MANUAL ON STORAGE OF FOOD GRAINS

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CHAPTER 1
STORAGE OF FOOD GRAINS

CHAPTER 1

STORAGE OF FOOD GRAINS

1.1 Introduction :

The need for storage of food grains has been there since the time when the agricultural practices were discovered by mankind as a source of food. Cereals, millets etc. which are cultivated over a period of 3 to 4 months have to be stored until the harvest of new crop. With the gradual change from subsistance farming to commercial farming by the farmers, development of community farming and also the intervention of traders, government and their agencies through purchase of marketable surpluses and storing them, various types of storage facilities were gradually developed to suit local conditions and requirements.

The farmer stores the food grains produced by him for food, feed, seed and he sells the surplus for cash or barters for essential commodities. He also stores the grain as a reserve for future years of drought, floods etc. Traders store the grain in anticipation of higher prices during the lean season. Government and their agencies purchase and store food grains for supply to the people in case of emergencies like floods, drought, war and also to stabilise market prices. The quantity of grain stored and the period of storage by individuals and institutions vary widely from less than a ton to a few millions of tons and from a few days to several years. Problems of storage are basically the same at all levels of storage. However, there are many differences in details. There are many estimates of losses in storage of grain, but many are guesstimates only and may not be based upon any scientific study over larger areas and covering different situations. Nevertheless the fact remains that there are losses in food grains during storage and it needs no emphasis that they have to be reduced to the minimum.

Storage in its overall connotation covers some complex and critical functions. Firstly it provides for the physical safety of food grains for longer periods, underlining the need for a good storage facility. Secondly it prevents losses and preserves the quality of grains including its nutritional value, through employment of package of scientific practices by trained manpower. Thirdly storage is a king pin for a sound food security system. Thus storage management forms an integrated part of post harvest operations and lies at the hub of management of food economy of any country.

In order to develop a sound storage management of food commodities, it is necessary to understand the concept and causes of food losses, requirement of a good godown, quality monitoring of food commodities during purchases and in storage, and pests and their control methods.

1.2 Concept and Causes of Food Grain Losses :

Losses in food grains can be broadly classified as loss in weight, loss in quality and nutritive value, and loss in hygienic quality. Loss in weight occurs as a result of drjage of grain, activities of insects, rats and birds. One black rat (R. rattus) can consume about 15g of food material and one sparrow (Passer domesticus Linn) can consume about 8g of food grains in one day.

Loss in quality occurs when germ and endosperm of the grain are eaten away by insects. In case of seed, if viability is lost, it is not fit for seed or malting purposes. Hygienic quality is lost if the grain is contaminated with excreta of rodents, living and dead insects, and insect fragments and their excreta (uric acid) and moulds. Some of the grain moulds produce toxic substances (eg. aflatoxin) which are hazardous to consumers. Each Norway rat is reported to excrete up to 10,000 faecal pellets and 4 litres of urine annually. It constantly sheds its hair also. Rodent activity in grain godown may lead to contamination with their excreta and hair especially on spilled grain. Rodents are known to spread some diseases through their excreta.

The deteriorative changes in food grains are visible and non visible types. Weevilled grain, germ eaten grain, mould damaged grain, discoloured grain can be detected on visual examination. Increase in fat acidity, presence of uric acid, loss in gluten quality in case of wheat, loss in viability can be found only in a laboratory. Fermented or rancid smell in food grains are perceptible.

During storage, different factors bring about losses in food grains and they may be grouped into biological and non biological factors. The biological factors comprise of insects, rodents, birds, micro-organisms and mites. The non biological factors are temperature, moisture, type of storage structure and handling equipment used. The biological factors are mainly responsible for losses and the non biological factors produce favourable conditions for the losses .

Some of the varieties of food grains are more susceptible to insect infestation than others due to inherent characteristics like hardness, different biochemical composition etc. A few species of insects (eg. primary pests- grain weevil and Khapra beetle) can attack completely sound grain but abrasion of the seed coat, breakage during harvesting and handling and admixture of cereal dust in the grain facilitate infestation by many other insects (eg. secondary pests - red flour beetle, saw toothed grain beetle). Broken grain gets mouldy easily. Losses and deterioration of food grains occur in water-leaking godowns, non rodent and bird proof godowns and where flooring is not moisture proof.

In some countries, some standards are prescribed to assess the quality of food grains. Maximum limits are fixed for weevilled grain, mould damaged grain, contamination with uric acid, rodent excreta and hair, presence of aflatoxin and also pesticide residues. The food commodities not conforming to these minimum standards of quality are not considered fit for human consumption . That means such lots are considered as lost for human consumption.

Loss in weight in food grains can be assessed easily while loss in quality and nutritive value or in hygienic quality is difficult to assess and quantamise it. Loss in quality will result in much more financial loss than what can be accounted from the actual weight loss. The estimation of loss in financial value rather than in food value, will help in evaluating the improved storage management and pest management practices. However, in times of scarcity, food grains are more valuable than its money's worth. (Ref. Nos. 2, 16).

1.3 Requirements of a good godown :

In case of large bulk storages, either in the form of upright silos or flat bins, the storage facility is built always on scientific lines by experts. However, in case of godowns, it is not the case. There are many types of godowns, good and bad. Roughly they can be divided into two categories. The first category is where only small quantities can be kept and the second category is where larger stocks can be stored. The requirements for an ideal storage are with reference to location, design and ancillary facilities.

In selecting a location for construction of a godown, attention should be paid to the hygienic and sanitary condition of the area. The location should be away from garbage dumping ground, sewage tanks, bone crushing mills, tanneries, and such other places which may affect the quality of food

commodities. The location should be on an elevated ground without fear of flooding in case of heavy rains. The godown should preferably be situated near a main road and railways. It should be near a procurement or distribution centre or exporting and importing points like ports.

The design of a godown to be built should take into account the following . There should be suitable foundation depending upon the site conditions. The plinth should be 80 cms above the ground level both for road and railway fed godowns. This will help loading and unloading of grain and it is also rodent proof as normally rodents will not jump beyond this height. There should be platforms, preferably covered, on one or both sides if it has to be fed by road and railways. To prevent rain water from getting inside the godown through the doors, there should be a slope on the platform to its outer edge. The floor in the godown should be damp proof, rigid, durable and free from any cracks or crevices. Bitumen or 700 guage polythene sheet can be used to make the floor damp proof. The doors should be provided preferably opposite each other. The doors should properly close without gaps between the door and floor or between door and side walls to prevent entry of rats and mice. Rolling shutter doors should be preferred. There should be windows between one and two meters above ground level and ventilators near the roof. Both of them should have a wire netting inside to prevent entry of birds and rodents. The outer surface of walls should be smooth to prevent rats climbing the walls. Inside surface of walls should be cement plastered giving no chance for the insects to hide in cracks and crevices. The roof should preferably of single span structural steel or tubular trusses or R.c.c. flat type, with no pillars and drainage pipes inside. Roofing material may be corrugated asbestos sheets or galvanised corrugated iron sheets. The sheets should project atleast 46 cm from the outer surface of longitudinal walls. Where gabled roof is constructed care should be taken that no hollow space is left between the walls and roof covering. A good system to drain away the rain water of roof should be provided so that no water would enter the godown. The rain water should be drained off by suitable open drains fairly away from the godown. Sufficient electrical lighting should be provided inside the godown as well as outside to facilitate operations during night also.

It is advisable to orient the long axis of the stores on an East West axis (± 10°) with the principal doors located on the North and South sides.

The design of the godown, should take into consideration the proposed

stack plan of the bagged commodity on the floor. This would help in deciding the inner dimensions of the godown as well as placement of doors and for optimum utilisation of the capacity. In case of large godowns of 5000 tons capacity and more, it is advisable to divide the godown into 3 or 4 compartments. This will help in quality control operations and also storing different commodities like sugar, oil tins, bales of jute bags etc. separately.

The ancillary facilities are (a) weigh bridge for weighing truck loads of grain, (b) railway siding for bigger storage depots, (c) raised open cemented platforms which can be used for cleaning, drying and segregation of good grain from damaged stocks, (d) mechanical cleaner, (e) weighing, bagging and stitching unit, (f) fire prevention equipment (g) office, (h) store room for pesticides, pest control equipment and material, Jute bags etc. (1)drinking water and toilet facilities (j) watchman kiosk and quarters. (Ref. Nos. 7, 12).

Selection of godowns for hiring :

Many times there will be a need to hire godowns from private parties, local government etc. for storing the food grains. The criteria for hiring should not be only rental charges and easy availability but it should be on the basis of its worthiness for safe storage of food grains. The godown should have the following minimum characteristics. It should have concrete flooring without cracks, non leaky and well laid roof, smooth plastered and white washed walls, plinth slightly above the ground level to avoid flooding of the godown in case of heavy rains, tight fitting doors, windows and ventilators which are in working condition, no gaps between walls and floor of the godown and with good approach road and clean surroundings. There should be no valley gutters and drainage pipes inside the godowns. If they are there, it should be ensured that the rain water from the roof drains off well outside the godown even in case of very heavy rains as otherwise there is a chance of flooding of water in the godown .

1.4 Estimation of Storage Capacity of a godown :

The storage capacity of a godown is the usable volume in it, which is less than the gross volume, because some space is left above eaves level for air circulation and ventilation ; some space is left between stack and stack and stack and wall and as gang ways, when the storage of food grains in the godown is done in stacks. Generally all godowns are built to a standard size

and an estimate of capacity is also provided. Sometimes it will be necessary to estimate the storage capacity which is done as follows :-

The length and breadth are measured. The height is taken from the ground level upto the level of first horizontal girder or beam. From this figure 1 meter is deducted because the height of the stack should be 1 meter below the girder or beam for easy operations. If horizontal girders are not there the stack height of 5 meters can be taken for calculations.

The storage capacity is estimated as follows :-

Capacity = length X breadth X (height - 1) -20% ÷ 1.6

Example : Length 100 meters
Breadth : 35 "
Height : 6 "

Capacity : 100 X 35 X (6-1) = 17500 cu meters
20% of 17500 = 3,500
17,500- 3,500 = 14,000 cu mt.
14,000 ÷ 1.6 = 8750 Tons or 9722 bags of 90 kg.

The reduction of 20% is made in volume because space has to be provided between stack and stack, stack and wall etc. If in a godown there are pillars, drainage pipes in the middle (in double bay roofing), projections from the walls, limit of 20% may have to be raised to 25%. After allowing for the free space to be provided in the godown for operational purposes, the space available for storage is arrived at and this figure is divided by 1.6 which is the average storage factor for different types of foodgrains. That is one ton of bagged grain will occupy 1.6 cu mt. of space. The final figure indicates the tons of foodgrains in bags that can be stored. This value can be converted into number of sacks also.

The store keeper should make an effort to utilise the capacity fully. Of course the limitation will be the number of bag layers which can be built for a particular commodity. In case of oil seeds, where the stacking beyond 12 - 15 layers is not recommended, the utilization of capacity will be less.

1.5 Stacking :

The floor in the godown should be divided into uniform size rectangular blocks to build up stacks. Stacks should not be too small as that means wastage of space and not too large as that will not permit proper inspection and fumigation operations. The size that is advisable is 15.5 meters

(10 blocks) length, 9.5 meters (9 length wise bags) wide with 18 layers high. The length can be varied depending upon the dimensions of the godown but keeping the width to 9 length-wise bags. This size is in line with the fumigation sheets available normally (20 X 12 meters). If the width is increased to 10 bags even, the height will have to be reduced to 17 bags as one fumigation sheet can not cover breadth wise of the stack. Then 2 sheets will be required for breadth wise covering and for full length covering instead of 3 sheets, 6 sheets will be required. In such cases the size of the sheets should be 22 meters X 12 meters. However, the size of the stacks will also depend on the size of the godown, the presence of pillars, drainage pipes, wall projections and the placement of doors. While preparing the stack plan, the following should be remembered . There should be space (minimum 0.8 meters) between wall and stack, and stack and stack. The stack plan should allow good ventilation through doors and the space between the stacks connecting the doors should be about 1.5 meters wide. This will also facilitate carrying bags in and out of the godown. The stack plan should ensure that the stacks are not built touching the pillars and vertical drainage pipes if they are in the godown. They must be left in the alleyways while making the stack plan. The space between the stacks on the longitudinal axis also should be about 1.5 meter wide to allow operations like carrying sand snakes, fumigation sheets, wheel barrow mounted sprayers etc.

If office space is considered necessary inside the godown, the stack plan should provide some space at one end of the godown where normal size bag stacks can not be built.

After deciding the stack plan, the dimensions of the stack must be marked on the floor through painting of stack lines (5 cm wide). Chalk lines are not permanent and soon get erased by the labour walking over it. It should be remembered that without boundary lines, the stacks can never be built properly by the labourers.

Dunnage :

Dunnage is a material placed beneath the bags. A wooden dunnage is made by nailing together short and long pieces of flat wood in a rectangular shape (1.5 meter X 1.0 meter). The specifications for wooden dunnage are given in annex I. Polythene sheet alone or sandwitched between two layers of mats (made of grass/stems/bamboo splits) can be used as dunnage. Wooden dunnage allows aeration of stocks and placement of aluminium phosphide tablets

moisture pockets on the top surface and sides, there will be mould development and caking of grain coupled with heating. Therefore periodical recording of temperature of the bulk grain is necessary to know the condition of grain.This is done using any of the different types of temperature measuring devices such as thermocouples which are installed in the bins and temperature readings are recorded in a control room. To prevent temperature gradients in the bulk grain and consequent translocation of moisture, aeration is resorted to. Airation ducts and a suitable fan (eg. exhaust type) is provided for this purpose. Cool and dry air will bring down temperature during aeration. In vertical silos transfer of grain from one bin to another bin is often done which will help in eliminating temperature gradients in the bulk of grain.

It is usually regarded that a silo will be constlier than the conventional bag storage. In addition, the infrastructural facilities like bulk transportation and bulk handling at the purchase and distribution centres will be required, which may not be possible to organise.

1.7 Open-Air Storage :

In times of surplus production and when heavy purchases are made, there will be shortage of covered accomodation with the purchasing agencies (government or government agents like corporations, agricultural bank etc.). It will also be difficult at such times to hire suitable covered accomodation from private parties, local government etc. Then storage in open air becomes necessary. However, this is not the best method of storage and therefore should be resorted to as an emergency measure and for limited periods only between consecutive rainy seasons. The following points should be kept in mind in case of open storage especially if it has to continue for longer periods.

The site selected for open storage should be above the adjoining ground and away from drainage system and canals to prevent possible flooding of the area. It is convenient to select a site with in the godown compound itself, otherwise it should be near marketing area with good approach road. Normally on such a site a plinth should be built with brick and mortar which should be about 15 cm above the ground level. If a plinth can not be built, stone ballast can be used to raise the ground level. The site should be cleared off vegetation and shrubs. Anti-termite treatment should be given if the area is infested with termites otherwise termites will damage wooden dunnage, jute

bags and that will result in the collapse of stacks. The storage space/ground intended for open storage should be sprayed with 50 percent BHC wettable powder by mixing 2 kg of powder with 20 litres of water and spraying at the rate of 3 litres per 100 sq. meters. It is necessary to spray this solution on the wooden dunnage as well if they are not painted with bitumen.

Stack plans should be drawn in advance. Stacks of the size 9.3 X 6.2 m will be convenient . The height of stacks can be upto 20 bags in case of sorghum and wheat. It is advisable to build the top of the stack in the shape of inverted 'U' to facilitate easy flow of rain water and prevent accumulation of water on the top surface, when covered. After the 15th layer, further stacking is done by reducing the number of bags on the breadth side in consequtive layers to obtain the shape of inverted 'U'. A layer of bags containing cut straw/husk on the top of the stack will help in minimising damage due to rains, birds, high temperature and condensation.

Use of dunnage underneath the bags is very important. Wooden crates with mats spread over it are preferable. If they are not available, wooden rafters, hollow cement blocks, according to the local availability can also be used. Another alternative is to use polythene sheet, sandwitched between two layers of mats.

It is advisable to cover the stacks with 800 - 1000 guage polythene sheets. After the cover is placed, it should be lashed to the stack with ropes which are tied to the dunnage. Mosquito net shape covers are most convenient to cover the stack. Such covers should have sleeves near the top edges of the stack on all four sides to act as outlets of air which will get trapped under the cover with high wind velocities. In preference to lashing with ropes, nylon nets can be used. When a number of stacks are built on a open site, the peripheral stacks should be built so as to act as wind breakers.

Care of polythene covers while handling needs no special mention. A sheet repair kit consisting of scissors, special adhesive tape, pieces of polythene sheet, sewing needle and thread should be available at the site of work. An electric iron or heat sealer will be necessary for repairing large tears in the polythene sheet. Inspection of covered stacks regularly is necessary to check for tears especially after heavy winds/rains.

Aeration of covered stacks is necessary to eliminate the problem of moisture condensation on the top surface. On all clear weather days, aeration

of stack is done by lifting the cover/sheet upto 4 to 6 bags and rolling up the sheets under the ropes. If the moisture content of the grain is less than 12 per cent areation should be done once a fortnight. If it is between 12 and 16 percent this practice must be repeated once in 3 days. If the moisture content is above 16 percent aeration must be provided every day till the moisture percentage comes to 16 percent and later as indicated earlier. With proper aeration ensured, no surface treatment with prophylactic chemicals will become necessary because the exposure to high temperature during day will bring the infestation under control. However when necessary, prophylactic and curative treatments should be given as described in the concerned sections of the manual. It is advisable to give the treatment druing evening hours.

If the open-air storage is built in dry climates and is planned to remove before onset of rains, the stacks can be left even without covering. Because of heat and ventilation resulting in dryness of grain, the insect problem will be minimum. Even in such cases it is advisable to check for infestation periodically and take remedial measures when necessary.

1.8 Under ground storage :

This type of storage is practised in many countries by farmers to store food grains. The shape, dimensions, lining given, ratio of underground and above ground portions differ widely. Large scale storage facilities of this type are available in Argentina, Cyprus and Kenya. In the latter two places, they are called Ctesephon bins or Wallerbins. These bins are partly underground and partly above ground and is circular at the ground level. In Turkey open bulk storage is practised with most or all of the quantity of grain (wheat) is above the ground and they are covered with polythene sheets and soil. These storages are rectangular at the base. The bunker storage in Australia is also partly underground and partly above ground and rectangular at the ground level. In developing countries, especially in arid or semi arid areas, there is a scope to use this type of storage when there is shortage of covered storage accomodation.

The main consideration in underground pit storage is location. The land selected should be on an elevated area. The water table should be much below the bottom of the pit through out the storage period. The soil should be firm for digging a trench. The area should not have been subjected to heavy rain fall during the last at least 5 years.

The size of the pit depends on the land available and quantity of grain to be stored in each pit. Sizes upto 100 meters in length can be chosen . However convenient width is about 10 meters due to problem of covering the pit at the end using earth loading machinery. The trench can be 2 meters deep. In case of smaller pits upto 250 tons, circular or rectangular trenches are dug manually. In case of larger pits rectangular trenches are dug using heavy earth scraping/digging equipment, along with a bulldoser. These pits or trenches are dug before/during summer months (Feb. - April) and left open for at least 3-4 weeks for drying. It is advisable to provide a lining of reinforced polythene sheet on the bottom over a layer of cut hay or dry grass/ leaves and also on the sides of the trench. Filling of the grain can be done using mechanical equipment like augers/chain conveyors/pneumatic conveyors. Other wise truck loads of bagged grain can be emptied into the pit. Manually the grain can be shovelled and heaped properly above the ground level. The grain will take a shape depending on the angle of repose. Data on angle of repose and bulk density of different food grains are given in annex III. The heaped grain should be covered with polythene sheet and mats made of local grass stems/leaves. Final covering should be done using soil and the thickness of soil layer should not be less than one meter. This can be done using heavy earth loaders. A drain around the storage should be made so that the rain water from the sloping storage structure is drained off to a far away place.

In case sophisticated underground pits, the whole pit is lined with cement concrete/brick walls and also made moisture proof. Over ground dome construction is also done to protect the grain from rain water. In such designs, the loading and unloading are done using pneumatic grain conveyors.

The grain selected for underground store should be dry and clean. With the respiration of grain and insects, if any, in the grain, the oxygen concentration in the inter granular space in the grain mass will fall down from the normal value and therefore there will be no insect problem. However, if the top soil cracks and the gaps are open upto the surface of grain, insects may survive on the grain surface. Covering of grain with polythene sheet before putting soil over it will eliminate this problem. The depletion of oxygen will be faster with mould damage of grain on the sides of pit. Under ground pits have the advantage of providing more or less even temperature in the grain bulk and thus reduce moisture migration problem to a great extent.

Quality monitoring systems include measurement of temperature, moisture

content of grain, insect activity and oxygen concentration. Grain samples can be taken using a thermo sampler or pneumatic sampler from different depths. With the thermometer provided in the thermosampler, temperature at different depths can also be recorded. However suitable arrangements have to be made on the top covering so that the instruments can be inserted to monitor the quality. Alternatively a built-in system for measuring intragranular relative humidity and temperature can be provided at the beginning itself. Temperature and relative humidity measuring probes are also available.

Another point to be remembered is rodent problem. Rodent problem is rather heavy in many areas. The rodents may make holes on the sides and on the above ground portion of the pit which may lead to water leakage into the pit during rains. Therefore rodent control using zinc phosphide baits and fumigation of burrows using aluminium phosphide tablets is necessary. These operations may have to be done frequently.

Even if the grain quality monitoring is omitted during prolonged storage, the site of the pits should be visited regularly once in 2 weeks to check rodent problem and also to cover the cracks on the surface of the pits. This will prevent entry of atmosphere inside the pit and also rain water. This inspection is a must in case of pits where polythene covering on the grain in the pit is omitted for one reason or the other.

At the end of the storage period, great care is necessary to remove the top soil before reaching polythene or grass mats covering on the grain. Preliminary removal of soil is done using earth loading machinary and the final cleaning is done manually, in case of large pits. In smaller pits, the whole operation is done manually . A little negligence will puncture or tear the polythene/ grass mat covering and results in heavy contamination of soil with grain.

Unloading of grain from the pits is done as in the case of loading using either mechanical equipment like pneumatic conveyors/augers coupled with weighing, bagging and stitching machines or manually. In the latter case, the bags are filled in the pit and carried to the trucks standing on the sides of the pit. In case of pits without lining, the grain from the sides and bottom of the pit, will contain more of soil and it requires segregation and cleaning. If discoloured and damaged grain is noticed while unloading, it has to be segregated, cleaned and if necessary dried for appropriate disposal. If insect infestation is noticed in some pockets (on the outer surface of the pit), the grain will require disinfestation in the godown.

CHAPTER 2
QUALITY ANALYSIS OF FOODGRAINS

CHAPTER 2

QUALITY ANALYSIS OF FOODGRAINS

2.1 Analysis of Grain :

Information on quality of grain is required at the time of purchase, receipt of grain at the godown, during storage and at the time of issue. At the time of purchase it will indicate its commercial value. At the time of receipt and during storage, the quality data would indicate actions to be taken such as disinfestation measures, drying, segregation of damaged grain. At the time of issue, the data would indicate whether quality conforms to market standards and also to regulations, if any, of the national government. The quality data will asume more importance when grain has to be marketed outside the country.

The quality of grain is determined by analysis of physical parameters and bio-chemical parameters. The physical parameters are general appearance, smell, moisture content, inorganic and organic impurities, immature and shrivelled grain, damaged and discoloured grain, broken grain, other food grains, admixture of other varieties, weevilled (insect attacked grain) and hecto-litre/bushel weight. The bio-chemical parameter is mainly protein. In case of wheat, gluten content (dry or wet), amylase activity/falling number value, loaf volume are also determined which are necessary from the end-use point of view. In case of grain intended for seed or malting purposes, the viability of the seed grain is also important.

Other quality factors are contamination of grain infested by diseases like smut, bunt and ergot. Examination is also made for presence of living and dead insects and pesticide residues, if any, as a result of disinfestation measures taken up during storage. In case of groundnut, especially, examination is made for presence of aflatoxin.

In addition, there can be contamination with harmful substances like pesticides, fertilizers, etc. during transportation and storage and that will make the grain unfit for food and feed purposes.

For examination of physical parameters, simple laboratory equipment will be sufficient. But for chemical and biochemical analysis more sophisticated equipment will be required and that can be provided only at selected places depending upon the requirements. A list of equipment needed for a regional

head office laboratory for physical analysis of grain is given in annex IV.

Sampling of Grain :

The main purpose of sampling and analysis of grain is to know the exact quality of grain . Drawing of representative samples is an important and essential part in sampling of grain. If the sample obtained is not representative, no amount of care in analysis will determine the true quality of the grain. Careless and inaccurate sampling will lead to wrong decisions.

Terminology Used :

Consignment :

The whole quantity of grain, intended to be of the same quality, which needs examination.

Lot :

A proportion of the consignment taken for evaluation of quality.

Primary Sample :

The quantity of grain taken from a single position in the lot.

Composite sample :

The quantity of grain formed by combining and blending the primary samples.

Test Sample :

The sample obtained by reduction of the composite sample and which is intended for physical and chemical analysis.

Sample for moisture :

A small sample of weight required for moisture determination, obtained from the composite sample.-

Procedure for sampling of bagged grain :

The scale of sampling is given below :

Scale of sampling

No. of bags in the lot	Number of bags to be sampled
Upto 100	20
101 - 300	32
301 - 500	50
501 - 1000	80
1001 and above	125

The bags should be selected at random. In order to ensure the randomness of selection, a random number table has to be used. Sampling can be done easily when the bags are being brought for stacking or when the bags are being removed for moving out of the godown. When sampling has to be done from bags in a stack , the following procedure is adopted. Samples are taken from four sides and top layer. From the sides and top surface the bags are selected at random for sampling, keeping in mind to select bags from different layers and different positions. Where necessary a ladder is used to reach bags high in the stack for sampling . In case of top layer, at 5 places selected at random, 2 or 3 bags are lifted and samples are taken from the deeper layer of bags.

Primary sample of grain is obtained using a slotted tube sampler or a simple grain sampler. In case of slotted tube sampler, it is inserted diagnolly in about one third of the bags to be sampled, length wise in another one third and width wise in the remaining one third. Each bag is sampled only once. Use of samplers is described in para 2.2.

Procedure for sampling of bulk grain :

Sampling of bulk grain is done using an appropriate sampler. In small heaps, slotted tube bag sampler is satisfactory. If bigger depths are to be sampled, double tube sampling probe or deep bin probe has to be used. Spots should be selected for sampling at various depths and places. The number of spots from which samples are required to be drawn should be according to the scale of sampling given below. In case it is not possible to reach the pre-arranged depths, samples should be drawn while the material is moved out or pneumatic sampler has to be used. Spots for sampling should be selected at random.

Scale of Sampling

Quantity of consignment	Number of spots from which samples to be drawn
Upto 300 Tons	30 spots
301 - 1000 Tons	50 spots
1001 tons and above	100 spots

The primary samples are examined and if they are found to be homogeneous in quality, they are allowed to go into the composite sample. In case of wide discrepency like high amounts of impurities, brokens, damaged grain, insect infestation etc. the bag from which the primary sample has been collected is marked visibly and the primary sample is kept separately.

The composite sample (about 2000g) is mixed well by coning method to obtain a homogeneous sample. This is done on a polythene sheet or wooden board or in a big flat plate. By shovelling the grain from the periphery of the cone to the apex, while circling the periphery, complete mixing of the product will occur. This is best done by hand.

Sub division of the sample is done using a sample divider (e.g. Boerner divider) which divides the sample into 2 halves. The division is done twice to obtain 500 g. sample. Subdivision can also be done by Quartering method from the coned heap of grain obtained while making a homogeneous sample. This is done by dividing the bulk into halves and then quarters using a flat piece of wood. Each quarter will be about 500 g.

Thus the compositesample is divided into 2 or more test samples as necessary. One sample is for moisture measurement and the second one for refractions, insect count etc. The sample for moisture (about 250 g. or more as required for the moisture meter used) is first placed in a polythene bag and heat sealed or tied well. This is placed in a close fitting cloth bag.

If required three sample bags are prepared, sealed and distributed one each to the buyer and the seller and the third is kept securely for future reference purposes. All analysis are to be carried out within 48 hrs after taking samples.

Foreign Matter :

The test sample is weighed and the weight is recorded. The test sample

is poured overaset of sieves with 4.00 mm, 3.35 mm, 1.70 mm 1.00 mm diameter round holes, previously arranged in a way so that the sieve with the largest perforation comes at the top and those with smaller perforations are placed in the order of their sizes. The pan without perforations will be the last one at the bottom. The sample of grain is agitated thoroughly. Foreign matter will separate out as per their sizes. Bigger pieces of clay, chaff etc. will remain on the first three sieves and fine dust will come down to the bottom pan. The sieves are separated and all foreign matter both organic and inorganic are collected on the bottom pan by forceps. The total foreign matter is weighed and the percentage calculated. If necessary, organic and inorganic foreign matter are separated and calculated separately.

Refractions other than Foreign Matter :

After the removal of foreign matter, the contents on the four sieves are mixed and spread out evenly on a flat smooth surface in a circular layer. From this spread of grain, exact amount of grain as indicated in table below is taken from different sides and the middle by means of small scoops. The weighed quantity is placed on an enamelled plate. Then various items of refractions other than foreign matter are picked by hand with the help of magnifying glass where necessary, in the order given in the table below. Each refraction is counted only once.

The separated refractions are weighed on a physical balance and the percentage of various individual refractions are calculated. The analysis is carried out in triplicate and the mean taken for reporting.

Quantity of Sample to be taken for determining refractions other than foreign matter

Food Grains	Weight (g) (minimum)
Wheat	50
Maize	50
Rice	20
Barley	50
Chick pea	50
Other pulses	25
Sorqhum	25
Millets	20

to black. Some times the dark colour spreads around the germ portion of the kernel and can be identified by visual examination.

(b) Pesticides :

Insecticides and fumigants are used extensively for disinfestation of food grains. Mixing of insecticides in the foodgrains much more than recommended dosages is done by farmers out of ignorance of the toxic hazards of consuming contaminated grains. Tolerance levels for the permitted insecticides & fumigant residues in foodgrains are suggested by WHO/FAO Codex Alimentarius Commission. Those standards or national standards if any, should be the guiding factor for judging the acceptability of foodgrains with pesticide residues.

(c) Miscellaneous materials :

A number of chemicals etc were reported to have got mixed up in foodgrains due to faulty method of storage and transportation. In this class are such materials like pesticides, lubricants, metal chips, fertilizers, cement etc. In such cases, careful segregation of uncontaminated foodgrains will be necessary and if it is not possible the whole lot has to be declared unfit for human consumption.

Terminology : (Ref. No. 11)

(a) Foodgrains : Foodgrains are edible cereals, millets and pulses.

(b) Refractions : The term applies to all components of grain which differ from sound grains.

(c) Foreign matter : Includes organic and inorganic matter. The inorganic matter is sand, gravel, dirt, pebbels, stones, lumps of clay and mud. The organic matter is chaff, straw, weed seeds, and inedible grains. In case of rice, paddy is considered as foreign matter.

(d) Other food grains : Any food grain other than the grain concerned.

(e) Varietal admixture : The presence of variety of the same grain other than the variety under consideration constitutes varietal admixture.

(f) Shrivelled/immature grain: Kernels or pieces of grain kernels that are not fully developed.

(g) Brokens : Pieces of kernels that are less than $\frac{3}{4}$ of the full size of kernels.

(h) Damaged grains : Kernels or pieces of kernels that are sprouted or

deeply discoloured and internally damaged as a result of heat, microbes and moisture.

(i) Insect damaged grain : Kernels that are partially or wholly bored/ damaged by insects.

(k) Fragments : Pieces of kernels that are less than one - eighth size of a full kernel.

(l) Chalky grain : In case of rice, kernels or pieces of kernels of which at least half the portion is opaque/milky white in colour and brittle in nature.

(m) Red grains : In case of rice, kernels or pieces of kernels having more than one - fourth of the surface covered with red cuticle.

2.2 Care During Purchase of Foodgrains :

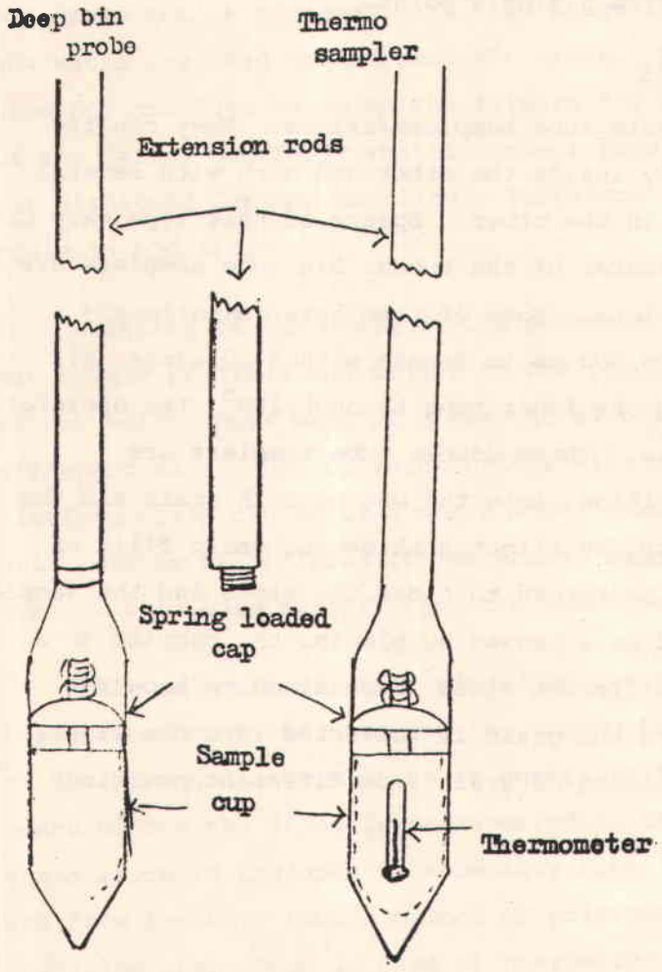
When purchase of grain has to be done, it is obligatory to follow the quality specifications prescribed by the competent authority. In the specifications , the maximum limits allowed for each refraction will also be indicated. In certain countries, in addition to prescribing individual limits for various refractions, a total limit for some refractions is also prescribed. This total limit will be less than the sum total of the limits prescribed for the individual refractions. In some countries, instead of giving limits for individual refractions, an overall limit is prescribed for 5 or 6 items. This could lead to confusion especially when only one or two items are present upto the total limits. Typical quality specifications of sorghum are given in annex VI.

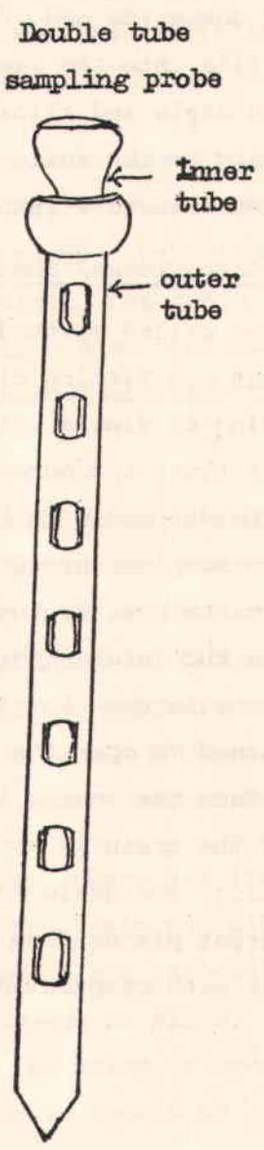
It is necessary to examine a representative sample from the lot offered for sale. If the lot is a lorry load of bags, samples of grain have to be collected from the bags selected at random and combined to make a composite sample. If the lot is loose grain, samples of grain are collected from different spots and depths and combined to make a composite sample. Scale of sampling in case of bagged grain and bulk grain is given in para 2.1.

When the market arrivals are huge, only visual examination of grain is done to judge the quality at the purchase points. In some cases, a simple sieving is done to remove fine dust, broken grain, small sized weed seeds and the relative quantity of the sieved out material is judged visually to decide whether to accept the grain lot or not. Visual examination is done even when there are more than one grade of quality. In these cases, experience is

Fig 2

Grain Samplers





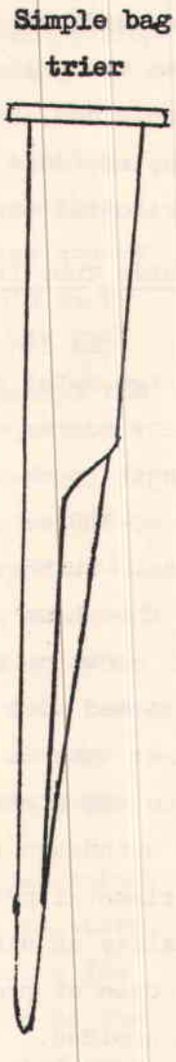
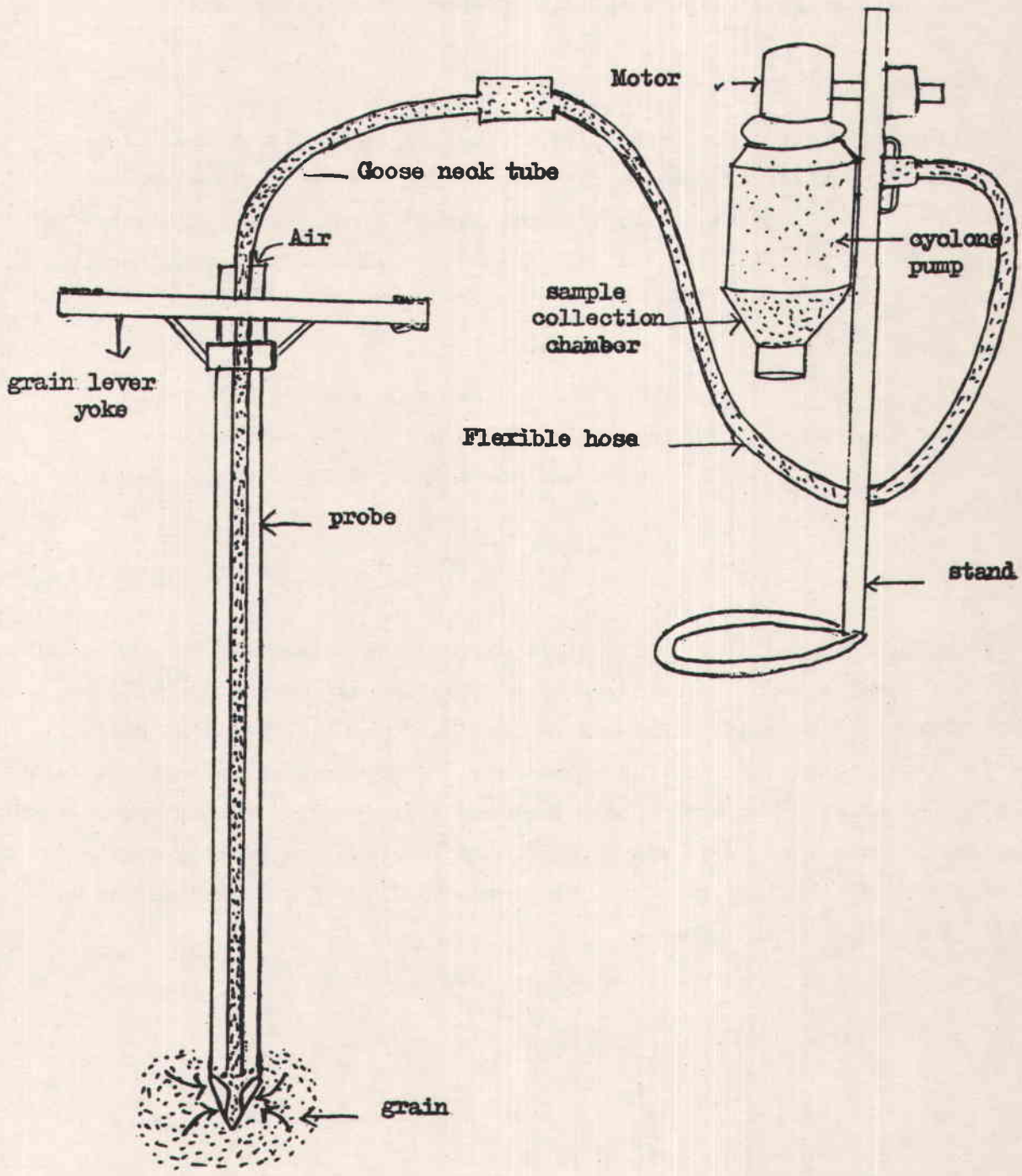


Fig 3

Probe - A - Vac. Sampler



Thermo Sampler:

It is similar to the deep bin probe but with a thermometer inserted into hollow spear head. The nose/tip is removed by simple twist. Temperature is read from the thermometer and sample is collected for further tests.

Truck Sampler :

This is used for catching samples of grain from trucks as they are unloaded. The sampler is used to cut through the stream of grain several times to obtain representative samples. It consists of a round steel container 305 cm long and 11.4 cm dia. with a 2.9 cm lengthwise slot and a wooden handle.

Pelican Grain Sampler :

It is used to obtain samples from a falling stream of bulk grain as in the case of loading a ship from a silo. The pouch of the sampler is approximately 45 cm long, 5 cm wide and 15 cm deep, made of top grade hide rivetted to a frame.

Pneumatic Grain Sampler :

The Cargill probe - A. Vac model is claimed to get samples from about 30 meter deep also. A motor (0.87 HP) powers a cyclone air pump to provide the suction force for pulling up the sample grain and pushing the probe further into the grain mass. The sampling probe consists of a number of long aluminium tubes joined together by spring lock lugs and a tip section through which sample grain is obtained. The tubes are double walled so that the sucking action inside the inner tube combines with the downward flow of air between the tubes to lift the sample grain upwards.

CHAPTER 3
CARE OF FOODGRAINS AT THE TIME OF STORAGE & ISSUES

CHAPTER 3

CARE OF FOODGRAINS AT THE TIME OF RECEIPT, STORAGE & ISSUES

3.1. Receipt of foodgrains:

Food grains are received in a godown directly from the procurement points or as a transfer from another purchasing agency or as a transfer from another godown, or from the port in case of imported grain.

Along with the grain consignment, there will be a despatch note indicating details such as despatching station, number of truck/wagon and also the name of the commodity, variety, quantity in weight and number of bags, quality, grade, categorisation etc.

Inspection of foodgrains at the time of receipt in the godown is necessary for many reasons. It will help to know whether the grade, quality, and variety mentioned in the despatch note tally with the grain received in addition to the number of bags and their weight. Secondly it will reveal damages which might have occured in transit. As the store keeper (or inspector) will be responsible for further maintenance of the grain stock in sound condition, he will have to know and record the initial condition of the grain received in his godown.

When a lot of foodgrain bags arrives at the godown, the grain bags have to be carefully examined while being unloaded from the truck/wagon. If some bags are found torn, leaking from the mouth or seams, or they are wet or containing heavily infested grain, they should be segregated for taking remedial action. Slack bags have to be filled to standard weight. Torn bags are replaced or mended suitably. Leakage of grain from the bags should be prevented by proper stitching. Wet bags should be opened and the grain dried. Heavily infested grain has to be cleaned and fumigated.

Representative samples of grain are drawn from each wagon or lorry at the time of unloading for analysis for quality, moisture content, insect infestation and damages and categorisation as per standing instructions. The principle of sampling and analysis are described earlier. A grain analysis report is prepared for submission to the regional office. A grain analysis report form is given in annex Vll.

The number of bags in each wagon or truck is counted and their weight recorded. In case of bags standardised at the purchase centre, 10% of the bags only can be weighed to recheck the weight. If the variation in weight of one bag on the average is more than 500g. then the entire lot has to be weighed. In case of bags not standardised at the purchase centres, 100% weighment will be necessary. This can be done by weighing the truck with bags first on a weigh-bridge and later truck without bags. The difference will give the weight of grain bags. The net weight of grain can be found by deducting the weight of empty bags from the gross weight for which average weight of ten empty bags selected at random, is taken.

It is necessary to collect spilled grain while unloading the truck or wagon, transporting the bags (manually) to the weighing scales and from there to the stack. Wherever cement flooring is not present, tarpulins or old and discarded fumigation sheets should be spread on the ground so that the grain falling from the bags may not get mixed up with soil. The spilled grain so collected should be cleaned, bagged and weighed before placing them on the stack.

Unloading of a truck or a wagon should not be done in rainy weather. Unloading of a truck should be completed by the end of the day and partly unloaded truck should not be left overnight. Trucks should not be allowed to enter the godown as it may damage the floor or the leaking engine oil etc. will lead to contamination of foodgrains. Many times, the trucks damage the walls and doors of the godown too.

3.2. Storage of Foodgrains

Even when a godown selected satisfies all requirements and stacks are built properly, it should not be assumed that food grains automatically remain in good condition. As has been explained earlier both biological and non biological factors play their roles resulting in losses in foodgrains both in quality and quantity. The foodgrain stocks received may contain visible or latent insect infestation in the form of eggs and immature stages in the grain mass and within the grain kernels. In case of latent infestation, adult insects will emerge only after a few weeks of storage. There can be leakage of water during rains or rodents and birds may cause damage during storage. Therefore periodic inspection of the godown is essential.

Inspection is carried out firstly with reference to the condition of the godown and secondly with reference to pest problem and causes for damages in grain.

The condition of the godown is checked with reference to godown hygiene as indicated in para 3.7. Before and during the rainy season, it is very essential to check the drainage system, and also near the doors, windows and ventilators whether water enters into the godown and if so remedial action has to be taken wherever necessary.

When the godown is closed, there will be increase in humidity due to driage of grain, biological activity of grain and insects if any. There will be increase in temperature from heat radiations through walls and roof during day time which is more pronounced during hot days. Increase in humidity and temperature will favour development of insects, mites and psocids in the grain. Also there will be musty odour. This can be noticed when the doors of the godown are opened after a long time. Therefore it is necessary to open the doors and ventilators on all days when the weather is clear. However the godown should be kept closed on days when the weather is humid or on rainy days to avoid entry of humid weather inside the godown.

Inspection for pest problem consists of : (a) checking for rodent activity (b) bird activity and (c) insect infestation.

The inspection for pest problem should be done once in a fortnight. Rodent & bird infestation and their control are discribed separately.

In case of insect infestation, the following procedure should be adopted. The floor around the stacks and the surface of bags should be examined for live insects. Care should be taken to examine the folds on the mouth and ears of the bag and also where two bags touch each other. Khapra larvae and moth larvae are found in such places. Examination of floor and bag surface on the dark side of stack for presence of insects is important. Striking the bags with palm also will induce the insects to come out of the bags. In case of khapra beetle infestation, it is usual to see large amounts of excuvae on the floor around the stack. Inspection at dusk with lights switched on in the godown (or using a torch light) will reveal the activity of flying insects. (eg. moths and red flour beetle). Infestation by Rhyzopertha spp. can be recognised by round spots (0.5 cm dia) of oozing flour on the surface of bags. As the Rhyzopertha spp. tend to be in pockets, such spots of oozing-flour can be found in large numbers on some bags here and there and not necessarily on the outside of the entire stack. Presence of adult moths on the walls & webbing on the bags are good indications of heavy infestation by them. White powder formation on the bags is a good indication of the insect activity, especially of Rhyzopertha spp. in the bags.

In case of light insect infestation, special techniques are used for its detection. This consists of using simple traps. One trap is a simple piece of corrugated cardboard (4 cm wide & 20 cm long). It is placed in between the bags overnight. Insect larvae and adults also will be found in the trap if present in the bags. Pieces of piping (30 cm long and 10 cm in diameter), are covered outside with grease coated polythene sheet and suspended from the roof of the godown at various heights to trap flying insects. In case of bulk grain, a tube trap is used. A polythene tube wrapped in rough paper but with the

top end open is inserted up right in the bulk grain. Many species of insects(eg. Red flour beetle) falling into the tube will not be able to escape because they can not climbsmooth surfaces. Phermone traps, which are commercially available are used to attract moths.

When insect infestation is noticed, it is necessary to determine the level or degree of infestation for taking appropriate action. For this, samples of grain (about 2 kg) are collected from the bag stack as described in para 2.1. The grain is weighed and sieved using a sieve (1.7 mm round holes). Whole grain remains on the sieve and dust along with fine broken grain and insects comes down. This fraction is sieved again, if necessary using finer mesh sieve (1.0 mm holes) to remove fine dust. All the fractions are examined for the species and number of insects, and the total count is expressed as number per kg. of grain. In case of heavy infestation, smaller portion of the grain sample is sieved to separate insects.

The lot of grain is classified on the basis of species of insects and their numbers as follows:

Major insects number/kg of grain	Minor insects number/kg of grain	Classification
Nil	Nil	Clear
Upto 3 (4)	Nil	Few
Nil	Upto 5 (10)	Few
above 3 (4)	Nil	Heavy
Nil	above 5 (10)	Heavy
above 3 (4)	above 5 (10)	Very heavy

The classification 'few' indicates need for prophylactic spraying and classification 'heavy' indicates need for fumigation or disposal of stocks early. A slight liberal classification can be adopted as indicated by the number of insects within brackets when there is limitation of trained staff, cost of disinfestation treatments is high and supply of pesticides is in-adequate. Once these hurdles are removed the above classification can be introduced. Attempts should be made to make the classification more strict, if it is economically feasible.

Sometimes it may happen that insect infestation in the sample is under the classification 'clear' but huge numbers (patches) of khapra beetle larvae or their cast skins or other insects (Tribolium species) are noticed on the floor around the stack and over the bags. Such circumstances warrant cleaning of bag surfaces and alleyways followed by prophylactic treatment.

3.3. Inspection of food grains at the time of issue:

Inspection of foodgrains at the time of issue is as important as at the time of receipt. The foodgrains are issued out of the godown either as a transfer of stocks to another godown, or for consumption or sale or for exports. A despatch note has to be prepared giving the grade, quality, variety, along with the number of bags and the total weight. For this purpose quality check has to be done as explained earlier in connection with receipt of grain. If necessary actions such as cleaning, drying, separation of damaged grain, fumigation have to be taken, so that acceptable quality of grain only is issued out.

A system of categorisation of foodgrains is also used in India which indicates the extent of insect damage to the grain and its suitability for issues to the consumer directly. In case of wheat and sorghum, the grain is categorised as follows:

Category	Percentage of weevilled/germ eaten grain
A	Upto 1%
B	Above 1 and upto 4%
C	Above 4 and upto 7%
D	Above 7 and upto 15%

The basis of categorisation is by volume. 20 ml. of the sieved test sample is measured and is spread on an enamelled plate. The weevilled grain and those which are slightly insect damaged or germ eaten are picked out and measured separately. For calculation of

percentage of weevilled/germ eaten grain, full value (in mls) of weevilled grain is taken and 1/3 the value (in mls) of slightly insect damaged and germ eaten grain is added to it. From the total value obtained, the percentage is calculated.

A & B categories of grain are issued directly to the consumers while C & D categories are issued to flour mills on the condition that the grain is cleaned/washed before grinding it.

Another important point is to determine the loss or gain in weight in every stack issued out. Loss occurs due to several factors as explained earlier and the gain occurs by absorption of moisture by grain from the atmosphere. Therefore recording of moisture content of grain at the time of receipt and issue is necessary. Determination of loss or gain is important even in case of bulk grain stored in silos and underground pits.

3.4. Damaged foodgrains and its disposal:

Kernels or pieces of kernels that are internally damaged with heavy discolouration as a result of heat, microbes and moisture are called damaged kernels. Damage to grain of this type occurs when wet grain is kept even for a few days in tropical climate without drying. The grain may be wet at the time of harvest itself. This happens in case of crops which are harvested at the time of rains. Paddy, sorghum and maize crops are harvested in some areas during monsoon weather. However in clear and dry weather, the harvested crop dries up very fast to lower & safer moisture levels (less than 13%). The harvested crop can become wet in the threshing yard due to unexpected rains. The grain can become wet during transportation. In storage the grain can become wet during rains as a result of leaks in the roof, splashing of rain water through the doors, windows and ventilators into the godown, overflow of drainage gutters located inside the godown and through flooding of the area. Grain bags may become wet on the bottom layers when the flooring is not made damp proof through seepage of water. Even in case of cemented floors it is observed that due to condensation of evaporated water (from the grain) on the floor,

the bags touching the cemented floor can become damp. In case of bulk grain, moisture migration takes place in the bulk of grain due to changes in temperature during the day and in different seasons and the moisture content goes beyond 16% in some pockets. High moisture levels will favour mould development resulting in heating, discolouration and caking of grain. Such damaged grain may contain mycotoxins if the fungal organisms are such which produce mycotoxins like Aspergillus flavus. Even otherwise, the damaged kernels will have much less nutritive value than sound kernels. In some countries, a maximum limit is fixed (eg. 5% by weight) for the presence of such damaged kernels, in a lot of grain beyond which the lot is considered unfit for human consumption.

Disposal of damaged foodgrains:

The damaged stocks that are received in the godown or occuring during storage, should be properly checked and segregated. Salvaging of good grain has to be done carefully. There will be 3 kinds of grain after segregation and salvaging operations (a) sound grain (b) grain containing partly damaged grain (c) grain containing high percentage of damaged grain. The grain lots are categorised on the following basis:

Sr No.	Percentage of sound/slightly damaged grains (including brokens & refractions other than foreign matter)	Category for which the stocks may be declared fit
1.	70 - 85	Cattle feed
2.	55 - 70	Poultry feed
3.	30 - 55	Industrial use
4.	Less than 30	Manure

The responsibility for categorisation of lots, less than 50 tons, can be given to the regional office, who will form a categorisation committee consisting of members from quality control, accounts, finance, marketing and storage divisions. In case of lots more than 50 tons, the categorisation committee should have people from the head office

as well; representing quality control, accounts, finance, storage & marketing divisions. The main function of these categorisation committees is to categorise the lots referred to them by the store keepers as quickly as possible and decide the category for disposal. These committees will consider the results of analysis of samples of segregated lots drawn in their presence, regarding appearance, colour, smell etc. in addition to the guidelines provided for categorisation. A report on damaged foodgrains is prepared including grain analysis report and the categorisation committee will record their recommendations on it. A form for reporting is given in annex Xl. On the basis of recommendations of the committee, the regional officer will take immediate steps for the disposal of the damaged grain lot, after obtaining proper quotations for lifting such stocks and under intimation to the Head Office. It should be remembered that such damaged grain will be a source of insects for infesting sound stocks in the godown and therefore those lots should be disposed off as early as possible.

In times of shortage there is a chance that such damaged grains may fall into the hands of unscrupulous traders who may sell it to consumers after cleaning and upgrading by mixing with good grain. Therefore it is essential to sell such lots to government agencies or recognised cattle and poultry feed manufacturers or starch making industries, directly and not through agents. A certificate should be obtained from the purchasing agency that they would use the lot only for the purpose for which it is categorised and sold and not for reselling and transferring to another person or agency. The regional offices should keep a list of such government agencies or private parties who would be needing damaged grain of different grades.

Once the damaged grain is disposed off, the empty bags and dunnage material used need disinfestation. Also the area where the damaged grain lots have been kept should be sprayed with 1-2% solution of malathion E.C.

3.5. Disposal of sievings:

There are times when large scale sieving operations are carried out even using mechanical grain cleaners in a godown. This will become necessary when the grain gets heavily infested during transit or long storage (when grossly neglected). Initially also the grain may contain higher percentage of inorganic and organic foreign matter including brokens and that will necessitate cleaning before issues or export.

The sievings will contain inorganic foreign matter like mud balls, dust & stones and organic foreign matter like cereal dust, glumes (in case of sorghum), chaff and small broken grain. In silos usually, there will be accumulation of such material collected through cyclones and mechanical cleaners.

These sievings have a value depending upon the organic matter content and can be used in the preparation of cattle & poultry feeds. As in the case of disposal of damaged foodgrains, the sievings also have to be accounted for and disposed of. The same categorisation committees can be entrusted with this work.

3.6. Disposal of damaged and torn jute sacks:

Damaged and torn jute sacks will accumulate in godowns and that will be a source of insect infestation to fresh stocks of foodgrains. A report on the quantity of such jute sacks available along with reasons for damages has to be prepared by the store keeper and submitted to regional/head office, with a request for permission to destroy them. A systematic accounting and writing off is necessary as those jute sacks represent an investment made by the organisation and therefore has to be properly accounted for in the records. After receiving written permission for the disposal of damaged/torn jute sacks, they should be burnt rather than throwing them away.

3.7. Godown hygiene & general maintenance:

Godown hygiene and general maintenance are important codes of storage practices. They not only give a tidy appearance to the godown but also reduces pest problem and prevents losses and damages to food grains. Guidelines for godown hygiene and general maintenance are given below:-

1. Cracks & crevices in the walls and floors should be repaired. The drainage pipes and gutters in the godown should be kept clean. The doors and ventilators should be in good operating condition and tight fitting with out gaps. The roof should not allow rain water to leak inside the godown.

2. The area surrounding the godown also should be cleared of shrubs/ bushes etc. and drainages maintained clean.

3. Rat burrows should be closed after fumigation with aluminium phosphide pellets/tablets, with glass pieces, stones and mud/ cement.

4. The wall surfaces, wall and roof joints, roof trusses, ventilators, doors, pillars etc. should be swept/brushed.

5. The surface of bags in stacks should be brushed lightly to remove dust, powder of food grain formed as a result of infestation, dead and living insects and webs. Brushing of bags after fumigation also should be practiced.

6. The floor between the stacks, stack and wall, at the entrance door and store corners etc. should be cleaned well. The sweepings should be collected in bags and disinfested. Disinfestation can be done either separately under a gas proof sheet or by including these bags in a stack while fumigating it. The fumigated sweepings can be sieved and cleaned for salvaging foodgrains and rest disposed off. Non fumigated sweepings should never be sieved inside the godown. Sieving should be done outside the godown

and the dust, insects etc. collected should be burnt or buried. The cleaned grain should be fumigated.

7. Unwanted and broken furniture, old bags etc. should be removed from the godown where food grains are stored, as the tendency is not to attend to these material and thus are always found covered with dust and webs. They form a source of insect infestation of foodgrains. They also give good shelter to rats/ mice where they can breed well.

8. All doors and ventilators should be opened on clear days (not on rainy days) to allow good ventilation which will reduce humidity, temperature and musty smell in the godown.

Once the work on godown hygiene is started, it should be continued on a regular basis. The frequency of operation should be decided by the godown in-charge and he should be made responsible for maintaining the godown hygiene inside and outside.

Equipment:

Every godown in-charge is responsible for hygiene and proper maintenance of his godown. Normally civil maintenance work of the godown building will be carried out by the engineering division but small minor repairs which require only a few minutes effort can always be undertaken by the godown in charge himself with the assistance of his labour. Such minor repairs will not require a great deal of training and can be carried out if a few simple tools are available. A list of equipment and tools needed for improving hygiene and proper maintenance of the godown is given below :

2 sickles, 2 shovels, 1 spade, 2 steel buckets, 2 dustbins, 10 large brooms, 50 kg hydrated lime, 50 kg cement, 2 paint brushes, 10 kg. paint for painting floor lines, 2 kg primer or enamelled paint for steel work, 1kg lubricating grease, 5 litre of bitumen, linseed putty (majun) in a sealed container (about 1 kg), 1 roll of electric insulating tape, a box of nails and

screws, knife, mason's trovel, adjustable wrench, a heavy chisel, carpenter's and electricians screw drivers and hammer.

In addition to the above, the godown in-charge should have 2 big hand sieves (1.00 x 0.5 meter) for cleaning spilled grain, 6 tarpaulins for collecting spillage from trucks, 2 ladders for climbing on the roof and on the stack, dust masks, a powerful torch, empty jute bags, adequate quantities of needle and twine for stitching bags and a platform scale. The godown keeper should make proper arrangements for storing them.

3.8. Periodical reports:

Recording and reporting of observations and action taken in a godown (or at the site of underground pits) are important codes of practices. This will discipline the staff at the godown level and will enable the regional and head quarters to know the condition of foodgrain stocks at different places. This will not be complete until the regional and head office staff also make regular and surprise visits to the godown and sites of underground pits to check themselves the condition of stocks and whether the recording and reporting are alright.

The reports which head office should get from the godown through regional offices are as follows :-

1. Monthly report on stock condition and action taken (annex Vlll a)

2. Monthly report on underground storage pits (annex Vlll b)

3. Quarterly report on stock position of empty jute sacks (annex lX)

4. Report on storage loss or gain, as soon as a stack of foodgrains is completely issued out (annex X)

5. Analysis report on damaged foodgrains, as and when necessary (annex Xl).

CHAPTER 4
STORED PRODUCT PESTS AND THEIR CONTROL

CHAPTER 4

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4.1 Insects

Adult insects are distinguished from all other animals by the following features. The body is segmented and has three parts, the head, thorax (mid - body) and abdomen. The head bears eyes, mouth parts and a pair of antennae (feelers). The thorax bears three pairs of legs and usually one or two pairs of wings. The abdomen contains digestive system, excretary and reproductive organs.

Amongst the insect pests of stored agricultural commodities there are 13 species which are of importance in tropical climates. They are as follows (Fig. 4) :

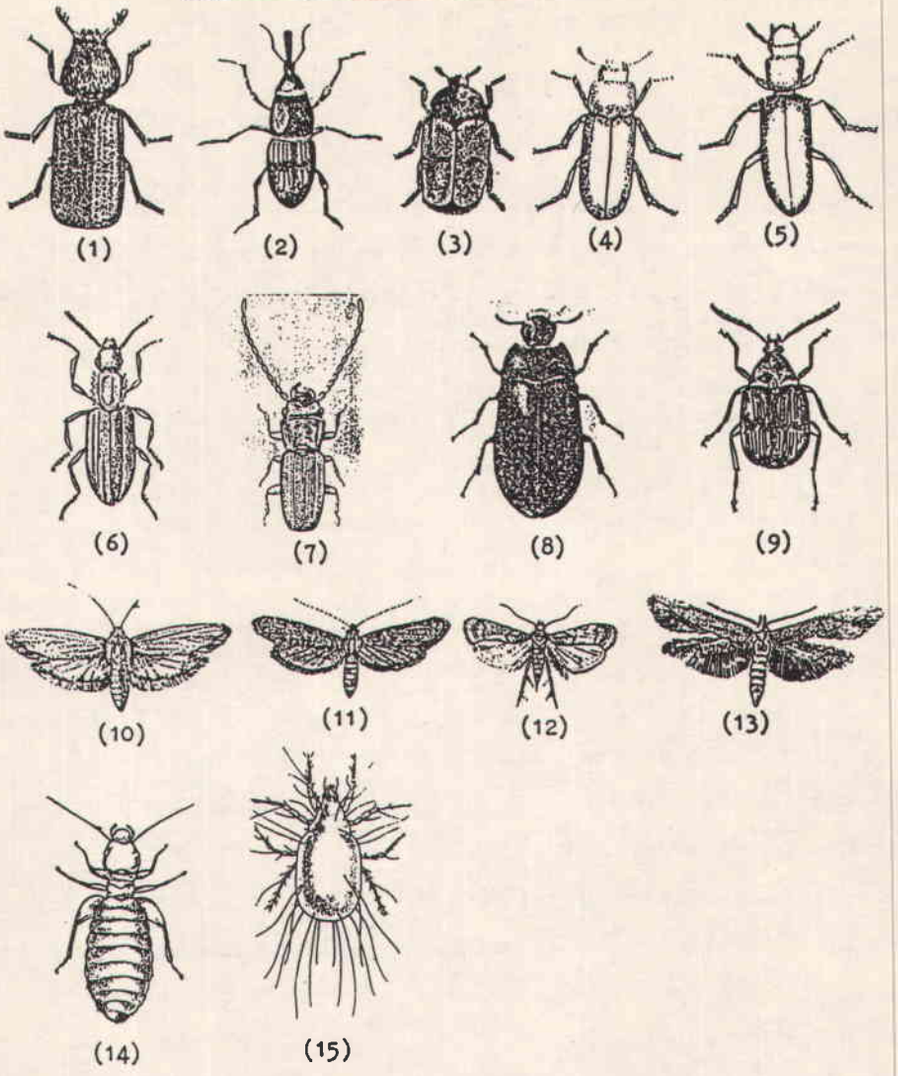
Scientific name	Common English name
1. Rhyzopertha dominica (Fabricus)	Lesser grain borer
2. Sitophilus oryzae (Linnaeus)	Rice weevil
3. Trogoderma granarium (Everts)	Khapra beetle
4. Tribolium castaneum (Herbst)	Red flour beetle
5. Latheticus oryzae (Water house)	Long headed flour beetle
6. Oryzaephilus surinamensis (Linnaeus)	Saw toothed grain beetle
7. Laemophloeus minutus (Olivier)	Flat grain beetle
8. Alphitobius piceons (Olivier)	Black fungus beetle
9. Pachymerus (Bruchus) chinensis (Linnaeus)	Pulse beetle
10. Corcyra cephalonica (Stainton)	Rice moth
11. Cadra (Ephestia) cautella (Walker)	Almond moth
12. Plodia interpunctella (Hubner)	Indian meal moth
13. Sitotroga cerealella (Olivier)	Angumois grain moth

In addition, there are other insects which become economically important at some places. They are maize weevil (Sitophilus zeamaize) (Motsohulsky), cadelle beetle (Tenebroides mauritanicus (Linnaeus), bisouit or drug store beetle (Stegobium paniceum (Linnaeus), cigarette beetle (Lasioderma surricorne (Fabricius), granary weevil (Sitophilus granarius (Linnaeus), confused flour beetle (Tribolium confusum (Jacquelin du val).

A brief description of the habits and life history of the 13 important insect pests is given in annex XII. Some of them are called major (primary)

Fig 4

Major & Minor Pests of Stored Products



Common English Name:

1. Lesser grain borer
2. Rice weevil
3. Khapra beetle
4. Red flour beetle
5. Long headed flour beetle
6. Saw toothed grain beetle
7. Flat grain beetle
8. Black fungus beetle
9. Pulse beetle
10. Rice moth
11. Almond moth
12. Indian meal moth
13. Angoumois grain moth
14. Psocid
15. Mite

because they are capable of damaging whole kernel of food grains and considerable damage and losses. Others are called minor (secondary) cs because they are incapable of damaging whole kernel and they follow the tack of major pests or infest broken grain or milled food grains.

Most of the insect species found in the stored products are of tropical or subtropical origin and require fairly high temperatures in the range of 27^{o} - 34^{o} C for their optimum development. At temperatures lower than 20^{o} C, population growth of these insects is significantly reduced. Temperatures in the range of 17 - 22^{o} C are considered relatively 'safe' from insect infestation, since completion of life cycle may take longer than 100 days. At lower temperatures, oviposition and fecundity of these insects are also much low.

The intragranular relative humidity and the resulting moisture content of the grain, required for optimum growth of various insect species differ very much. In general, storage insects develop fast at intragranular relative humidity of 55- 75 % corresponding to 11.5 to 14.5% moisture content in cereals. Insects continue to develop below 55% relative humidity but at slower rate. The limiting relative humidity for insect development varies greatly between insects and species and exceptionally may be as low as 30 - 35%, corresponding to around 9% moisture content in cereals. Even in case of dry grain, the intragranular relative humidity is not less than 30%. Grain with 9% and less moisture content is relatively safe for most insects other than Khapra beetle.

4.2 Insect Control in Stored Foodgrains : (Ref. Nos. 1, 17)

Curative Treatment:

Fumigants are used for control of existing infestation within the grain mass. The most commonly used fumigants are methyl bromide and phosphine eventhough several fumigants and mixtures of fumigants are available and used at one time or the other. Fumigation while it is effective can not be undertaken very frequently. It is so because firstly it requires fumigants which have to be imported in case of many countries and need foreign exchang and also fumigation leaves some residues in the grain. If fumigation is carried out repeatedly the residue levels may rise beyond tolerance limit render the grain unfit for consumption. Normally the grain should no ore than twice and third fumigation should be undertaken onl

absolutely necessary. It should be remembered that fumigation is only a curative method, that is it will eliminate all stages of all insects. But when the fumigant is allowed to escape during degassing operation, the stock of food grain can get infested once again . Therefore there is a need to undertake adequate steps to maintain godown hygiene at a high standard and resort to prophylactic treatments which are described later.

Before undertaking fumigation in a godown, walls, wall-roof joints, trusses, pillars, bag surfaces etc. should be brushed to remove crawling insects, dust etc. The floor around the stacks should be swept along with the spilled grain and spillage collected in bags. The spilled grain should be cleaned outside the godown and the dust, insects etc. are buried or burnt. The cleaned grain should be disinfected separately or by placing them in the stack to be fumigated. A prophylactic spray on the stack and around the stack on the floor and walls with malathion (0.5 - 1. 0%) is recommended before fumigation.

Sheeting of Bag Stacks and Air tightness :

The bag stack to be fumigated has to be covered with gas proof sheets. If the stack sizes are standardised into 2 or 3 types, mosquito net type fumigation covers can be prepared and can be used for covering the stacks. Otherwise rectangular fumigation sheets have to be used for covering the stacks. In this case special technique is used for folding the sheets, spreading the sheets, and joining the 2 sheets on the stack.

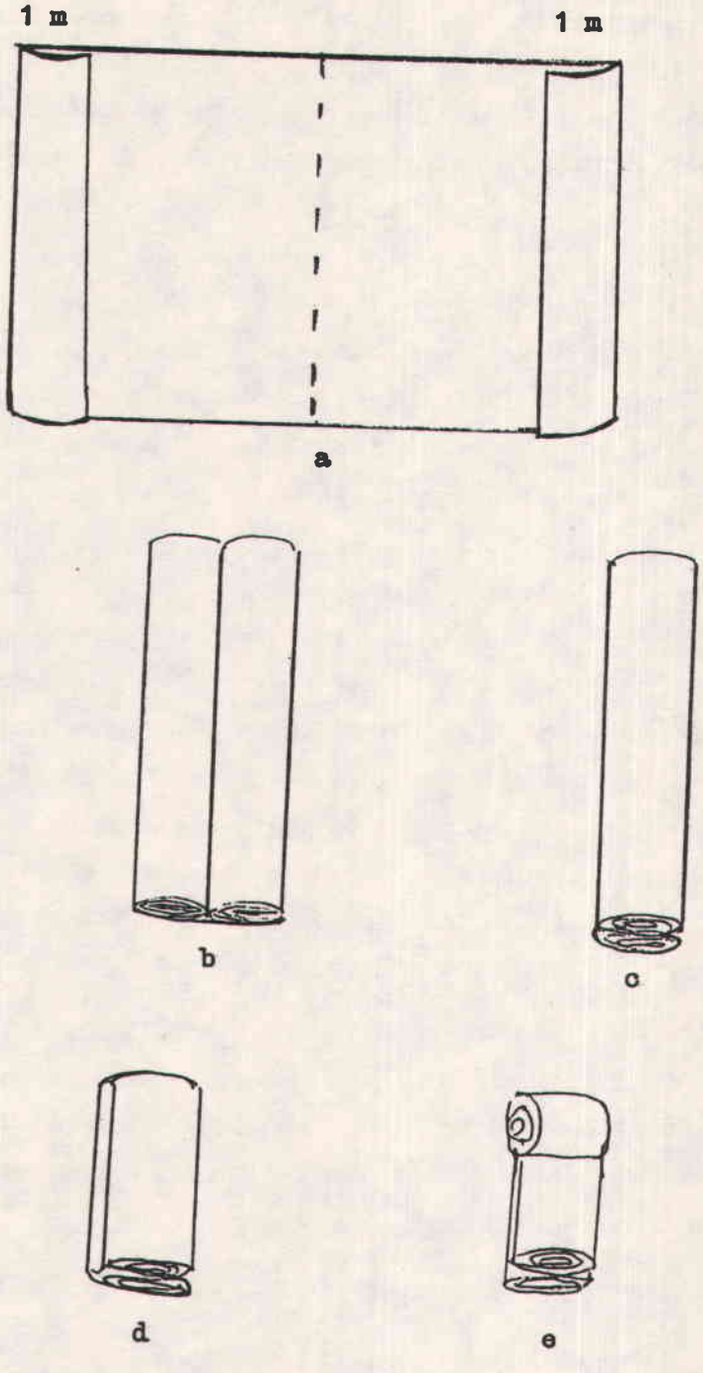
Folding and Spreading of a Fumigation sheet: (see Fig - 5)

The sheet is opened out on a flat surface. The central line perpendicular to the length of the sheet (a) is noted. Then from one end 1 m. wide strip is folded first, then second time, third time and so on until the central line is reached. In case of 20 M X 12 M sheets there will be 10 such folds. Similarly 1 m wide folds are made from the other side also simultaneously (b). Then one side fold is placed on the other side fold (c). This is then folded and rolled (d and e). Thus the sheet is stored and transported.

To spread the sheet on the stack, the operations are reversed. The folded sheet as at (c) is placed first on the correct end (width wise of the stack usually) at the centre on the top of the stack so that it gives a required spread on the floor (minimum 0.5 m). Then the sheet is unrolled on both sides

Fig 5

Folding of a fumigation sheet



so that the edges of the fumigation sheet lie flat on the floor on the longitudinal side of the stack.

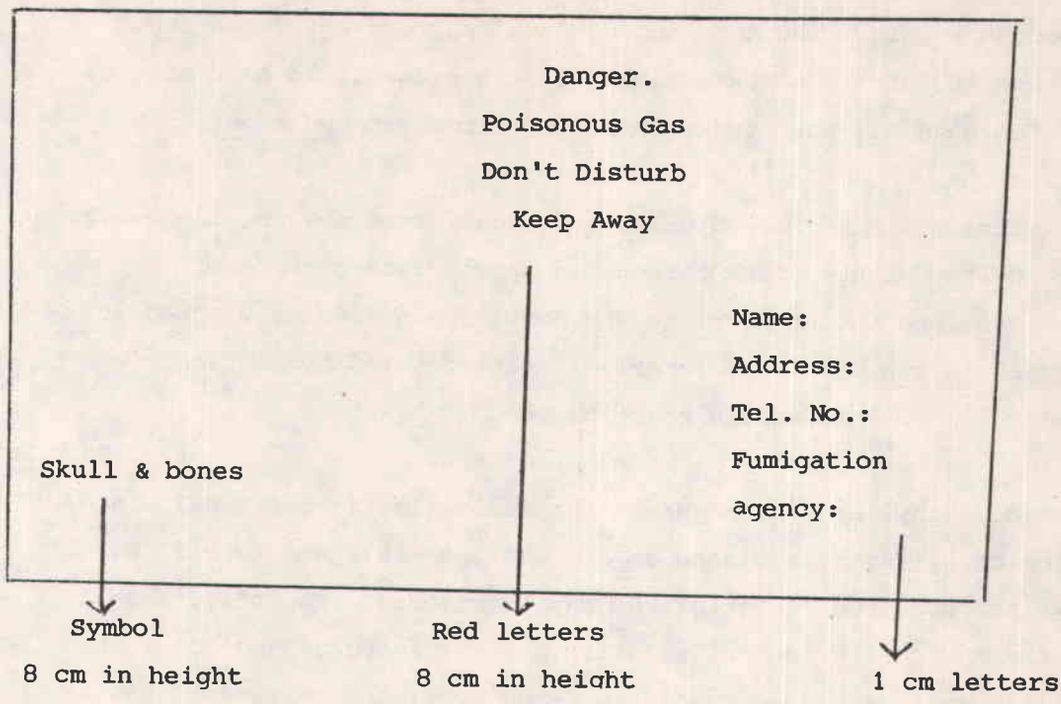
Joining of 2 Sheets :

The first sheet is spread on the stack as explained above. Then the leading edge on the stack is folded back minimum 50 cm, along its entire length that is on the top and 2 sides of the stack. The second sheet is spread on the stack in such a way that the edge overlaps the folded edge of the first sheet. Then these two edges of both the sheets are rolled tightly until all the overlap is fully taken up on the top and sides of the stack. The rolled joints are tightly clamped at about one meter intervals on the vertical sides and 2 to 3 meter intervals on the top of the stack. The folded edge on the floor on both sides of the stack is pressed down on to the floor using sand snakes. The length of the overlap when either 2 or 3 sheets are used can be first calculated before sheeting operation is done.

If the width side of the stack itself requires 2 sheets, then the whole stack will need multiples of 2 sheets. The spread of the sheets and joints have to be worked at first before commencement of sheeting operation. There will be joints in 2 directions. It is important to plan sheeting in such a way that the rolled joints on the longitudinal axis of the stack do not overlap and are separated by at least 1 m to avoid the problem of rolling a joint that has 2 other rolled joints on top of each other. However this type of 2 direction joints should be avoided, if possible, by restacking the grain bags to suit the available fumigation sheets.

Warning Notice :

A warnning notice should be placed at a convenient place indicating that the enclosure is under fumigation with a poisonous gas and persons should keep away from it. A specimen is given below.



4.3 Methyl bromide fumigation :

Methyl bromide is packed in cans, cylinders and ampoules and is available as pure material or a mixture containing 2% chloropicrin which is added as a lachrymatory warning agent. For grain fumigation, cans or cylinders are used. Pack sizes range from cans containing 700 grams to 100 kg cylinders.

Properties:

Methyl bromide is a colourless liquid with a low boiling point of 3.6°C. Therefore it is put in cans or cylinders under pressure. At normal temperature and pressure, it is in a gaseous state. On the other hand chloropicrin has a high boiling point of 112°C. Methyl bromide is odourless at normal dosages used. The gas is 3.3 times heavier than air. The gas is non in-flamable, does not react with most metals except aluminium. Methyl bromide at higher concentrations or repeated fumigations may decrease the viability of seed and in some products like flour etc. it produces undesirable odours.

Fumigation: Dosage & Procedure :

Methyl bromide is used at different dosages. Lower dosages are recommended for wheat, paddy, rice and maize and higher dosages for sorghum and millet. In tropical climates, a dosage of 22 g/cu mt. with an exposure period of 48 hours, is satisfactory for all commodities. With higher concentrations, exposure period is proportionately reduced. It is necessary to fumigate all

stacks in a godown within a short period to avoid any cross infestation. Starting from one end of the godown, each row of stacks should be fumigated. It is best to fumigate all the stacks in a compartment at one time.

In case of fumigation of bagged grain under gas proof sheets, the gas is introduced at the top of the stack through an appropriate pattern of distribution piping and outlet nozzles. The nozzles are loosely wrapped in hessian/ jute/ cloth and placed preferably in pits created by lifting one bag at each place where nozzles are to be placed.

The weight of methyl bromide required for fumigation is first calculated. The methyl bromide cylinder is placed on a platform scale and initial weight recorded. Then the required weight of the gas is released gradually. The flow rate of the gas can be controlled using a pressure guage (not less than 40 p.s.i,). After releasing some quantity, (about 10%) the release of gas is stopped and the gas tightness of the stack under fumigation is rechecked using a halide detector or gas detector tube. Where necessary, rectification is done. Then rest of the methyl bromide is let into the stack.

Methyl bromide, introduced at the top of enclosure will move downwards through the enclosure. In some circumstances (in very high stacks) layering of methyl bromide may occur producing high concentrations of gas towards the bottom and low concentration at the top, where complete kill of insects may not be there.

Where cans are used to supply methyl bromide for small scale fumigations either the fumigant is introduced as a gas or as a liquid. In both cases a can piercing attachment is used.

Degassing :

Degassing is done in stages by lifting the corners first and later after 30 minutes all the sheets are pulled down. Until there is no trace of gas as confirmed by halide lamp or gas detector tube, no person should go near the stack, without a gas mask.

Gas mask and Gas Detection Equipment :

The operators carrying out the fumigation work should wear gas mask fitted with a canister-type P. Leaking of gas from cylinders, pipe work and fumigation

area etc. can be detected using halide leak detector lamp. In the presence of methyl bromide gas (or any halogen compound) a colour ranging from a pale green to bright blue is imparted to the flame and an approximate measure of concentration can be obtained from the intensity of colour.

The colour reaction for a halide leak detector lamp with methyl bromide is given below:

Methyl bromide (PPM)	Colour of flame
0	No colour
10	Very faint green at edges
30	Light green flame
60	Moderate green flame
100	Green
120	Strong green, blue at end
240	Strong green/blue
500	Strong blue/green
1000	Blue

Gas detector tubes are also available for different ranges of concentration. They are calibrated. The air which is likely to have methyl bromide is drawn through the detector tube, once or more times using bellows or a syringe (depending on the make), when there will be discolouration in the tube. The length of dis coloured column in the tube indicates the gas concentration.

Precautions :

1. As methyl bromide is odourless, persons may be unaware of exposure to dangerous concentrations. Although chloropicrin is added in some preparations because of its high boiling point, it may not vapourise easily to produce eye-irritating effects. It is characteristic of methyl bromide fumigation that large quantities of fumigant are rapidly released even at the start of the fumigation. Therefore it is essential that operators should wear gas masks fitted with right type (type-P) of canister.
2. If a canister is used in high concentrations of methyl bromide even briefly, they are rendered unfit for further use. Therefore it is advisable to keep handy self-contained.breathing apparatus. Great care should be taken while releasing the fumigant.

and warm, call the doctor. If symptoms are mild, the patient recovers within one or two hours. If the symptoms are strong and lasting, immediate hospitalisation is necessary.

4.5 Evaluation of success of fumigation treatment :

The success of fumigation of food grains is governed by a number of factors. They are dosage rate, distribution of the fumigant, exposure period, temperature and moisture content of the grain, nature of the fumigant, cereal dust present in the grain, type of insect species and the airtightness achieved in covering the stack or in the godown under fumigation.

In tropical climates the temperature is above 20°C in general and between 25° - 35°C during most of the time and these conditions are favourable for insect activity and mortality also when fumigated. Moisture content less than 8% in grain does not allow release of phosphine from aluminium phosphide preparations at a fast rate. The susceptibility of insects and their immature stages vary with fumigants. Mortality of insects in the cereal dust formed through intense insect activity will be less many times. Non achievement of airtightness due to use of gas proof sheets with tears and pin holes, improper sealing of the edges of the sheets on to the floor etc. will result in less mortality rate. In case of methyl bromide all sheets will not prove sufficiently gas tight especially at higher temperatures as found in tropical climates. Therefore it is necessary to assess the insect mortality after each and every fumigation operation which will help in rectifying the defects, if any, in further work.

The success of fumigation can be found out by a number of methods, some using special equipment and some others in a much simpler way.

By Calculating CT Product :

In case of methyl bromide, it has been shown that the product of concentration of the fumigant in the enclosed space (mg/litre) and the time (hrs) of exposure period remains constant within certain range of concentrations. The CT product necessary to obtain 100% mortality in test insects can be found out in a laboratory by simulating conditions obtained in practice. Then by estimating the fumigant gas concentrations periodically in the space under fumigation and calculating and comparing the integrated CT product with that obtained in the laboratory, it is possible to know whether the fumigation

operation is successful. Thermal conductivity analyser and interference refractometer are used for determining methyl bromide concentrations.

By examining the insects on the surface of bags :

After fumigation, the surface of bags and floor around the stack are examined for live insects. Care should be taken to check the folds on the mouth and ears of the bags and the space between two sacks. It is advisable to carry out the examination as soon as the gas proof sheet is removed because any delay would result in reinfestation (cross infestation) of the fumigated stack from the walls of the godown or neighbouring infested stacks. It should be remembered that during dusk, the insect activity will be high especially in case of Tribolium castaneum adults which will fly from place to place. Therefore a delay especially overnight delay in examining the stack can lead to a wrong judgement. It is also advisable to collect insects declared as dead on the spot, from various places on the stack surface and floor and take to the laboratory and examine after over night incubation on insect - free grain in a petridish. Examination under the warmth of a 40 - 60 watts lamp is recommended as the heat radiation from the lamp will induce movement in sluggish insects. A gentle probe with a needle will also make the sluggish insects to move about.

By examining the insects in the grain sample drawn from the bags after fumigation :

Grain samples are collected from different bags on the four sides and top surface of stack using a grain sampler. On the top surface 2 - 3 layers of bags should be removed at 4 places and the grain samples collected from bags in lower layers. Care should be taken to draw samples specially from those bags where insect infestation is suspected or found earlier. It is advisable to collect at least 2 kg. of sample from several places. The grain sample is sieved using appropriate sieves to collect insects free from whole grain and fine dust. The insects thus separated should be examined immediately and also after incubation overnight as described earlier for noting down the living insects.

By Incubation of post fumigated sample of grain :

The earlier two methods will help to observe easily the mortality of adult insects and larvae of Khapra beetle and moths . The immature stages of some insects can be within the grain kernels and those of some others in the grain mass. If these immature stages of insects are not killed, there

lacerating the body or by absorbing waxy substances from the insect cuticle and thus exposing insects to dehydration and death. Smearing of vegetable oil on legumes is observed to protect them from insect attack. Different inert materials, oils and plant leaves are used to a limited extent at farmers' level and they are not being used in large scale storage of foodgrains. The insecticides which are commercially used for prophylactic treatment are contact insecticides which are described below.

Malathion :

It is widely used for prophylactic treatment. Emulsifiable concentrate (E.C.) formulation of 50% or 57% and of premium grade is used. Maximum concentration recommended for application on walls, roof, floor of empty godowns and containers is 2%. 0.5 to 1.% concentration is recommended for treatment of foodgrain bag surfaces. 30 to 50 ml per sq. mt is the normal rate of application of the diluted solution on different surfaces . It is moderately persistant except in damp and alkaline conditions of the surface on which it is sprayed.

DDVP :

It is known as dichlorvos also. It is sold under different trade names like vapona, nuvan, etc. The formulation commonly used is 48% E.C. or 100% technical concentrate. DDVP strips are also available. E.C. formulation is diluted for use as sprays and for space treatment. It is also applied as a mist using mist sprayer. DDVP has a slight fumigant action in addition to its being a contact insecticide. It has a knock-down action on insects as in case of pyrethrins.

Pyrethrum :

This is a mixture of 6 compounds (pyrethrins) and is prepared from dried flower heads of chrysanthemum like plants. Pyrethrum E.C. formulations (2.5%) are available for use as sprays after dilution (1:100). Piporonyl butoxide is used as a synergist to pyrethrins and reduce the dosage rate. This has a quick knock down action on insects. It is not a persistant insecticide and its effectiveness is not for more than 3 days normally. It is a most common insecticide formulation sold for domestic pest control.

Pirimiphos methyl :

This is an organo-phosphorus insecticide and is available under the trade

name Actellic. It is available as 25 and 50% E.C. formulations for use after dilution. Wettable and dust formulations are also available. It's mammalian toxicity is similar to that of malathion. It is moderately more persistant and more toxic to insects than malathion.

Fenitrothion :

It is available under the trade names Sumithion, Folithion and Accothion. This is an orango-phosphorus insecticide, which has slightly higher mammalian toxicity than malathion but more persistant than it. In some countries fenitrothion is mixed in food grains as a grain protectant. It is available in different formulations and E.C. and wettable powder formulations can be used in food grain stores after dilution.

Other insecticides :

There are many other synthetic insecticides including synthetic pyrethroids which are recommended for use in food grain stores. They are bromophos, iodofenphos, methacrifos, phoxim, bioresmethrin, permethrin, deltamethrin etc.

In addition to those insecticides which are used in food grain godowns without fear of residue problem in foodgrains, there are other more toxic insecticides which are also used in storage of food grains. They are dieldrin and carbamate insecticides like bendio-carb, propoxur and dioxacarb. Dieldrin is used for control of cockroaches and termite proofing of storage buildings. Carbamate insecticides are used for control of cockroaches and ants. As these insecticides are relatively more toxic to mammals, they should not be used in such a way as would result in contamination of foodgrains.

Selection of newer insecticides for prophylactic treatment :

The selection of insecticides for use in food grain storage is done with great care, keeping in view acute and chronic toxicity record of the insecticides, their persistance and contamination hazards. Therefore, eventhough many insecticides are available for use against insects on agricultural crops etc. only a few are recommended for use in the food grain stores.

In recent years, one of the problems which has been encountered in control of insects, is the development of insect resistance to the insecticides ordinarily used especially malathion. Therefore a number of new insecticides are being tested to replace or supplement malathion . It is being realised

in a number of countries, that at least 2 or 3 insecticides should be registered for use in storage and preservation of food grains. The selection of newer insecticides is based on the relevant data available in international literature, recommendations of Codex Alimentarius Commission and also on the data obtained within the country itself. Many developing countries are rightly developing facilities for evaluation of pesticides and determine pesticide residues in food products under the conditions and practices prevalent in the country. The mammalian toxicity of different insecticides used in storage and preservation of foodgrains is given in annex XIII.

Formulations :

The insecticide is formulated mainly into 4 types for application.

Emulsifiable concentrate (E.C.) :

The formulation consists of insecticide, emulsifier, stabilizer and a solvent. The insecticide concentration varies from 20 - 80 percent. On dilution with water, a stable milky white emulsion is formed. The test for satisfactory emulsion is that there should be no oil separation and not more than 2 ml. out of 100 ml, cream separation one hour after mixing in 100 ml measuring cylinder. They are used for surface application on store fabric and on surface of bags etc.

Wettable powder (W.P.) :

The formulation consists of insecticide, mineral powder, emulsifier and stabilizer. The concentration of insecticide ranges between 25 - 80 percent. Dilution with water produces a uniform suspension but the suspension settles down slowly and therefore requires agitation periodically. Not less than 50% of the active ingredient should be in suspension 30 minutes after mixing, in case of satisfactory formulation. The W.P. formulations are used for spraying on absorbing surfaces such as cemented walls, brick walls etc. However application of W.P. formulations evenly is more difficult than E.C. formulations and also they will leave visible residues.

Oil Solution :

The formulation consists of insecticide and mineral oil. Many domestic spray formulations are ready - to - use formulations and contain odourless kerosine. Power sprayers are required in case of sprays containing heavy oil.

Most foggers and mechanical aerosol generators use oil solutions.

Dusts :

These formulations consist of insecticide and a mineral dust. Usually they contain 1 - 5 percent of insecticide. Dusting is done using hand operated or motorised knapsack sprayers. They are useful for dusting around stacks, wall and floor corners, cracks and crevices and outside of the stores.

Application :

The rate of application and the amount of deposit of active ingredient of the insecticide are dependant on particular pests to be controlled and the length of persistance desired. Normal application rates for prophylactic treatment are given in annex XIV. However, each country has its own regulations regarding application of insecticides. For example mixing of insecticides in any formulation directly in the grain is not permitted in some countries while it is allowed in some other countries.

Emulsifiable concentrates and wettable powders are diluted with water to the required concentration. For water diluted sprays, the rate of application is 50 ml per sq. mt. (5 litre per 100 sq. mt). The volume is increased upto 100 ml per sq. mt. in case of porous surfaces and is reduced to 25 ml per sq. mt for very smooth surfaces. The aim is to obtain uniform covering of the surface without any run-off. This precaution is required especially while spraying on the surface of grain sacks.

Dilution of the concentrated formulation is made using the following formula :

$$V_1 \times C_1 = V_2 \times C_2 \quad \text{where}$$

V_1 = Volume of concentrated formulation to be taken for dilution

C_1 = Concentration of the insecticide in the above formulation

V_2 = Volume of the spray liquid required

C_2 = Concentration desired in the above spray liquid.

Example : To make 100 litres of 1 percent spray liquid using 57% malathion E. C. formulation.

V_1 = X litres, C_1 = 57%, V_2 = 100 litres, C_2 = 1%

Inserting the data in the above formula :

We get : $X \times 57 = 100 \times 1$

$\therefore X = \frac{100 \times 1}{57} = 1.76$ litres (apporox)

That means 1.76 litres of malathion concentrate have to be diluted to 100 litres with water.

Concentration of diluted spray needed for a range of volume and active ingredient application rates can be calculated using the following formula :

$$\text{Concentration of diluted spray (\%)} = \frac{\text{Application rate required (g/sq. mt) x 100}}{\text{volume of spray applied (ml/ sq. mt)}}$$

Example : To spray at a rate of 0.5 g per sq. mt on a surface at the rate of 50 ml per sq. mt, the concentration of diluted spray will be

$$\frac{0.5}{50} \times 100 = 1 \text{ percent. (1 g a.i. per 100 ml)}$$

Equipment for prophylactic treatment : (Ref. Nos.3,6)

(a) Equipment for Spraying :

Different types of sprayers are available for spraying diluted emulsifiable concentrate (E.C.) or wettable powder (WP) formulations of insecticides They may be broadly divided into 2 categories. (a) hand operated sprayers and (b) motorised sprayers.

Hand operated sprayers :

They are of two types : hydraulic sprayers and pneumatic sprayers. Hydraulic sprayers have to be operated continuously with the side arm provided, during spraying operation. A long lance allows spraying upto about 4 meters. The capacity of the sprayers range from 15 - 20 litres and the output is 0.3 to 1 litre per min. depending on the nozzle. Pneumatic sprayers have the facility to pressurise the tank using a hand pump and spraying therefore can be done continuously. These sprayers have capacities ranging from 5 to 15 litres and have an output similar to that of hand operated sprayers depending on the nozzle size.

Both these types generally do not have agitators which are needed when wettable powder formulations are used. Therefore the sprayers need periodic inversion and agitation of the tank for dispersion of the wettable powder. Hand operated sprayers can be fitted with fan spray jets or swirl nozzle. When wettable powder formulations are used any filter behind the nozzle is removed.

Motorised Sprayers :

These are useful for spraying of insecticide over large areas, high walls and ceilings. They work on 3 hp engines. The spray liquid which enters the air stream from the engine at the nozzle is broken down into fine droplets and forced out in a stream. The capacity of a motorised knapsack sprayer is about 10 litres. The operator should take care of the exhaust pipe while operating and handling such a knapsack sprayer to prevent burns.

Another version of motorised sprayer is the one which is mounted on wheel barrow or trolley. They work on 3 - 5 hp engines. They have built in large tanks (100 litres) to carry spray liquid. These sprayers may deliver 10 - 30 litres of spray liquid per minute. They are useful for spraying large empty warehouses. With high rate of delivery of spray liquid and bigger droplet size, spraying on bags may lead to wetting of bags.

Equipment for space treatment :

Space treatment will be required to control flying insects-moths, or even beetles which fly during dusk in the mornings and evenings in the godowns. The insecticide is dispersed in air either as an aerosol, mist, fog or smoke using appropriate equipment.

Aerosols :

Aerosol formulations are good to treat smaller space. Aerosols or fine mist sprays are produced from canisters containing insecticide in a solvent and liquified gas under pressure. Liquid carbon dioxide is also used as a propellent in some aerosol canisters and they are good to treat large spaces.

Mist blowers :

They operate on petrol/diesel/electrically operated engines. The shearing effect of an air blast on the spray liquid produces a fine mist.

Dispersion of the liquid from a high speed spinning disc also has the same effect. Oil formulations of insecticides are normally used. In some designs water based formulations also can be used.

Fogs :

Thermal foggers use hot air, hot exhaust gasses or steam to produce a fog of very small droplets. The insecticide (oil formulation) is vapourised by the hot exhaust gases and when the vapour reaches cooler air, it condenses to form a dense fog with very fine droplets of 10 microns diameter. Different designs are marketed. Some are portable and some are mounted on trolleys.

Vapour Dispensors :

Slow release dichlorvos plastic strips are also available. They are hung in the stores at a density of 1 strip per 30 cu-mt. free space. These may be effective on moths but not on beetles very much. Alternatively, an automatic spray machine connected by a time clock to give short burst of spray each evening, is recommended instead of slow release strips. This will ensure optimum DDVP levels in the space for good mortality of insects.

It should be remembered that space treatments using dispersed contact insecticides differ completely from fumigation. The fumigant will penetrate into the bags and bulk of produce while space treatment is effective on insects present outside the bag stack and bulk of produce. They are better than spraying because the smoke/fog/mist will penetrate cracks and crevices in the godown and also reach those places which can not be easily reached/covered with a spray lance. Normal application rates for space treatment are given in annex XV.

Contamination and residue tolerances :

Considerable attention has been focussed on the nature and possible effects on human beings of insectidal residues appearing in food stuffs. The Food and Agricultural Organization and World Health Organisation have set up special committees to investigate and report on the nature and significance of residues formed in food stuffs as a result of application of pesticides at different stages both in the pre harvest and post harvest stages prior to human consumption. These special committees review a number of pertinent factors involved in the use of each pesticide. Important factors are toxicological significance of any residues formed and average fraction of the total diet

likely to be constituted by a food contaminated by a particular insecticide. Through their Codex Alimentarius commission FAO and WHO recommend international tolerance for insecticide residues in specified food products. The national governments consider the recommendations of the Codex Alimentarius commission and keeping in view, the national practices followed in agriculture, handling, processing and food consumption fix tolerance limits for insecticides/fumigant residue in various food products. Many times, these limits are more rigid than the Codex limits. The Codex maximum limits for pesticide residues are given in annex XVI.

Precautions :

1. Use the insecticide formulations before the expiry date.
2. Always read the lable carefully and follow the manufacturer's instructions.
3. Recheck the calculations for dilution and supervise the dilution operation.
4. Do not spray more than 30 - 50 ml per sq. meter of bag surface area.
5. Do not spray with less pressure in the sprayer as that would produce bigger droplets.
6. Before spraying operation, brush the bag surfaces, walls etc.
7. Do not spray on naked grain. All the spilled grain on the floor should be collected and bagged before spraying operation.
8. Take special care to spray on corners of the godown, cracks and crevices, wall surface, floor space between stack and stack and stack and wall.
9. Open the doors while carrying out spraying operations. In case of space treatment, all the doors of the godown should be closed except the entrance door which is also closed after the operation.
10. Read the general precautions in handling and using pesticides (annex XVII).

4.7 Grain mites :

Mites are very small and are hard to see with naked eye. When there are large numbers, they tend to over flow from the commodity and are visible as a brownish dust at the base of stack or on the surface of bags. It has a translucent shiny round body. Colour is pale straw to dark reddish brown. These are not true insects on account of following distinctive features. It has 8 legs. Body is not divided into head, thorax and abdomen as in the case

of insects. The body is divided into 2 parts, and has no wings. They are provided with numerous long hairs on the legs and back.

The most common species is the flour mite, Acarus siro Linn (Family Acaridae, Order Acarina) which attacks in addition to flour, whole grain, hay and cheese. Other important mites include species of Tyrophagus oudms, Glycyphagus hering and Thyreophagus rondani which occur on similar commodities. When present in large numbers, they promote sweating, impart disagreeable odour to the grain and cause itching and irritation or dermetitis to workers handling infested commodities. They attack germ portion of grains resulting in loss of germination.

The mites which infest stored food do not thrive in dry conditions. They do not attack commodities if the moisture content is below 12 percent but they will breed at 14 percent and will increase considerably at 15 - 18 percent. Even when the grain mass is in general dry, if the surface picks up moisture, it will enable mites to breed there.

The life cycle is very simple. The adult female mite lays its eggs loose in the food. It can lay nearly 500 eggs during a life of 42 days. The egg hatches into a six legged larva which changes to an 8 legged nymph and then to the adult. There are 1 - 3 instars, each active stage is followed by an inactive hypopi stage (cyst like stage) when it is resistant to starvation and desiccation. Under optimum conditions (28 °C and RH 70%) egg to addult takes 9 - 12 days.

Physical methods of control :

The grain and godown must be kept dry. When there is infestation on bag surface, the bag surfaces should be brushed thoroughly or vacuum cleaned and the sweepings thus collected should be burnt immediately.

Chemical methods of control :

Chemicals in the form of contact acaricides or fumigants may be used. They may be used in empty godowns and on dunnage to kill mites already present in the building. They may be used for a routine prophylactic treatment and also for curative treatment to control an out-break of mites, during storage of foodgrains.

The most effective chemical as an acaricide is lindane. It is used as

0.5 percent dusting powder and dusting is done around bases of infested stacks and also over bags. Aqueous sprays are not recommended because of the risk of increasing mite population with more humidity. An oil spray containing 3 percent piperonyl butoxide as in case of synergised pyrethrins, has been found to be equally effective. Malathion which is widely used for insect control is not very effective against mites.

The fumigants which are used to control insects in stored food grains have also been found to be reasonably effective against mites. Methyl bromide, mixture of ethylene dichloride and carbon tetrachloride, phosphine and ethylene oxide have been successfully used. In case of methyl bromide, doubling of dosage rate or exposure time is recommended as certain stages in the life cycle of mites are known to be resistant to methyl bromide.

4.8 Grain Lice :

They belong to the Order Psocoptera and Family Psocidae. The insects belong to several closely related species of the genus Liposcelis. These insects are pin head- sized and very active. They are pale grey or yellowish white in colour. They have filiform antennae. They are wingless, soft bodied with fairly large heads and poorly developed eyes. They are more oblong than roundish thus can be easily distinguished from mites. Upto 100 eggs are laid by the female which hatch into nymphs (similar to adults but smaller in size i.e. metamorphosis is in-complete). There are a few instars. Developmental period from egg to adult is about 3 weeks. They are usually found in coastal regions or in rainy season with high humid weather.

All grains with high moisture is susceptible to psocid attack. Infestation of this pest is indicative of unhygienic damp condition of the godown, where ventilation is not given for a prolonged time. The pest is associated with high insect infestation or mouldly conditions. Infestation of psocids often persist even after fumigation when insects are controlled. These pests at the most affect germ portion and thus do not cause major damage to the grain . They feed on broken grain and cereal dust. However heavy psocid infestation gives very unhygienic appearance with these insects crawling all over.

Control methods are mainly good ventilation on clear days, prevention of damp in the godown and storage of dry grain.

4.9 Storage micro-organisms : (Ref. No. 21)

Micro-organisms are very minute, cellular organisms which can not be seen by naked eye. Micro-organisms affecting stored grain are mainly fungi, bacteria, yeast and actinomycetes. The most important factors for their normal development are nature of food, moisture, oxygen and temperature.

Fungi :

The fungi associated with cereal grains have been divided into 2 types, field fungi and store fungi.

Field Fungi :

They are mainly species of Alternaria, Fusarium, Helminthosporium and Cladosporium. They invade the grain before harvest and require water activity value (AW) for growth greater than 0.93 (grain moisture content of 22% - 25%). These fungi gradually die out during drying of crop and in storage because of lower moisture content.

Store Fungi :

They are mainly species of Aspergillus and Penicillium. Species of Alternaria, Mucor, Cladosporium and Sporendoma are also sometimes found in stored foodgrains and their products. They invade the grains after harvest during drying and in storage. They require water activity value (AW) of about 0.70 (grain moisture content of 13.5% - 14.5%), lower than that required by field fungi.

The infestation of food grains by store fungi will result in loss of germination which is important in case of seed grain, discolouration and damage of grain, loss in nutritive value, production of mycotoxins, rancidity, off odours and bitterness resulting in loss of consumer acceptability and market value. The mycotoxins associated with different fungi are given below.

Mycotoxins associated with different fungal organisms

Toxin	Organism	Commodity
Aflatoxin	Aspergillus flavus, Aspergillus parasiticus	Groundnut and its products, sorghum, cotton seed meal and corn.
Ochratoxin A	Aspergillus ochraceus and Penicillium viridicatum	Maize
Citrinin	Penicillium citrinum & Penicillium viridicatum	Rice
Zearalenone or F2	Fusarium graminearum, Fusarium roseum (Gibberella zeae)	Corn
Trichothecenes or T2	Fusarium tricinctum, Fusarium graminearum, Giberella zeae	Corn

Nature of Food :

They can grow on a variety of food grains and their products, oil seeds, species etc. under favourable moisture and temperature conditions.

Moisture :

The measure of the availability of water to fungi is the ratio of the vapour pressure of water in the substrate to that of pure water at the same temperature. This quantity is referred to as water activity (AW) or when it is expressed as a percentage, as the equilibrium relative humidity (ERH). The equilibrium relative humidity (ERH) is numerically equal to the AW of the system. AW = ERH/100.

The water activity of a food greatly influences its susceptability to invasion by micro-organisms. Different foods in equilibrium with the same relative humidity of the atmosphere have different moisture contents because of differences in their composition.

The minimum equilibrium relative humidity (ERH) and water activity required for Aspergillus species are between 68 - 85% and 0.68 - 0.85 respectively, while for Penicillium species, the values are 80 - 90% and 0.80 - 0.90 respectively.

The moisture contents which correspond to an intragranular relative humidity of 65 percent are called 'safe' moisture contents. Typical 'safe' moisture contents for different grains are given below. Fungal growth generally occurs only at an RH in excess of 65 percent.

Maximum permissible moisture contents for cereals (About 27 °C)

	Normal Storage %	Long term storage (reserve stocks) %
Wheat	13.5	11 - 12
Maize	13.5	10 - 11
Paddy	12 - 13	10 - 12
Rice	13	10
Sorghum	13.5	10 - 11
Millet	16	14

The moisture content figures given for normal storage are for equilibrium with 70% RH and for long term reserve storage lower moisture contents in equilibrium with a relative humidity of 65 percent or less are recommended. At and below 'safe' moisture, metabolic activity will be minimum and there will be no significant development of micro-organisms. (Ref. 16, 21).

It should be remembered that eventhough the average moisture content of the grain is within safe limits, there can be development of high moisture pockets in the grain mass, due to diurnal and seasonal variations in temperature especially in case of bulk grain. These high moisture pockets will favour the development of store fungi. In hot areas, the above limits for moisture contents should be reduced by 1%.

Temperature :

The optimum temperature for several species is about 30°C which is a common ambient temperature in tropical countries. Some fungi such as A. candidus and A. flavus grow even at 50°C - 55°C and by their metabolic activity increase the temperature of grain to that level, which is called wet heating.

Atmosphere :

Many fungi are aerobic in nature, that is requiring normal oxygen

content in the atmosphere. However there are fungi causing deterioration in grain which can grow in atmospheres containing 0.1 to 0.2% oxyge. and in atmospheres containing more than 80% carbondioxide. These fungi are mainly responsible for spoilage in under ground storage.

Control Methods :

Drying :

Drying of grain followed by storage under dry conditions is the easiest way to prevent fungal damage in food grains. Maximum permissible moisture contents for cereals have been given in the table. Crops which are dried to these levels of moisture content can be stored without mould damage.

Chemical Control :

Some gases such as ammonia, sulphur dioxide and methyl bromide have been shown to control mould growth. Chemical preservatives such as propionic acid, calcium propionate, sorbate alone or in combination with carbon dioxide have been recommended. However none of them are used on a large scale on food commodities because of limitations like toxicity, excessive cost, undesirable effects on processing quality of grain, difficulty of application and lack of toxicity to store fungi.

Other Methods :

Reduced temperature coupled with low moisture are effective than mere drying. Adequate aeration and low temperatures are helpful to store crops with moisture contents upto 17 percent in cold countries. However this is not possible for large scale storage of foodgrains in tropical countries. Physical damage to the grain during harvesting and in subsequent handling should be avoided as that would give access to micro-organisms in particularl, fungi. Clean grain with minimum brokens will store better than grain contaminated with cereal dust and broken grain.

It has been shown that some species of fungi e.g. A. restrictus are closely associated with grain weevils. High insect infestation leads to the development of store fungi because in addition to injection of some species of fungi into the grain, they also create conditions (higher humidity and temperature) for its development. In such circumstances disinfestation of grain will become necessary followed by drying of high moisture pockets.

Bacteria, yeasts and Actinomycetes :

Bacteria, yeasts and actinomycetes require higher moisture levels in foodgrains for development and by the time they come into play, there would have been high fungal damage in the grain etc. The result is complete damage to the food commodity which will be unfit for human consumption or even as feed.

Prevention of damages by these organisms is by storing clean and dry foodgrains and preventing pick up of moisture in storage, as in case of prevention of fungal damage.

4.10 Birds : (Ref. No. 18)

The birds commonly attacking food grains in the godowns are given in the table below . Sparrows and pigeons are common visitors. Some times crows and mynahs also enter the godown, especially when they are not opened for a long time, through other entry points.

Common name	Order	Family	Scientific name
Sparrow	Passeriformes	Ploceidae	Passer domesticus (Linn)
Pigeon	Columbiformes	Columbidae	Columba livia (Gmelin)
Crow	Passeriformes	Corvidae	Corvus splendens (Vieillot)
Mynah	Passeriformes	Sturnidae	Acridotheres tris-tis (Linn)

Sparrows and pigeons may make nests at convenient places in the godown e.g. unused ventilators and eaves. Crows and mynahs enter from outside only . Sparrow and mynah can eat upto 8 - 10 g. of food grains per day. Pigeon and crow can eat upto 20 g. of foodgrains per day. These birds damage the bags by pricking and making holes in them. Their excreta on the top layer of bags and floor is a common sight in the godowns with heavy bird infestation. Some of them are responsible for spreading diseases. They create unhygienic conditions in the godown with their excreta, feathers and dead bodies too.

Bird Control :

Control of birds consist of closing the entry points and removal of nests in the godown . Godowns can be made bird proof by fixing wire mesh (0.6 cm) on windows, ventilators and at the eaves. Old polythene sheets cut into

ribbons and hung on the entrance of doors will prevent entry of birds and will not obstruct movement of people through the doors. Wire netting on the doors which can be closed will prevent entry of birds and will allow ventilation . But it will make operations like carrying of bags in and out difficult.

Bird scarers which produce loud sounds are employed with some success. One equipment uses actylene gas produced by dropping of water on calcium carbide. The ignition of the gas is regulated so that ignition and loud combustion sound occur once in 45 - 60 seconds. The equipment is hung at the ceiling of godowns outside or on nearby tree tops to get better results.

Chemical methods include use of baits poisoned with strychnine and endrin or baits containing stupifying chemicals. In the case of the latter, the birds fall unconscious after eating the baits. They are picked and killed or thrown out at far off places.

Use of sterilants like ornitrol is suggested but may not be effective for bird control in godowns. Tape recorded 'alarm calls' of different birds are played at high pitch in infested area to scare away birds. This method also may not be useful in godowns.

4.11 Rodents and their Control : (Ref. No. 8,9).

Rodents comprise a major group of pests which are of great economic importance due to their role in problems of food and health of man. The animals that are usually referred to as rats, belong to the Order-Rodentia, Family-Muridae and sub families of Murinae and Gerbillinae and include many genera and species.

In Sudan, the important genera identified are Rattus, Arvicanthis, Mastomys, Mus, Tatera, Tatarillus, Gerbillus, Acomys and Meriones. The biology and behaviour of different genera are different. The main characters to distinguish rodents are the colour of the fur, hairs, length of head and body length of tail, size and shape of ear, fore and hind foot length, fingers and toes, mammae, nasals, dentition, weight of adults, sounds created and shape and size of faecal matter.

The common English and scientific names and distinguishing features of common rodents are given in annex XVIII The rodents commonly found in the foodgrain godowns are only R. rattus, R. norvegicus, M. musculus and some times A. niloticus and M. natalensis (Fig.6).

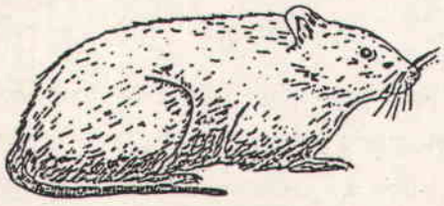
Fig 6
Common Rodents in Sudan

Rattus norvegicus

(1)

Mus musculus

(2)

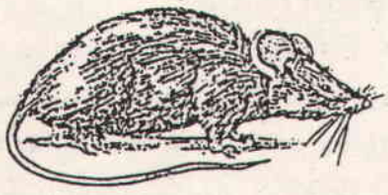


Arvicanthis niloticus

(3)

Rattus rattus

(4)



Mastomis natalensis

(5)

1. Rattus norvegicus
2. Mus musculus
3. Arvicanthis niloticus
4. Rattus rattus
5. Mastomis natalensis

Habits :

A knowledge of the habits of rats is important for their control. Roof rat can climb high on rough walls and penetrate through eaves into godown, while Norvegicus rat remains mainly in or near the ground. Rats can not climb smooth walls. Rats can jump upto about 75 cm and the black rat can not stretch beyond 20 cms. House mice can penetrate into buildings through gaps in doors, windows etc, more easily due to its small size. Rats and mice enter the buildings through sewers via drains, vertical pipes close to walls, through defective doors, windows and ventilators, by tunneling under walls and foundations and by crawling along branches of trees, telephone and other cables. They also enter godowns through transport vehicles.

Norvegicus rat tends to use the same run-way always and runs close to walls and between sacks of food rather than across open spaces and exhibits new object reaction very much. Roof rat is less regular in habits and may pass across the floor and show less of new object reaction than Norvegicus rat. On the other hand house mouse likes to explore new objects and situations. House mice tend to be nibblers where as roof and Norvegicus rats tend more towards steady eating. The incissors of rats constantly keep growing and therefore they have the habit of gnawing at any thing they come across such as furniture, doors, bags etc. which keeps the size of incissors under control.

Damages :

Rodents cause considerable damage in foodgrain godowns. They eat food grains and nibble and destroy much more than what they eat. An adult roof rat can eat about 16 g. and house mouse about 8 g. of food material per day. They contaminate the food with their excreta and hairs. Each rat drops 25 - 50 faecal pellets, passes 19 - 20 ml of urine every day and constantly sheds some of its coat of 500,00 hairs. Handling and consumption of food grains contaminated with faeces and urine of disease infected rats are reported to cause some diseases too. Rats also cause damage to jute sacks leading to spillage of grain and falling of stacks in a godown. They damage wooden doors, furniture by gnawing at them. Burrowing of rats under the floor results in sinking of floor in godowns.

Detection of Rodent Activity :

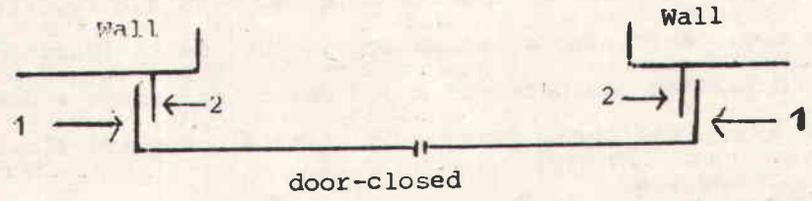
Rodent activity in a godown can be detected by their tell- tale signs. Sound of rats, smell, presence of faecal pellets and urine marks, burrows, partly torn paper, files, holes in bottom layers of bags in a stack, gnawed furniture and doors, black and greasy smears on walls and girders, presence of their nests and nesting material indicate, the presence of rats in a godown. Many times, they can be found running by the side of walls during day time also.

Rodent Control :

It is not possible to completely eradicate rodents in an area. However, efforts should be made to minimise their problem. The strategy to protect stored foodgrains are rodent proofing, sanitation, trapping and poison baiting.

Rodent proofing methods include fitting the vertical and horizontal drainage pipes and cables with 20 guage metal guards projecting about 25 cms.; closing and protecting all points of entry below one metre from the ground; building joints, girders, pipes, pipe sleeves etc passing through walls without gaps; providing close fitting doors and windows and also fitting a 30 cm high 20 guage metal plate at the bottom on front side of doors and windows. Construction of a high plinth above ground level, without steps and provision of a projecting collor all round the plinth will make the godown rodent proof. Maintenance of rodent - proof provisions in a godown in sound condition is equally important.

In case of godown with sliding doors, a simple method can be adopted to prevent entry of rodents into the godown through them, when there are gaps even after closing. It is shown in the diagram below :



1. 2 mm thick iron plate 45 cm length and of necessary width is welded on the door edge. The bottom of the plate should be about 0.5 cm above the ground level.

2. angle iron of 2 mm. thick 45 cm length with appropriate width is fixed to the wall. The bottom of the angle iron should be about 0.5 cm above the ground level.

Sanitation in and around the godown will reduce rodent problem. Uncared for bushes, heaps of building material, garbage outside the godown provide shelter for them. Similarly old and unused furniture, sacks etc. heaped in a corner of the godown will provide a good shelter for rats . Therefore great attention should be paid for sanitation and tidiness in and around godowns.

Trapping :

Trapping is an effective way to control rats and mice populations in many situations. Trapping is preferable in godowns than poison baiting as sometimes rats may die inside the stack and create a problem for the removal of dead rats. It is necessary to use very attractive food to compete with available food material to lure rats .Trapping effeciency is increased by enlarging bait pan, with more number of traps and correct placement and by use of proper size of traps. The trap must be first set with a proper bait in such a manner that it will not shut when the bait is eaten. After 2 or 3 days of prebaiting in this manner, the trap can be set to trap the rat. This will eliminate trap shyness of rats .

Poison baiting :

The use of poison baits is the quickest way of reducing high rat population. Various poisonous substances are being used for this purpose which may be broadly classified as single dose (acute) or multiple dose (chronic) poisons.

Single dose poisons are red squill, strychnine, arsenious trioxide, alpha naphthyl thio.urea, barium carbonate, norbormide, sodium fluro acetate, thallium sulphate and zinc phosphide. Zinc phosphide remains one of the most widely used rodenticides today due to its fairly good safety record, low cost and reasonably high effectiveness against rodents.

Multiple dose poisons are anticogulants. They are generally slow poisons, which prevent coagulation of blood and death occurs by internal and external bleeding. The rats begin to die only after continuous consumption of anticoagulant bait for atleast 3-4 days. The slow action of the poison is considered a safety factor. Such anticoagulants are couma-tetra-allyl chloraphacinon warfarin, pival, coumachlor, diphacinon etc. There is another anticoagulant Brodifacoum (klerat) which acts fast and the animals die after consuming the poisoned bait only once.

Use of Zinc Phosphide :

The main steps of zinc phosphide poison baiting either for surface baiting or burrow baiting are preparation of baits, selection of baiting points, prebaiting with non-poisoned baits and poison baiting.

Zinc phosphide is used at 2% level in baits. To make 100 g of poison bait, take 96 g. ($\frac{3}{4}$ of tea cup) of a bait material (whole or crushed sorghum, maize, wheat etc.). Add 2 g. ($\frac{1}{2}$ tea spoon) of any vegetable oil. Mix well and add 2 g. ($\frac{1}{2}$ tea spoon) of zinc phosphide and mix well. Use a wooden spoon for mixing. Fried material, bread crumbs etc. can be used advantageously for preparation of poison baits.

Select the places for baiting, keeping in view the rodent entry points run - ways, Sheltering places and where rat trouble is noticed. In order to eliminate bait shyness and accustom the rats to the bait, place non-poisoned baits for 2 days at least. By observing the intake of baits from different baiting points, select the best baiting points. After pre-baiting, place poison bait at night in the selected baiting points. At each place keep about 25 g. (5 tea spoons). Next day collect the unused poison baits and dead rats and bury them deep in the ground.

In case of burrowing rats, in and around the stores first live burrows should be identified. For this, close the burrows in the evening loosely with paper and mud with the paper projecting out on sides for easy detection of the burrows closed. Inspect them on the following morning. The burrows which are opened are live burrows. Poison baiting is done by placing about 10 g. (2 tea spoons) of poison bait inside the burrow, preferably loosely packed in a thin paper prepared like a torpedo and pushing it inside the burrow. In this case also it is advisable to carry out prebaiting for 2 days. This

method of baiting (torpedo baiting) will reduce danger to non target animals like sheep, goats, cows etc.

Use of Fumigants :

Live rat burrows inside and outside the godown can be fumigated using aluminium phosphide pellets. 2-4 pellets, depending on the size of the burrow, should be placed deep in the burrow in the morning when rats (nocturnal type) stay in the burrows and the burrows closed tightly with mud. Non opening of the burrow on the next day indicates death of rats. The burrows inside the godown should be closed well using glass pieces, stones and cement.

Use of anticoagulants :

Anticoagulants are available as solid or water soluble baits. Ready to use wax preparations are also available.

For preparation of 500 g. of ready - to-use solid bait, take 450 g. (4 tea cups) of crushed food grain (sorghum, maize or wheat) 15 g. (3 tea spoons) of sugar and 25 g. (5 tea spoons) of 0.5% anticoagulant concentrate (e.g. warfarin) and mix thoroughly. Add 10 g. (2 tea spoons) of oil and mix thoroughly.

For preparation of 500 ml of liquid anticoagulant bait take 25 g. (5 tea spoons) of water soluble anticoagulant concentrate (0.5%) and dissolve in 500 ml (4 tea cups) of water.

Select the baiting points as described in case of zinc phosphide and place 125 g. (1 tea cup) of ready-to - use bait in a shallow container. In case of liquid bait, about 125 ml. (1 tea cup) of liquid bait should be placed in each of the selected places in suitable shallow containers.

The bait stations should be inspected daily in the first week to see whether the rats are consuming the baits properly, if not the baiting points should be changed suitably. If the rats consume the baits, they should be replenished well so that the rats consume the baits regularly in sufficient quantity.

The rats begin to die after 3 to 4 days of placement of baits. It is advisable to keep the baits in the godown for a period of about 3 weeks, continuously to obtain maximum kill. Later a few permanent baiting points may be kept at places of rodent entry to control migratory rats and reinfestation. In case of liquid baits, there will be a need for frequent replenishment as the baits dry up soon.

In case of brodifacoum, ready-to - use wax baits are available or the anticoagulant can be mixed in sorghum, sugar and oil for baiting. They should be placed at selected places as indicated before. It should be remembered that consumption of brodifacoum baits even on one day (even 1-3 gr. of bait per rat) is sufficient to kill rats. However brodifacoum baits are placed 3 or 4 times with intervals of one week to obtain good mortality. Mortality may occur after 3rd day upto 12th day after consumption of the poisoned baits. This method of baiting is called pulse or interval baiting.

Bait stations :

Bait stations are of different types and many of them can be made locally. The rats like to eat in privacy and where there is less light. The poison bait should not be available for dogs and cats. Therefore the bait station should satisfy these conditions. Appropriately cut wooden box or 2- 4 gallon tin, cement G.I pipes of 45 cm long and of 6-10 cm dia can be used as bait stations. Even 45 cm X 15 cm wooden planks with two rings can be placed in an inclined position against the walls with rings put on 2 nails driven into the wall. That will make a stable inexpensive bait station.

Precautions in Using rat Poisons :

Zinc phosphide is a highly poisonous material. It should be handled with great care. Prepare the poison bait only on the day when it is to be used. Mix poison baits with wooden spoons only in a well ventilated area. Use hand gloves while handling poison bait. Collect unused poison baits and dead rats and bury them in the ground to avoid secondary poisoning, that is poisoning of cats and dogs etc. when they eat dead poisoned rats.

Aluminium phosphide produces phosphine when exposed to atmosphere. Phosphine is a highly toxic gas which should not be inhaled. Open the tin/ flask of aluminium phosphide preparation in open air and handle the tablet/ pellet after wearing hand gloves.

The anticoagulants are comparatively more safe than the single dose poisons. However anticoagulant baits should not be accessible to dogs and cats.

4.12 Maintenance of Equipment used in Storage of Food Commodities

Different equipments and materials are used in food grain godown for preserving the stocks free from deterioration. It is necessary to keep the equipments and materials in proper condition so that they can be taken out and used when necessary on a short notice. It is observed at many places that after use, these equipments and materials are left un-attended to resulting in damages to them. In developing countries, most of the equipment and materials are imported or obtained through 'aid' programmes from friendly countries. If the equipments/ materials become unserviceable it will be difficult for their early replacement. Therefore great care is necessary for maintenance of equipments and materials received for use in the godown. It is one of the duties of a godown-in-charge.

Different equipments and material supplied to the godowns may be broadly classified into the following:

1. Equipment for prophylactic treatment - sprayers, dusters and fogging machines.
2. Equipment and material for curative treatment- fumigation sheets, sand snakes, clamps, methyl bromide fumigation kit.
3. Safety equipment- gas masks, canisters, eye shields, dust masks, hand gloves, halide lamp and other gas detecting kit.
4. Miscellaneous material: wooden pallets, mats, polythene sheet, tarpaulins, rat cages, platform scale, grain samplers, wheel barrow, platform trolley, ladder, grain cleaning sieves etc.

Sprayers :

They may be manually operated or power operated knapsack sprayers or trolley mounted power sprayers. Before keeping the equipments in store after use, the spray lance, nozzle, delivery tube should be completely cleaned by working the sprayer for a few minutes with clean water. The spray tank should be kept free of any rust and kept clean of all sediment and particles. Clean water should be poured into the tank through the filter for cleaning.

The pump should be checked regularly for worn out washers, bearings and valves. Any defective parts should be changed in time. Spray gun should be checked for leaks. The tap or control valve should be checked in closed position and with full pressure for any leaks. Springs and washers should be replaced if defective.

Nozzles should be handled carefully. Any mishandling and damage will alter the droplet size or spray particles. Clogged nozzles should be opened and cleaned. Use of metal needles should be avoided during cleaning of nozzles. Blowing the nozzles with mouth is dangerous and should be avoided.

In case of power operated sprayers, the level of oil in the oil chamber should be checked, and maintained. The carborater should be kept clean of any dust. All the moving parts should be properly lubricated and checked for wear and tear. A log book should be maintained for each power operated sprayer.

In case of fogging machine cleaning after use is important as the thermal action carbonises solvents and choke the nozzle. The engine portion needs checking periodically. Replacement of worn out parts is necessary to prevent starting troubles and leakage of fuel.

Fumigation sheets :

A slight damage will make the sheet useless for fumigation. They should not be pulled from the edges on the godown floor and on the ground with pebbles and stones. Walking on the covered stack with shoes or boots with metal attachments on the sole, should be avoided. Any tears noticed on the covers should be repaired. The sheets should be folded or rolled and tied when not in use. They should be stacked neatly above the ground level and covered to prevent dust accumulating on them. Exposure to direct sun light should be avoided because it may lead to deterioration of the quality of the sheets. Rats will damage the sheets and so they should be protected from rat damages. If necessary rat control measures should be undertaken in the stores.

Sand Snakes :

They should not be dragged on the floor and should be kept in a dry place. The ends of the sand snakes should be closed/ tied properly as

otherwise sand will leakout when it is used. Rats may damage unfilled sand snakes and therefore they should be stored properly.

Clamps :

After use, it is necessary to count the number of clamps. Many times they are just left at the site of fumigation. They should be kept together in a card board or wooden box in a dry place. Rusting will spoil the clamps.

Methyl Bromide Fumigation Kit :

After every fumigation, it is necessary to check whether all nozzles are intact on the fumigation lines. Manytimes they are left within the bag stack while pulling the lines (tubes) from the stack. Clamps should be tightly fitted to avoid such problems. The whole kit should be kept in a cool place and not exposed to sun. Otherwise the rubber/ plastic tube connections will become brittle and split here and there resulting in leakage of fumigant gas during fumigation operation. Nozzles need special cleaning after use before storing and before fumigation operation.

Gas Mask and Canisters :

Gas masks should be stored properly without being damaged by rats. The canisters should be stored in a cool and dry place away from contamination of any gases. Water renders a canister useless. Hence all precautions should be taken to keep them dry and prevent any moisture entering it. The expiry date on the canister should be noted and it should be used before that date.

Hand Gloves :

They get softened and stick to each other when kept together in a hot place. After use they should be washed and dried. Talcum powder should be dusted on both inside and out-side and stored in polythene bags.

Halide Detectors :

They are relatively trouble free if they are stored in a dry place. The burner head orifice is extremely small and must be kept free of clogging with dust or any other particles. The reaction plate/ cone / wire need replacement when it becomes heavily corroded.

Other Gas Detecting Kit :

They are special tubes for detecting phosphine and methyl bromide gas in air. These require special care. Exposure to heat or breakage of tips will render them useless. The expiry date should be noted and they should be used before that date.

Wooden Pallets, mats and Polythene Sheets Used for Dunnage :

It is better to store them at one appropriate place. Wooden pallets and mats should be protected from termite attack and fire. Before re-use they should be disinfested with malathion E.C. 1% solution.

Rat Traps :

Rat traps made of metal wires will get rusted if exposed to humid weather. Spring action of the rat entrance door or of a break-neck trap may be lost when rusted. Therefore they should be stacked neatly over the ground in covered stores.

Other miscellaneous material like platform scales, wheel barrow, platform trolley, grain cleaning sieves, tarpaulins, grain samplers also have to be kept neatly in the store. The brass parts of the samplers should be polished periodically to give a good appearance. The grain sieves if they are damaged can not be used. So special care is necessary in this case.

The breakdown of equipment may be due to several factors. One of the reasons is the errors committed by the operators while handling the equipment. It is, therefore, necessary that persons employed for operating the equipmerts should know how to use them properly. Another common cause for break down of an equipment is the use of defective tools while handling or in the maintenance of equipment. Therefore proper tools should be purchased and maintained in good condition. The operators should also get adequate training in the mechanism and maintenance of various equipment.

4.13 Estimation of loss in Grain due to Insect Infestation :

The loss in stored grain is estimated for commercial purposes by noting the difference between the gross weights of a particular lot of grain when received and when it is issued out. The total loss in weight, thus obtained, will represent loss due to driage of grain, due to infestation by insects,

birds and rodents. With high moisture and mould damage also there will be loss in dry matter of grain. Mere gross weight calculations will not give correct idea of grain losses when there is moisture pick up by the grain or driage of grain, unless the weight loss is expressed on moisture free or constant moisture content basis.

Estimation of weight loss due to insect infestation is necessary to check whether proper storage and pest management procedures are adopted at a particular place. It will also help in making a cost-benifit analysis of disinfestation measures undertaken. The loss in weight in grain due to infestation is estimated by count and weigh method as follows: (Ref 20).

Collect a grain sample (about 2 kg) from the grain stack by drawing grain using a double tube bag sampler from bags selected at random. From this sample, take 3 lots of about 25 g. each as described in chapter 2.1. Count the total number of grains and separate insect damaged and undamaged grains and count them. Take their weights also. Calculate the mean values, and the percent loss due to insect infestation using the formula given below:

$$\text{Percent loss: } = \frac{(U \times Nd) - (D \times Nu)}{U\ (Nd + Nu)} \times 100$$

where:

U = wt of undamaged grains
Nu = Number of undamaged grains
D = wt of insect damaged grains
Nd = Number of insect damaged grains

An idea of loss in grain due to insect infestation can also be obtained by estimating the increase in cereal dust in the grain and percentage of insect damaged grain.

For cereal dust estimation, collect 2 kg of grain as described in chapter 2.1. Sieve the grain using a sieve with one mm. round holes and collect the cereal dust. Weigh it and calculate the percentage of dust. From this value the dust percentage in the grain at the beginning of storage is subtracted to obtain the increase in dust percentage during storage. The increase in percentage of cereal dust indicates insect activity and damage to grain. It should be remembered that cereal dust estimates will give

only an indication of level of infestation. The amount of dust produced by different insects are not same. Some dust produced may settle down to lower layers and some quantity may come out of the bags too.

The percentage of insect damaged grain is calculated using the data obtained in weight loss estimates by the following formula;

$$\text{Insect damaged grain \% (by number)} = \frac{Nd}{Nd + Nu} \times 100$$

The percentage of insect damaged grain (by number) will give an idea of level of infestation and quality of grain. However, this value will not give a true picture of weight loss because damages caused by different insects differ much and the amount of weight loss in an insect damaged kernel may be little or more.

4.14 Inspection of godowns and Recording of disinfestation Work :

The pest control operator is often asked to inspect foodgrain godowns and disinfest grain stocks belonging to different agencies. In such cases, he will have to follow systematic procedures for inspection of the godown and food grain stocks; for estimation of level (degree) of insect infestation and recording disinfestation treatments given by him. This will help in submitting reports to the agencies employing him for such a work.

Inspection of the godown is carried out to check the condition of wall, roof, floor, ventilators, rodent entry points and water damage; suitability for godown fumigation; hygiene in and around the godowns including rodent burrows; number of stacks; whether the stacking pattern allows ventilation, whether the stacks are placed conveniently for inspection and fumigation, whether there is spillage of grain on the floor.

The level of insect infestation is estimated by drawing samples of grain from each stack and identifying and counting the number of insects as described in chapter 3.2. The level of insect infestation is expressed as number of insects per kg of grain separately for all insects.

The details of fumigation and prophylactic treatment given are recorded stackwise. The details in regard to fumigation are commodity, number of bags in the stack, volume of the stack in case of methyl bromide fumigation and weight in case of phosphine fumigation, date of fumigation, dosage and quantity used, exposure period and result of fumigation. In case of prophylactic treatment, the following are recorded. Date of treatment, insecticide and formulation used, dilution and result of treatment. In addition weather conditions and any other relevant points are also recorded.

The set of forms to record the details of godown and disinfestation treatment is at annex XIX .

CHAPTER 5
STORAGE OF SEED GRAIN

CHAPTER (5)

Storage of Seed Grain

5.1 Losses in Seed Grain:

Availability of good seed is necessary for a good crop. Seed grains have life and respire like all living organisms. They contain moisture, carbohydrates, protein, fat, vitamins and minerals and also different enzymes. These food constituents help the seed to germinate and grow into a plant under favourable conditions. Healthy and vigorous growth after germination is necessary for a good crop, which emphasises the need for good seed.

Several factors are responsible for losses in seed grain during storage. They may be broadly classified as biological and non biological factors. Biological factors are insects, mites, fungi, rats and birds. Non biological factors are oxygen concentration, temperature and relative humidity. Losses occur both in quality and quantity.. (Ref. Nos. 4, 5).

The group of insects and mites consists of a number of them, which have been described earlier. Some of the insects namely lesser grain borer, rice and granary weevil and khapra beetle attack whole grain. Pulse beetle is specific for pulses. Other insects do not attack whole grain but feed on broken grain and grain already damaged by other insects. From the seed point of view moths are also important as they feed on germ portion which is softer than other parts of the grain. Sometimes red grain beetle is also found to feed on germ portion especially when the grain has higher (14%) moisture content. Optimum conditions for the development of storage insects are 11 - 15% moisture content in grain and temperature of 25° - 32°C. In case of oil seeds, moisture levels of around 5 - 6% are also favourable for insects. Temperatures below 20°C and moisture content below 8% in cereals do not favour development of most of the common insects.

The grain which has been attacked by insects may germinate if the germ is not damaged or eaten away, but it will die soon because of non availability of nutrients during earlier stages of its development.

Rats and mice which infest the godown consume seed grain resulting in loss of seed in quantity. In addition they nibble the grain especially germ portion causing damage to the seed. Birds also consume grain resulting in loss

in weight. Storage fungi grow on the seed under favourable conditions. The most important storage fungi are:-

a. Aspergillus spp. b. Penicillium spp. c. Alternaria spp.
d. Mucor spp. e. Cladosporium spp. f. Sporendoma spp.

Favourable conditions for the development of storage fungi are water activity value of 0.70 corresponding to about 14.5% moisture content of the grain and temperatures around 30°C. Development of fungi is favoured by presence of broken grain and plant debris and infestation with insects and mites. Dry seed grain can pick up moisture in storage. Leakage of rain water on the bags, seepage of water through floor and walls, flooding of godown through gutters in the godown or through doors/windows and ventilators, exposure to humid atmosphere will result in development of high moisture pockets in the grain during storage. In case of legumes, it is found that if the moisture content is reduced, the life of the seed will be considerably long.

The storage fungi on grain will result in reduced or loss of germination. Discolouration and damage of the embryo takes place initially and when the fungal infestation is severe, the discolouration is inside and outside of the whole grain as well. Severe mould damage will result in heating of grain (called wet heating) and there is caking of grain due to development of mycelia. Biochemical changes in the grain due to fungal enzymes will result in rancidity and off flavours.

Temperature is another important factor in affecting respiratory activity of the seed. If the storage temperature is reduced by 5°C, the life of the seed particularly of legumes is said to double itself. Seed however should not be stored over number of years, as the viability will decrease on prolonged storage especially in case of oil seeds. At lower temperatures (below 20°C) even higher moisture (12 - 14%) in the seed is not dangerous. In a tropical climate, with temperatures generally not lower than 20°C and usually about 25° - 35°C moisture content not more than 9% preferably about 8% will be suitable in case of cereal grains. For better preservation of seed viability, storage of seed at lower temperature is practised which method can not be adopted for large scale seed storage because of high cost factor.

Oxygen tension in the storage atmosphere should be normal. This will not be a problem in above ground bag storage where ventilation is available. In an underground pit (matmura), there will be no transfer of gases from outside

to inside and vice versa. With higher moisture content in the grain and mould damage on the sides and bottom of the pit, the oxygen concentration may fall below 1% even and in such cases the loss of viability may be more than 30 - 40%.

5.2 Prevention of Losses in Seed Grain:

Prevention of losses in storage requires attention to a number of factors during receipt and storage of seed.

Selection of grain for use as seed is of primary importance. Clean and dry grain with no/minimum brokens, less of mechanical injury to the kernels, low percentage of shrivelled and immature grain, and also discoloured and damaged grain has to be selected in addition to paying attention to the purity of variety for use as seed grain.

The requirements of godown for seed storage are same as those for food grain storage. Prestorage precautions have to be taken before storage of seed. The godown floor, walls, pillars, trusses, ventilators etc. should be swept/brushed. All webs should be removed. The floor and wall should be checked for cracks and repaired. Surroundings of the godowns should be cleared of shrubs and bushes and drainages maintained clean to avoid flooding during rains. The empty godown should be disinfested using malathion E.C. (1% solution). If there are rat burrows inside and outside, they should be fumigated with phosphine and later closed well with glass pieces, stones and cement.

Bag stacks should be built properly within the boundaries of the stack plan drawn on the floor. The stack plan is drawn keeping in mind that there should be space between wall and stack, stack and stack (minimum 0.8m) and the pillars or drainage pipes are left in the alley ways. The seed grain bags should be stored on wooden dunnage or dunnage made of polythene sheet sandwitched between two layers of mats. The stacks should be built compact.

The seed grain stocks should be examined once in a fort night by drawing samples from bags on four sides and top surfaces. A record should be maintained to show degree of infestation, if any, with names of insects present in the grain. General observations on leakage of water during rains, rodent and bird trouble should also be recorded and remedial action taken.

If the stock of seed grain contains more than one insect of the following

species, khapra beetle adult/larvae, lesser grain borer, rice/granary weevil or moth larvae per kg of grain or 3 other insects (namely red flour beetle etc.) per kg of grain, it needs fumigation. In case of legumes presence of pulse beetles, one insect per kg of grain, also warrants fumigation.

The dosages and exposure periods of the two fumigants namely methyl bromide and phosphine are given below.

Methyl bromide: 22gm per cu mt with an exposure period of 48 hrs. Phosphine; 3 tablets of aluminium phosphide per ton of seed with an exposure period of 5 days.

Fumigation of seed having more than 12% moisture content and repeated fumigation (more than 2 times) of even dry grain with methyl bromide should be avoided. Fumigation with phosphine is considered harmless in case of seed grain.

Prophylactic Treatment:

It serves to prevent cross infestation mainly. The commonly used insecticide is malathion (50 or 57% EC) of 0.5 - 1.0 percent concentration. Diluted malathion is sprayed on the walls and alleyways . It can be sprayed on the surface of bags too (30 - 50 ml per sq. meter). Knapsack sprayers (manual or power operated) and wheel barrow sprayers can be used for spraying in the godown. Care should be taken not to wet the bags. Fogging with malathion is useful to control moths.

Sometimes seed grains are mixed with insecticides such as lindane and BHC dusts to prevent insect attack during storage. However such treated grain in excess of seed requirement can not be used for human food or purposes. Seed treatment with pesticides and fungicides before sowing is better as it will be more effective against insect pests and fungi in the soil. Also mixing of insecticides before storage will not give protection against stored grain insects through out the storage period.

Rat Control:

Rat damages should be identified in the godown, by observing the telltale signs such as rat pellets and damages to bags. Rats can be seen running in between stacks. Rats should be controlled by eliminating entry of rodents

into the godown. If that is difficult, measures for their control using traps, poison baits (anticoagulant baits inside the godown and zinc phosphide baits outside the godown), fumigation of burows using aluminium phosphide tablets have to be taken, as described in another chapter.

Storage hygiene:

Maintenance of storage hygiene is very important. Once in a month, the walls, bag surfaces should be brushed and the spilled grain in the alley ways collected. The grain is seived out and the cleanings should be burnt or buried. Prophylactic treatment of the godown with malathion should follow cleaning operation.

Ventilation:

Ventilation in a godown on all clear days is necessary for reducing temperature and humidity build up in the godown. This would help control of moths, mites, and psocids in the godown. All the doors and ventilators should be opened for proper vetilation. Ventilation however should not be done on rainy days.

CHAPTER 6

STORAGE OF MISCELLANEOUS ITEMS

CHAPTER (6)
Storage of Miscellaneous Items

Many miscellaneous items are received by grain handling agencies and are required to be stored many times. These items can be broadly grouped as follows:

1. Cooking oils
2. Milk powder and milk products
3. Canned food material and packed food like biscuits
4. Cereals, cereal products or blended products of various grains etc.
5. Sugar.
6. Fertilizers

6.1 Cooking Oils:

They may be of vegetable origin like peanut oil, soya bean oil; animal origin like butter oil and hydrogenated oils like margarine. They are packaged differently in 4.5 or 22 litre tins or in 180 litre drums. Sometimes the small capacity tins themselves are packed in fibre board or wooden cases.

Big drums must be kept in one line and not one over the other. Oil tins can be stored at a height of 8 -10 tins high depending on the size of tins. Canned oil tins in fibre board cases can be stacked one over the other but it should be ensured that the fibre board boxes do not bulge out and the tins become compressed and dented. This precaution has to be taken in all cases of stacking of oil tins. Usually there is a problem in case of butter oil tins and great care is needed in stacking them.

It must be remembered that oil tins leak through the caps if they are not properly fitted and through the solder around the seals if it is damaged. Leaking of oil due to punctures made in the tins through in-correct nailing of wooden cases, bad dents on the body of tin is common. Leaking tins must be identified and kept separately in open trays to prevent spoilage of floor. As soon as possible the oil should be transfered into sound tins . Oils become rancid and smell badly and so cleaning and wiping of tins with adhered oil is necessary. Even in tins, the oil becomes rancid on long storage especially at temperatures of 30^{o}C and above and will not be acceptable to consumers. Therefore storage of oil beyond one year in tropical climates is not advisable.

Attempts should be made not to keep the oil tins in direct sun light and in low metal roof sheds where temperature will be high.

6.2. Milk Powder and Milk Products:

Whole milk powder is packed in hermitically sealed and gas packed tins of 0.5 to 1.0 kg to prevent oxidative deterioration. In case of skim milk powder, polythene bags or paper/foil/plastic bags are used. They are again packed in fibre board cases, often made from polythene coated board. Storage life of such packs are satisfactory. 25 kg paper sacks are also common. If a polythene liner is provided, they are also satisfactory. Fibre board drums with a thick polythene lining is quite good. Evaporated whole or skim milk is packed in cans of 397 and 340 g capacity. They are packed 48 to a case with proper cushioning to prevent mechanical damage. Condensed milk is packed in 400 - 450 g capacity tins.

Milk powder deteriorates in quality at higher temperatures (30°C and above). Evaporated whole milk/condensed milk deteriorates more rapidly. It is advisable not to store milk powder for more than 6 months and liquid milk products not more than 3 months in tropical climates. Milk powder should not be exposed to atmosphere because it will absorb moisture and lumps are formed. There is thus deterioration in quality. Great care is necessary in handling polythene/paper packages and fibre board drums. They should not be stacked in such a way that the bottom layers get crushed. Rodents will create a problem in the stores. Spilled powder from damaged packages must be promptly cleaned as they will become sticky on absorption of moisture and then moulds will develop on them. If spilled powder remains stuck on the packages, it should be cleaned well, preferably with a vacuum cleaner. Milk powder absorbs smells from other material and therefore care should be taken not to store fertilizers, dry fish etc.. near milk powder bags/ cases. The storage area should be cool and dry and free from rodents. All milk powder packages should be stored on a proper dunnage.

6.3. Canned Food Material and Packed Foods like Biscuits:

Great care is necessary in handling canned food. Deterioration will set in when the contents in a broken tin are exposed to atmosphere. Leakages are common in canned food. Cans must be kept in a dry place to prevent rusting on the outer surface. Prompt action is necessary in segregating tins which are leaking and cleaning the place to avoid foul smells. It should be remembered

that some pathogenic organisms like C. botulinum may be present in deteriorated canned food. Therefore professional advice will be necessary before doubtful quality canned food with foul smell is issued out for consumption.

Food material like biscuits are packed very carefully as consumer packs and they are in turn packed in tins or carboard and wooden boxes for traders use. Normally there will be no problem in case of tins but problems do arise in other packings. Breakage of packing may expose the consumer packs to outside atmosphere and to insect infestation. Rodents can do damages to non-metal packings. Storage hygiene and rodent control are very important in the places where they are stored. Cool and dry places are to be preferred. Infestation in biscuits and such products will make them unacceptable to consumers even if the insects are dead. Prophylactic spraying using DDVP is advisable to check insect problem, if any, in the places where packed food products are stored.

6.4 Cereals, Cereal Products and Blended Products of Various Grains etc.

All these food materials are prone to damages by insects, mites, rodents and birds. The milling of cereals into flour renders them more susceptible to deterioration in quality. Absorbtion of moisture is more quick in flour than in whole grain. Flour is generally packed in paper or polythene lined sacks to prevent moisture absorbtion. They are usually of 5 to 50 kg. consumer packs. Blended products of various grains are also similarly packed. Bursting of bags and spillage of contents take place often. Cleaning not only of floor where spilling has taken place but also the surface of other bags on which the contents have fallen is important. Spilled flour attracts insects and rodents. Use of dunnage under the cereal and flour bags, maintenance of hygiene and rodent control are important. When insect infestation is noticed, fumigation with phosphine should be carried out. Methyl bromide is not recommended in case of oil seeds, cereal flour and blended food products for fear of fumigant residues and bad odours in fumigated products. In case of cereals, methyl bromide fumigation is also alright. Prophylactic treatment once in a fort-night during rainy season and once in a month in other seasons is necessary. DDVP EC (50%) after dilution (1:150) can be used for prophylactic treatment. It should be remembered that prevention of infestation is better than cure. Presence of live or dead insects in packed foods like cereal flours and blended products of various grains is not liked by consumers.

6.5 Sugar:

Sugar is an hygroscopic commodity and will absorb moisture from the atmosphere. Damp from the floor and walls and humid weather are adverse conditions for safe storage of sugar. The moisture absorbtion can be so much as to convert sugar into syrup and ooze out from the bags and on the floor. Great care in selection of godown is important. It should have cemented floor preferably made damp proof. There should be no leakage of water through roof, ventilators, windows and doors during rains.

Use of dunnage for stacking sugar bags is a must. Wooden dunnage or polythene sheet sandwitched between two layers of mats can be used. The stack height can be up to 20 bags high. Sugar should be packed in new A- Twill sound jute bags stencilled with relevant details such as name of mill, grade of sugar, date of production, weight etc. No leaking bags should be stacked without mending. Use of hooks should be completely avoided. No disinfestation treatment should be given to sugar stocks. When neighbouring food-grain stocks are to be fumigated, it is necessary to cover the sugar stocks with polythene sheet or covers during the fumigation and degassing operations.

Aeration of sugar stock has to be selective and controlled. During humid weather, the sugar stocks should be covered with polythene sheets only temporarily. Continuous covering of sugar stocks should be avoided because that will develop heating and translocation of moisture to surface. It is advisable to have a hygrometer in sugar godowns to record daily humidity and plan selective aeration. Sugar stocks which are not storage worthy should be disposed of so that further deterioration may not take place.

6.6 Fertilizers:

The main problem in storage of fertilizers is their hygroscopic nature. In tropical climates, the extreme variations in temperature and climatic conditions render the storage more difficult. Safe storage of fertilizers depends on the following important factors:

a. The intrinsic quality of the fertilizer
b. Climatic factors
c. Mode of packing
d. Storage godown
e. Dunnage and stacking

Intrinsic Quality of Fertilizers:

The intrinsic qualities are chemical composition and its hygroscopic nature. In addition the granule size influences the storability. Bigger size granules have lesser surface area to absorb moisture and so lesser tendency for cake formation. Some of the common fertilizers are listed below with their properties:

Hygroscopic, acid treated or explosive fertilizers	Non-hygroscopic fertilizers
1. Calcium ammonium nitrate (neutral)	1. Potassium sulphate (neutral)
2. Ammonium sulphate-nitrate (acidic)	2. Potassium chloride (neutral)
3. Nitro phosphate (likely to cause damage to jute sacks)	3. Ammonium sulphate (acidic)
4. Urea (acidic)	4. Ammonium phosphate (acidic)
5. Super phosphate (likely to cause damage to jute sacks)	5. Ammonium chloride (acidic)
6. Rock phosphate (likely to cause damage to jute sacks)	6. Di-Calcium phosphate (basic)
7. Triple phosphate (likely to cause damage to jute sacks)	7. Bone meal (acidic)
8. Di-ammonium phosphate (likely to cause damage to jute sacks)	
9. Potassium nitrate (explosive in nature)	

Climatic Factors:

Hygroscopic fertilizers are greatly affected by variations of temperature and relative humidity (R.H). Increase in temperature lowers the R.H.and therefore the keeping quality of fertilizers is better. When the R.H. increases due to rainy weather or near coastal areas, the keeping quality of the fertilizers is poor. R.H. over 60% is not suitable for safe storage of fertilizers and cake or lump formation of the fertilizer is hastened. With more humidity, the whole fertilier bag becomes a pasty mass and starts oozing out of the bag. But in dry areas, the fertilizer retains its solid condition and free flowing nature.

Mode of Packing:

In case of hygroscopic fertilizers, the type of packing exerts consider-

13. Method for sampling of smaller size food grains, Indian Standard 2814 - 1978, Indian standards Institution, India.

14. Methods of analysis for food grains. Part II Moisture, Indian Standard 4333 (part II) - 1967, Indian Standards Institution. India.

15. Methods of analysis for food grains. Part I - Refractions, Indian Standard 4333 (part I) - 1977, Indian Standards Institution. India.

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(Annex I)

Specification Of Wooden Dunnage (Wooden Pallets):

1. Each dunnage piece shall be 1.5 m x 1.00 m .
2. The lower members shall be 10 cm by 5 cm in section. Their total number shall be 5 and each piece should be 1.0 m long spaced 36.25 cm from center to center.
3. The Upper members shall be also 5 in number, each 1.5 m long and 7cm by 5cm in section spaced 23.75 cm from center to center. The higher dimensions of the section of each member will be vertical.
4. The pieces shall be made from soft wood and shall have no joints or cracks or loose knots.
5. The dunnage shall be properly nailed with sufficient nails to make the frame reasonably rigid and properly fitted. There shall be at least 2 nails at each corner joint and no nail shall project from the wood so as to be a source of danger to the jute sacks.
6. All nail heads shall be at the top only.
7. Wood damaged by white ants shall not be used.
8. The top of each dunnage piece shall be in one level.
9. Each dunnage shall be properly painted with two coats of protective material to prevent activity of ants, termites and wood borers. (Ref. No. 10).

(Annex III)

Some Physical Properties of Grain

Commodity	Bulk density kg/cu mt)	Angle of repose (degrees)	Commodity	Volume of bagged commodities (cu mt/ ton net weight)
Wheat	730 - 840	26 - 28	peas, beans and lentils	1.3
Sorghum	641 - 743	33	wheat ,rice	1.6
Rough rice (paddy)	440 - 666	36	maize, sorghum peanut kernels	1.6 - 1.8
Peanut Un-shelled	282 - 384	-	flour	2.1
Corn shelled	718 - 769	27		
Barley	641 - 692	28		

(Annex IV)

List Of Equipment For A Regional/Head Office Laboratory For Physical Analysis Of Grain

1. Air oven - 1
2. Sample divider - (Boerner) - 1
3. Enammelled plates - round different sizes - 12
4. Sample scoops - different sizes
5. Counter scale- capacity 1 kg with weight box - 1
6. Portable balance with weight box - 1
7. Physical balance with 5 mg sensitivity - 1
8. Moisture meter with accessories - 1
9. Hecto litre weight apparatus - 1 (optional)
10. Glass slabs.
11. Simple bag sampler (30 - 40cm) - 4
12. Double tube bag sampler - 2
13. Magnifying lens - 2
14. Polythene sample bags
    12 cm x 20 cm, 300 guage - 500
    15 cm x 22 cm, 300 guage - 500
15. Sample slips - 1000
16. Cloth sample bags. (20 cm x 30 cm) - 500
17. Wet and dry bulb thermometer -1
18. Whirling hygrometer -1
19. Desiccator -1
20. Aluminium moisture dishes - 12
21. Tongs - 2 pairs
22. Scalpel
23. Forceps (fine point and blunt point)
24. Spring balance (cap. 1kg x 5 g.)
25. Binocular microscope (x 5 to x 50)
26. Seed counter (Tally counter - hand operation)
27. Polythene sheet: about 1.5 m square
28. Brushes - different types
29. Dust masks (paper disposable type)
30. Calculator (pocket type with simple functions)
31. Heat sealer - 1
32. Glass jars (wide mouth 250,500,1000 ml capacity) - 24

moisture content between 7 and 17%, the procedure of grinding, drying and weighing as explained earlier is followed. The gain in moisture content and loss in moisture content during rehumidification and preliminary drying respectively are taken into account for calculating the actual moisture content of the test sample. (Ref. No. 14).

Quality Specifications For Purchase & Receiving of Dura (Sorghum) by the Agricultural Bank of Sudan (Season 1986 - 1987)

1. The produce must be of 1986 - 87 crop and any produce from previous seasons should not be accepted.

2. The produce must be clean and free from defects from trading angle, such as broken grain, weevils, smut and discoloured grains(Talawi), and also impurities should not exceed 5%.

3. All the varieties of dura including Sudanese Hageen which are cultivated in the branch area may be purchased.

(Note:- Details of other conditions and restrictions for purchase and receipt of dura are given in ABS adminstrative order).

(Annex VI - C)

Specifications for Jowar (Sorghum)

US Department of Agriculture (USA)

Grade	Minimum test weight per bushel	Maximum limits of—			
			Damaged kernels		
		Moisture	Total	Heat-damaged kernels	Broken kernels, foreign material, and other grains
	Pounds	Percent	Percent	Percent	Percent
U.S. No. 1.....	57.0	13.0	2.0	0.2	4.0
U.S. No. 2.....	55.0	14.0	5.0	0.5	8.0
U.S. No. 3.....	53.0	15.0	10.0	1.0	12.0
U.S. No. 4.....	51.0	18.0	15.0	3.0	15.0

U.S. Sample grade .....U.S. sample grade shall be sorghum which:-

a. Does not meet the requirements for the grades U.S. No. 1, 2, 3, or 4.

b. Contains more than 7 stones which have an aggregate weight in excess of 0.2 percent of the sample weight or more than 2 crotalaria seeds (Crotalaria spp.) per 1,000 grams of sorghum

c. Has a musty, sour or commercially objectionable foreign odor (except smut odor) or

d. Is badly weathered, heating, or distinetly low quality (see 26, 552 (d)).

Sorghum which is distinctly discoloured shall not be graded higher than U.S. No. 3 .

(Annex VII)

Grain Analysis Report

Ref. No. Date:

1. Region — Lab. No. of Sample:
2. Place
3. Name of despatching station
4. RR No./Truck slip NO. & date
5. Wagon No./Truck No.
6. Commodity
7. Quality
8. Quantity wt./No. of bags

	Refractions	Percent
A.	Foreign matter	
B.	Other food grains	
C.	Damaged grains	
D.	Slightly damaged grains	
E.	Shrivelled grains	
F.	Brokens	
G.	Moisture	
H.	Admixture of other varieties	
I.	Weevilled grain	
J.		
K.		

Remarks: the quality is/is not according to specifications/despatch note

Analyser

Officer in Charge
of Laboratory

(Annex IX)

Stock Position Of Empty Jute Sacks

Date

Region:
Godown:

Date	Opening balance			Receipt			Issues			Closing balance		
	New	Used	Unfit	New	Used	Unfit	New	Used	Unfit	New	Used	Unfit

(Annex X)

Report On Storage Loss/Gain

Region:

Name of Godown:

Place :

Type of grain :

Stack No.	Stock receipt				Stock Issues				Period of storage	Percentage of loss/gain
	No.of bags	Weight	Date of receipt	Average moisture content	No. of bags	weight	date of issue	Average moisture content		

Remarks and reasons for loss/gain

Name and Signature of Store Keeper

Date :

Sr. No.	Common English Name	Scientific Name	Major or Minor Pests (type of insect)	Main distinguishing features and their identification	Damaging state of pests and damage done	Remarks
1	2	3	4	5	6	7
4	Red flour beetle	Tribolium castaneum (Herbst)	Minor(beetle)	Adult 3 to 4 mm long, reddish brown in colour, flattened and oval in out line, well developed and distinct, head thorax and abdomen.	Serious pest of rice and flour. Neither larvae nor adult feeds on sound grains generally, but feeds on grains already damaged by other pests. Also attacks germ part of sound grains.	Abundantly found in granaries, mills and warehouses.
5	Long headed flour beetle	Latheticus oryzae (Waterhouse)	Minor(beetle)	Adult is slender, flattened 3.17 mm long pale yellow in colour, smaller in size than T. castaneum.	Both adult and larvae feed on flour and meal but do not attack sound grains generally . Follows the attack of other major pests and fungus.	
6	Saw toothed grain beetle	Oryzaephilus surinamensis (Linnaeus)	Minor(beetle)	Adult has a row of sharp saw like teeth along each side of its thorax. Adult is slender, flat and brown in colour.	Flourishes well in stores having flour, biscuits and raisins and cereal products. Particularly found in rice. Adult and larvae both follow the attack of other major pests.	Was first described from specimen from Surinam hence the Specific name.
7	Flat grain beetle	Laemophloes minutus (Oliviere)	Minor(beetle)	It is the smallest beetle found in stored grains and is fastest runner in stored grain insects. It is small flattened, reddish brown beetle. 1.5 mm long and very long antennae,	Adult follows the attack of other major pests. Its larvae are fond of embryo of grains and attack germ portion.	It is cosmopolitan in distribution.

Sr. No.	Common English Name	Scientific Name	Major or Minor Pests (type of insect)	Main distinguishing features and their identification	Damaging state of pests and damage done	Remarks
1	2	3	4	5	6	7
8	Black fungus beetle	Alphitobius laevigatus (Fabrius)	Minor (beetle)	Adult is black, very dark reddish in colour and is 4.23 to 6.21 mm in length. Thorax profusely punctured, found in damp, dark and dingy parts of stores, below matting in mills or warhouses.	Adult does not damage sound grains, but attacks moist and broken grains. Also prefers milled products. Larvae also eat on food products of all kinds.	
9	Pulse beetle	Pachymerus (Bruchus) chinensis (Linnaeus)	Major pest of pulses	Adult is dark brown or chocolate colour and has swollen abdomen and measures about 4.23 mm. Head is small with blunt projection. Body clothed with short hair.	Serious pest of pulses ; makes a circular hole in the grain. Larvae stage does the main damage making the grain hollow.	Adults are good fliers infestation starts in fields.
10	Rice moth.	Corcyra cephalonica (Stainton)	Minor (moth)	Adult is pale, greyish brown coloured moth.	Serious pest of stored paddy rice and other cereals. Also infests dry fruits, cocoa, chocolates, biscuits, and flour. Only larvae stage is destructive.	Occurs in all parts of world.
11	Almond moth	Cadra (Ephestia) cautella (Walker)	Major moth)	Adult is of greyish colour with transverse stripes on its outer wings. Wings expanse is less than 25.0 mm. Larvae spin silken cocoons taking grains inside them.	Larvae only are damaging. Germ portion of grain is mainly damaged, silken tubes clog the machinery of mills pest of importance to cereals and products.	Found in most parts of world.

ANNEX XIII

Toxicity data of some insecticides associated with the protection of stored products

Acute mammalian toxicity (LD_{50}-mg/kg body weight)

Insecticide	Rat (oral)	Dermal	Hen (oral)
Bromophos	4 000-8 000	2 000	9 700
Chlorpyrifos	135- 155	202	32
Chlorpyrifos methyl	950-1 100	> 2 000	> 2 000
Dichlorvos	56- 108	75-110	15
Fenitrothion	250- 500	3 000	35*
Iodofenphos	2 100	> 2 000	> 2 000
Malathion	1 000-1 400	4 100	-
Methacrifos	700	3 100	-
Pirimiphos methyl	2 050	2 000	30 -60
Tetrachlorvinphos	4 000-5 000	> 2 500	2 500
Chlordane	450- 600	700-850	-
Lindane	90	1 000	30-60
DDT	110	2 500	
Bendiocarb	34- 48	600- 1 000	-
Carbaryl	500- 850	4 000	2 000*
Dioxacarb	60- 80	1 950 (3 000)	-
Propoxur	90- 130	800- 1 000	20*
Bioallethrin	500- 860	3 000- 5 000	-
S-Biol	800-1 500	1 500	-
Bioresmethrin	7 000	10 000	10 000
Resmethrin	1 400	3 000	-
Piperonyl butoxide	10 000		
Pyrethrum	580- 900	2 000	
Tetramethrin	4 600-6 500	> 4 000	5 000
Cypermethrin	250	> 1 600	
Deltamethrin	130- 140	> 2 000	
Fenvalerate	450	> 4 300	
Permethrin	1 500-4 700	> 4 000	
Phenothrin	10 000	> 5 000	

Note: The figures for oral toxicity are for rats or as specified. Dermal figures are for rats, rabbits or unspecified.

* Pheasants

Source ref. No.17

Annex XIV

Normal Application Rates of Insecticides For Prophylactic Treatment

Insecticide	Dust Admixture with Cereals (ppm)	Surface Treatments (g/m²)		Space Treatment (mg/m³)
		Walls	Bags	
Malathion	8 - 12	1 - 2	1 - 2	-
Pirimiphos methyl	4 - 10	0.5	0.5 (3 months)	50 - 100 at 1 ml/m³ (fog) 35 - 40 (smoke)
Fenitrothion	4 - 12	0.5	0.5 - 1	-
Bromophos	6 - 12	0.5 - 1	0.5 - 1	-
Chlorpyrifos methyl	4 - 10	0.5 - 1	0.5 - 1	-
Dichlorvos	2 - 20*	0.5		Simple fogging or aerosol 35-70 mg. Daily fogging or aerosol 10 mg. strip changed every 2-3 months 1 - per 30 m³
Methacrifos	5 - 15	0.2	0.4*	50 - 150
Iodofenphos	-	1-2	-	-
Tetrachlorvinphos	-	1-2	1-2	-
Lindane	1-2.5	0.5		40 - 80 (fog), 25 smoke
Pyrethrin / piperonyl butoxide (1:5)	3	-	0.075-0.1	1-2 (applied at 1 ml 0.3% for 1.5 to 3m³).
Phenothrin	5	-	-	-
Permethrin	-	0.5-0.10	0.5-0.10	-

Codex Maximum limits for Pesticide residues
(Codex Alimentarius volume Xlll - 31st October 1983)

Maximum Residue Limit

mg of insecticide per kg of commodity, ie mg/kg or ppm

Commodity	Bromophos	Dichlorvos	Fenitrothion	Lindane	Malathion	Piperonyl butoxide	Pirimiphos methyl	Pyrethrins	Inorg. bromide	Phosphine	* Deltamethrin	* Methacriphos	* Bioresmethrin
Raw cereals	10	2	10	0.5	8	20	10	3	50	0.1	2	10	5
White bread	0.5		0.2				0.5						
Wheat flour (white)	2		1				2				0.5	2	
Whole meal bread	2	0.5					1						
Wheat flour (whole meal)			5		2		5		50		2	10	
Peanuts		2				8	5			0.01			
Soyabeans		2	0.1										
Beans (dried)				1	8								
Flour & other milled cereal products		0.5			2					0.01			
Lentils		2			8								
Oil seed						8		1					
Rice polished							1						

* Based on FAO/WHO Joint committee recommendations 1982

Precautions in handling and using pesticides:

Since pesticides are poisonous chemicals they can also be toxic to higher animals. Some are more toxic than others.

The following general precautions must be taken in handling and using pesticides:

1. Always read the label carefully and follow the manufacturer's instructions.

2. Keep pesticides in labelled containers only.

3. Store pesticides under a lock in a safe place and out of the reach of irresponsible persons and pets.

4. Never store pesticides near food-stuffs or medicines.

5. Do not use the empty containers of dangerous pesticides for any other purpose than for storing pesticides. Empty containers which are of no use should be properly disposed off.

6. Use protective clothing and other devices while handling dangerous pesticides. This is a must.

7. Do not tear open the pesticide containers but cut them with a knife.

8. Prepare spray solutions from concentrated pesticides in deep bottomed vessels with the help of long-handled mixers. This is to protect the operator from the splashes of the pesticide and to make it easy for him to stir it in standing position.

9. Wash hands thoroughly with soap and water every time:

   (i) when the sprayer is filled with pesticides;
   (ii) before eating, drinking or smoking;
   (iii) at the end of the day's work.

(c) Cleanse the skin thoroughly with water

(d) Rapidity in washing is most important in reducing the extent of injury.

Eye Contamination:

(a) Hold the eyelids open

(b) Wash the eyes gently with a stream of running water immediately. A delay of even a few seconds greatly increase the extent of injury.

(c) Do not use chemicals . They may aggravate the injury.

Prevention from Collapse:

(a) Cover the patient with a light blanket

(b) Do not use a hot water bottle

(c) Raise foot of the bed

(d) Give strong tea or coffee. Tea is useful for children

(e) Do not exhaust patient by too much or too vigorous treatment.

(f) The following should be done by a physician or a trained dispensary chemist.

(i) Apply elastic bands to arms and legs

(ii) Give hypodermic injection of stimulants such as caffeine and epinephrine.

(iii) Administer five per cent dextrose solution intravenously

(iv) Give blood or plasma transfusion

Common rodents and their distinguishing features

Annex XVIII

	Common English name	Scientific name	Main distinguishing features
1.	Roof rat or black rat	Rattus rattus	Black/brown in colour, Fur-soft, snout - long and tapering, uniformly tapering, length greater than head and body together, well marked rings on tail, large and translucent ears, reach the eye when stretched, adult 150 - 250 g.
2.	Brown rat or sewer rat	Rattus norvegicus	Brown in colour, heavier built than black rat, adult 200-300g, Tail - not longer than head and body, tail not uniformly tapering, fur - soft, snout - wide and blunt, ears - small half buried in fur, opaque and thick.
3.	House mouse	Mus musculus	Light to dark gray, adult 20 - 30 g. snout small and pointed. Tail slightly longer than head and body, fur-short and smooth, ears - round and prominent and extends upto the eyes when stretched, adult 14 - 25 g.
4.	Multi mammate rat	Mastomys nutalensis	Female has high number of mammae (upto 24). Fur is thick and soft. Younger Mastomys can be distinguished from an adult house mouse by the large size of hind legs. Adult rats have yellowish/dirty white ventral side, back grey to brown, tail-equal to head and body.
5.	Nile grass rat	Arvicanthis niloticus	Fur - relatively thin, hair - harsh, dorsal side - hair is blackish and buff coloured (pepper and salt), ventral side greyish white. Ears have ochre to reddish brown hair, tail is shorter than head and body, Adult - 50-120 g.
6.	Spiny mouse	Acomys dimidiatus	Similar to Mastomys in fur colour and size of head and body but it has long, needle like hair on dorsal fur. Tail is short and easily breaks off when the animal is chased. Adult 35 - 55 g. They have wide range of colour.
7.	Gerbil	Tatera robusta Taterillus gyas, Garbillus bottai.	Fur - yellow/sand colour, long tail, with a tufty tips. Protruding eyes, long hind foot, adult 50 - 110 g.