bags*
100 to 10.000	$\sqrt{\text{number of bags}}$
more than 10.000	$\sqrt{\text{number of bags}} \div 2$

*** if the grain is very inhomogenous, the number of samples must he increased**

Storage responsible who ate not familiar With square roots and who do not dispose of a pocket calculator, can also use the following scheme:

Minimum Number of Primary Samples in Stacks with a Large Number of Bags

Bags	Samples	Bags	Samples	Bags	Samples
50- 100	10	800- 900	30	2 500-3 000	55
100 - 150	12	900 - 1 000	32	3 000-3 500	59
150 - 200	14			3 500-4 000	63
200-250	16	1 000- 1 200	35	4000-4 500	67
250-300	18	1200-1400	37	4500-5000	71
300-400	20	1 400- 1 600	40	5 000-6000	77
400- 500	22	1 600- 1 800	42	6000-7000	83
500 - 600	24	1 800 - 2 000	45	7 000-8 000	89
600 - 700	26			8 000-9 000	95
700 - 800	28	2 000 - 2 500	50	9 000 - 10 000	100

When produce is delivered a primary sample should be taken out of every second bag on the vehicle.

· Distribution of the sampling points

The sampling points must be evenly distributed over the total stack surface. This means that comparatively big surfaces should have more sampling points than the smaller ones. If the total stack surface area is 120 m², for example, and the surface area of one side 40 m², 1/3 of the samples must be taken from this side. On a side with 24 m², accordingly, 1/5 of the samples have to be taken.

An experienced storekeeper will be able to estimate the approximate distribution without calculating the sizes of the single surfaces. The following picture gives an idea of the distribution of sampling points on the individual surfaces of a stack:

It is advantageous to have standardized stack sizes in the store in order to facilitate routines like determining the number of sampling points or calculating the dosages for treatments against stored product pests..

Quality control

A minimum amount of equipment must be available in every store or storage complex for quality control examinations:

- **moisture meter**
- **sieves**
- **hand magnifying glass**
- **Pair of scales**

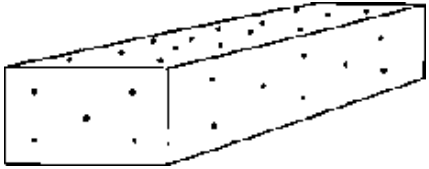


Figure 70

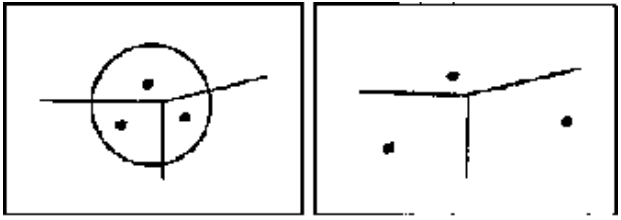


Figure 71

The samples taken are subjected to various kind of examination either, as primary samples or as a standard sample. If there is any doubt as to the quality of a certain lot, samples should be tested in a laboratory.

· Visual test and smell

Examine the composition and smell of the produce when taking the sample! A mouldy smell indicates fungi festation. Any changes in the colour of the grains may also be due to moisture damage or damage from heat because of high drying temperatures or "hot spots".

· Measuring the grain moisture content

For detecting grain moisture content primary samples have to be analysed, as increases in the moisture content of some bags resulting from condensation or leakages in the roof can no longer be recognized in standard samples

Measurement should be performed immediately after taking the sample, as the moisture content can change rapidly after the sample has been taken. This test is generally done with commercially available moisture meters. Take care that the produce is not filled into the apparatus by hand as this increases the moisture on the surface of the grain and leads to incorrect readings! Strictly observe the instructions for use of the moisture meters!

In case of exceptionally high readings, take additional measurements to determine whether the increase is limited to a certain area (e.g as a result of rainwater penetration), or whether it affects large areas of the entire stack! Take out bags for drying if necessary!

Enter all readings in the stock journal and stack card.

· Control for infestation by Insects

Examine the standard sample, as it is not of any importance where exactly the insects come from! If the level of infestation is

unacceptable, the entire stack must be treated in any case.

Sieve out any insects which might be present using a single sieve with a mesh size of 1 - 2 mm or better several sieves with decreasing mesh sizes (e.g. 3, 2 and 1 mm)! Carefully examine the remains in every sieve for insects!

A number of pests, such as *Sitotroga cerealella* or *Sitophilus spp.* develop inside the grains and are thus not noticeable in controls of this kind. Hidden infestation can be discovered by means of a water test:

Place a sample of the grain in a container with water. Infested grains are lighter than healthy ones and will therefore float on the surface. Check whether they are really infested by cutting them open!

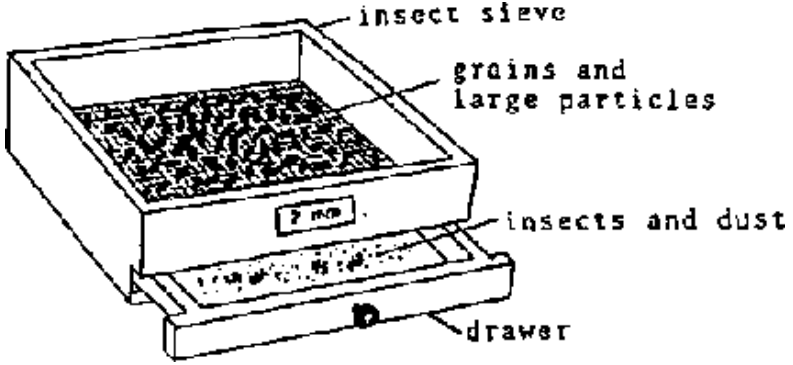


Figure 72

Identify any insects (see chapter 7) in order to decide if any action should he taken to deal with them and which kind of treatment is required!

Whether action should be taken depends on a number of factors:

- **the degree of infestation**
- **the kind of insect pest species (primary or secondary pest)**
- **the period the produce will be in storage**
- **the purpose the produce will be used for (food, feed, export)**
- **the quality standards demanded on selling the produce.**

Example:

In Egypt the following criteria for the application of control measures are common (resulting on examination of standard sample):

- 1 living primary pest specimen (adult beetles only)

⇒ fumigation becomes necessary

- more than 4 secondary pest specimen (adult beetles only)

⇒ fumigation becomes necessary

This number of insects could be made up of different species.

· Grain temperature readings

Unusually high temperatures in a mass of grain are an indication of the activity of micro-organisms and pests, e.g. in a "hot spot" (see section 2.2.3).

Grain thermometers are available with rigid thermo-probes made of metal which are used to pierce the bags. Electronic thermometers usually have a thermo-probe with a flexible lead. This is either soldered to a rigid metal rod or is placed in a bag or grain sampler.

Empty the bags with a higher temperature and examine the contents!

Determine the extent of the damage by controlling the surrounding bags!

· Checking for impurities

An examination for impurities is particularly necessary on purchasing or accepting delivery of produce at the store.

Poorly cleaned produce has a shorter storage life than clean produce. Dust, for example, is hygroscopic and raises the moisture content of the stored produce; broken grain allows secondary pests to gain access to the stored produce (see chapter 7). in addition, impurities reduce the storage capacity and

increase the storage costs due to extra weight.

Impurities are separated by sieving the sample being examined. This is performed using two sieves, one coarse and a fine one, whose mesh sizes must be suited to the produce being examined. Impurities such as stones, pieces of straw, pans of maize spindles etc. are sieved out by the coarse sieve whereas impurities such as sand, dust, insects, broken grains, etc. will pass through the fine sieve.

Impurities which are of the same size as the stored produce cannot be sieved out and must be separated individually.

Sieves sets with a lid and a bottom pan are recommendable. Sieving should be performed by shaking the set of sieves for ½ - 1 minute.

If there are no sieves available, impurities may be separated from the stored produce by means of winnowing or, if the quantity is comparatively small, simple sorting out on a bright surface.

For a quantitative assessment of the impurities, a set of scales

weighing accurately to 0.1 g is necessary. This is necessary wherever:

· quality standards are prescribed
· the degree of impurity is taken into account in the price of the produce

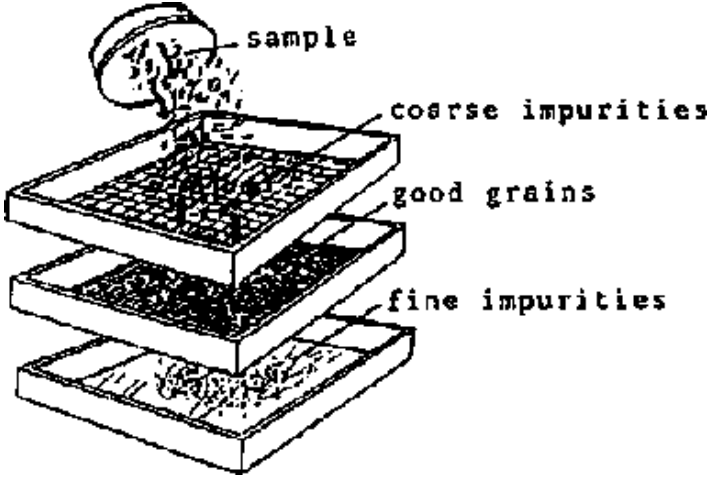


Figure 73

***Examinations for* impurity are not necessary in the course of routine control of the stored produce during the storage period.**

There are special regulations for seeds.

5.2.5 Book-keeping

The storekeeper has to record the state of the store and the produce as well as of his activities. Book-keeping is based on the following elements:

- **store journal**
- **stock sheets (where suitable)**
- **stack cards**
- **monthly report**
- **warehouse checklist**

Models for these elements are presented below, along with explanations for their use.

Store journal

The store journal contains a record of all procedures carried out in the store, such as incoming and outgoing produce, results of inspections and treatments, etc. Entries should be made daily and

after any activities have been performed. The store journal consists *of* two tables:

· Balance sheet

The balance sheet contains nil information on movements of the stored produce, the place of origin or destination, the stack number (or lot number in the case of seed) and reference to the relevant documents like invoices or receipts. These must be filed chronologically. The storekeeper confirms every procedure with his signature.

· Control sheet

The control sheet contains information on all activities in the store, such as inspections and their results, treatments, cleaning and ventilation, any repairs and weather data. An additional quality control book is required for seed stores in which the results of the laboratory tests which form a part of the essential internal quality maintenance programme are recorded.

The store journal should be firmly bound and the pages

numbered. The first part should consist of the balance sheets and the thicker rear part of the control sheets. A separate journal should be kept for each store and should remain in the store.

STORE JOURNAL (PART 1): BALANCE SHEET

Commodity: Warehouse:

Date	In (t)	Out (t)	Balance (t)	Number of bags	In/out stack Nº	Origin/ destination	Document Nº	Signature

Figure 74

STORE JOURNAL (PART 2)
CONTROL SHEET

CONTROLS						TREATMENT				CONTROLLED AERATION	CLIMATE		
Date	Commodity	Stack No	m.c. %	Insect infestation (degree, species)	Other observations (rodents, condition of warehouse, etc.)	Kind of treatment	Chemical used, application rate	Result of treatment	Cleaning & repairs	Vents manipulated (time)	Temp. °C (time)	r.h. %	Signature

Figure 75

Stock sheets

In storage centres and in seed stores, store book-keeping is composed of journals from the individual stores or lots, making it very time-consuming to calculate the actual amounts of produce present in the stores. In such cases it is practical to keep stock sheets. A stock sheet shows the current overall stock of the storage centre at any one time on a single page. The stock sheet is divided up according to the type of produce and, in the case of seed, according to type, category and state of processing.

STOCK SHEET

Entries should consist of the date of any movement, the new overall total stock and the reference to the store where the movement has taken place. This enables the details of the procedure to be checked in the balance sheets of the relevant store.

Commodity[1]								
Date *	Store Nº *	Balance (t)	Date *	Store Nº *	Balance (t)	Date *	Store Nº *	Balance (t)

* Date and Nº or name of store of last movement of a particular commodity.

[1] Useful for storage centres with several separate stores and for seed centres to record the overall balance of the commodities stored. Details of the movement are then found in the store journal of the store where the movement has taken place.

Figure 76

Stock sheets are also kept in the form of a firmly bound book.

Stack cards

Every stack is given a stack card placed where it is clearly visible, This serves to identify the stack and the produce and contains details on inspections and pest control measures performed.

Monthly report

The storekeeper's monthly report serves to inform superiors on amounts of produce and its state, on the storage conditions as well as on activities and any problems in the store. These reports should also be referred to on the inspections of the store regularly done by the superior.

Warehouse checklist

The warehouse checklist is an instrument of control. It essentially serves as a means of evaluating the tasks mentioned in the storekeeper's job description. The checklist can also be used by the storekeeper in the course of regular controls of storage conditions, the state of the buildings and the storage management.

STACK CARD

FOOD DISTRIBUTION CORPORATION

Warehouse № / Name:

Stack №: **Commodity:**

Lot №: **Variety:**

Origin:

Date	In (t)	Out (t)	Balance (t)	№ of bags	Signature

Figure 77

STACK CARD
SEED CORPORATION

Warehouse Nº / Name:

Lot Nº :
Commodity:
Origin :

raw seed ☐
precleaned seed ☐
processed seed ☐
treated with:

VARIETY

CATEGORY

Date	In (t)	Out (t)	Balance (t)	Nº of bags	Signature

Figure 78

Back of stack card

Stack dimensions (to be entered with pencil and to be corrected when changing):

Iength: .... m	Surface area : .... m	Amount of water needed for surface treatment : ... l
width : ... m		Amount of chemical needed to be mixed with the water : ... ml EC/g WP
height: ... m	Volume : ... m	Number of tablets needed for stack fumigation : ... tablets

Date of inspection	m.c. %	Insect infestation, other infestations	Date of treatment	Kind of treatment	Chemical used	Application rate	Remarks	Signature

Figure 79

M O N T H L Y

Storekeeper / P

Commodity:

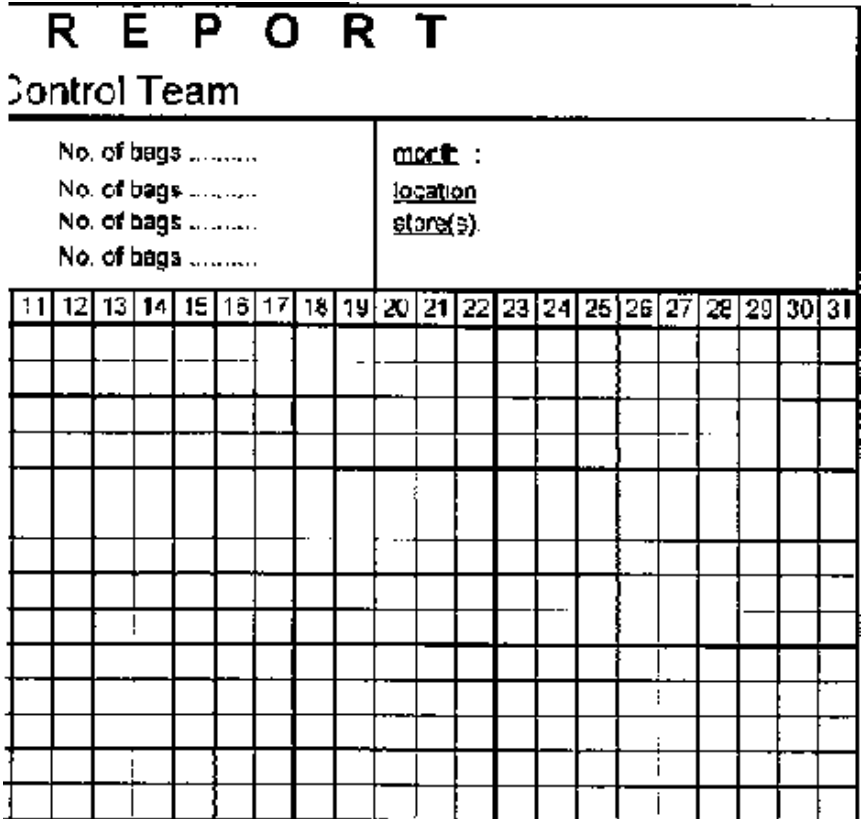
in ..... t, out .....
in ..... t, out .....
in ..... t, out .....
in ..... t, out .....

Activity	Days:	1	2	3	4	5	6	7	8

Surrounding of store cleared and cleaned									
walls and floor cleaned									
waste burned and buried									
vents operated (controlled ventilation)									
store checked for sign of:									
- damage: damage found?	yes*/no								
- rodents: rocents found?	yes/no								
- birds a o : birds or others found?	yes/no								
- insects: - flying insects found?	yes/no								
- crawling insects found?	yes/no								
sample taken of stack	number(s)								
living insects found in sample(s)?	yes/no								
moisture conten below safe storage level?	yes*/no								
grain temperatur normal?	yes/no								
stack(s) number(s) ... sprayed									
stack(s) number(s) .. fumigated									
whole space fumigation									
store sprayed									
fogging									
rodent contro in operation									
repairs executed*									
presence of stack cards									
* explain:									

remarks: i.e. use of insecticide, fumigant, application rate, etc.

Figure 80



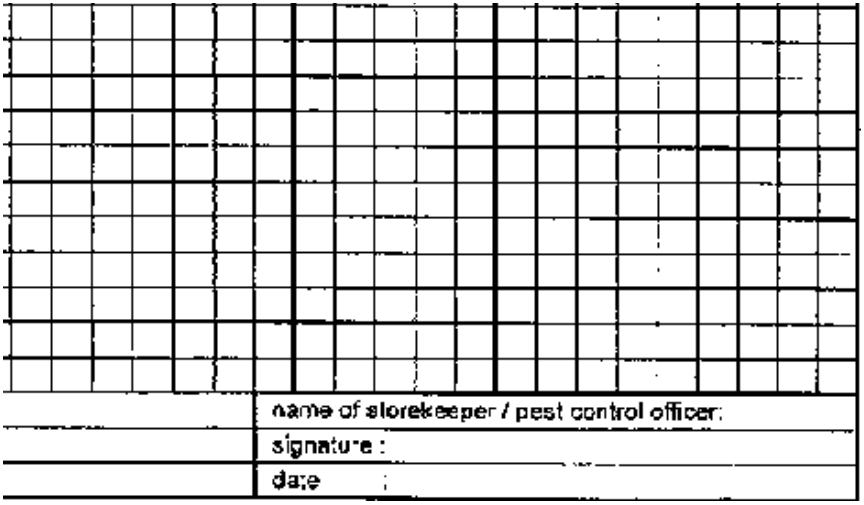


Figure 81

WAREHOUSE CHECKLIST

Location: Name of store: Capacity: t
Products stored: Amount stored: t

1. Condition of warehouse surrounding

Is the surrounding of the warehouse free of:

a) accumulation of grains, old bags, junk and trash?
b) weeds, tall grass and bushes?
c) evidence of rodents?
d) standing water?

2. Condition of warehouse exterior

a) is the roof intact?
b) is the water drainage intact?
c) Are the walls without holes or cracks?
d) Do the doors close hermetically?
e) Are the ventilation openings protected against the penetration of insects, rodents and birds?

3. Condition of warehouse interior

a) Are the walls, the door and the roof undamaged?
b) is the floor and the roof clean?
c) Is the floor free of spilled grain, dirt, and trash?
d) Do the ventilation openings function properly?
e) is the store free of residues of former treatments (empty

phosphine tubes, phosphine residues, rodent baits, etc.)

4. Storage practices

a) Are all empty bags stored on pallets?
b) Are all stacks at least 1 m apart?
c) Are insecticides, fertilizer and other products stored separately from the grain?
d) Are all bags in the stacks without holes?
e) Are all stacks built in a safe way?
f) Are stack cards in use far all stacks?
g) Are the stock journals kept up to date?

5. Presence of pests

a) is the store free of flying insects?
b) Are the walls and the bags free of crawling insects, larvae and pupae?
c) is the store free of traces of rodents?
d) is the store free of traces of birds?

6. Pest control

a) Has any pest control treatment been done shortly before or during the inspection?
b) if so, what kind of treatment?
c) Which pesticide has been applied?
d) in case, bait stations against rodents are in use, are they supplied with fresh baits?

7. Recommendations

Inspector	Storekeeper
Name:	Name:
Signature:	Signature:
Date:	Date:

5.2.6 Equipment

The following equipment is necessary in order to correctly run a store:

- Pallets

- Brooms
- Shovel
- Rubbish bin (e.g. oil drum)
- Rake
- Bucket
- Sampler
- Sample container
- Sample divider
- 1 l-cup
- Magnifying glass
- Forceps
- Set of sieves (1.5 mm, 2 mm and 3 mm, plus other mesh sizes if necessary)
- Air thermometer
- Glasses to collect insects
- Hygrometer or combined thermo-hygrometer
- Grain thermometer
- Grain moisture meter
- Torch
- Balance to weigh impurities of grain (down to 0.1 t)
- Decimal scales (up to 1000 kg)

- Ladder
- Tape measure (20 m)
- Reporting form
- Tool kit, with equipment to repair damaged bags

    · Saw
    · Hammer
    · Screwdriver
    · Pincers
    · Trowel
    · Nails, screws, etc.

The equipment required for pest control is listed in chapters 8 and 9.

5.3 Further literature

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