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Module

on

Storage And Handling Of Cereals: Control Of Infestation

By

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TEXT

Introduction

Losses occurring in food during harvesting, transportation and storage. The largest loss of post- harvest is during storage of grains. These losses arise from attack of insects, micro-organisms and animals; improper handling. This may lead to physical and chemical changes, all of which are interrelated. When serious infestation by the pests occurs there is extensive weight loss accompanied by damage to quality. Intense insect activity often results in mold growth which not only completes the destruction of the feedstuffs but also poses serious health risks to humans and animals. Hence, efforts are made to store the grains in the safest possible way.

Storage of cereals:

Storage involves holding and preserving food grains from the time they are produced until they are needed for consumption.

Aim of storage are;

- To ensures a continuous flow of goods in the market.
- To protects the quality of the products from deterioration.
- To fulfill the demand especially the seasonal demand, on a continuous basis.
- It helps in the stabilization of prices by adjusting demand and supply
- Storage is necessary till further processing of the raw materials.
- Storage provides employment and income through price advantages.

Types of storage systems:

<u>Underground Storage Structures</u>; Underground storage structures are used for home scale storage. They may also be lined with stones or sand and cow dung or cement. They may be circular or rectangular in shape. The capacity varies with the size of the structure.

Surface storage structures; Food grains above the ground surface structures can be stored in two ways - bag storage or bulk storage.

Bag storage: These is one of the common practice in our country. The bags may be made of jute or plastic. Each bag contains a definite quantity, which can be bought, sold or dispatched without difficulty. It is easier to keep separate lots with identification marks on the bags. The bags which are identified as infested on inspection can be removed and treated easily.

For large scale storage of bags Cover and Plinth Storage (CAP) is used. It is a brick pillars to a height of 5mts from the ground, with grooves into which wooden crates are fixed for the stacking of bags of food grains. The structure can be fabricated in less than 3 weeks. It is an economical way of storage on a large scale.

Bulk or loose storage: in this type of storage the grains are dumped in large quantity inside the storage structures. Pest infestation can be controlled as these are airtight conditions. They can be of many types like:

For small-scale storage

PAU bin: This is a galvanized metal iron structure. Its capacity ranges from 1.5 to 15 quintals. Designed by Punjab Agricultural University.

Pusa bin: This is a storage structure is made of mud or bricks with a polythene film embedded within the walls. Developed by ICAR.

Hapur Tekka: It is a cylindrical rubberised cloth structure supported by bamboo poles on a metal tube base, and has a small hole in the bottom through which grain can be removed.

Silos: In these structures, the grains in bulk are unloaded on the conveyor belts and, through mechanical operations, are carried to the storage structure. The storage capacity of each of these silos is around 25,000 tonnes (fig 1).

Losses due to storage insect's infestation in food grains are as follows:

1. Quantitative or weight losses.

2. Qualitative losses
3. Losses of seed viability
4. Damage to storage containers.

1. **Quantitative or weight losses:** In India, losses during storage may range from 33% to 73% due to insects. It is reported that number of damaged kernels increased from 2.7 to 48. 5%, when wheat was stored in untreated bags for 5 months. Government of India Committee for estimates of losses indicated that when insect damage was quantified, losses in various food grains were 3% in wheat, 2% in rice, 2% in jowar, 3% in bajra, 5% in millets, 5% in gram and 5% in pulses, and on an average it was 2.55%. Some of the losses recorded in various African countries are recorded in table 1.

In paddy storage, quantitative losses caused by insects were reported to be 2.5 – 5.8% in 8 months of bag storage. 4.6% in 6 months in jute bags and bins 10% in gunny bags during 12 months of storage.

2. **Qualitative losses:** along with loss in weight, there are qualitative loss in terms of nutrient contents, caloric value, and other adverse transformation during storage. The growth of insects, molds, and mites in stored grain also results in production of toxins and allergens. Insect and rodent attack is always followed by microbial attack. Damage and bio-deterioration of the grains are caused by their combined activities. Qualitative losses caused by storage insects are further categorized in three main heads as follows:

- Loss of nutritive and caloric values. Chemical changes in grain content. This can be change in starch, protein and fat along with dry weight decreases due to the enzyme activity of the microbe and saliva of the insect.

- Contamination of grains with pathogenic and toxicogenic microbes. Insects produce uric acid, inoculate fungi and bacteria, and leave faecal matter and castoff skins on the grains, creating a foul odour, quinone and other harmful substances may be produced. Many fungi form dangerous mycotoxins.

- Increase in moisture content. Infestation of storage insects also enhances the grain moisture during the course of their multiplication. Grain moisture of stored wheat increased from 14.6 – 14.8 to 17.6 – 23.0%.

3. Losses of seed viability**:** Retention of seed viability during storage is essential to increase crop productivity. Insects attack to the seed, first damage the germ which is softer than the kernel and as a result its germination is lost.

4. Damage of storage containers**:** many insects and rodents can destroy wooden based storage containers, and even polyethylene lined bags

There are a number of storage insects which attack almost all the stored products (table 2)

Source of infestation during storage

1. Some storage insects like paddy moth and lesser grain borer infest grains right on the standing mature crop to stored crops. Such infestation is termed as horizontal infestation.
2. Lateral infestation of storage insects is common. They occur during post-harvest operations

from previously infested crop. They can come from threshing floor, previously used and infested transport system and stored grains left from last season harvest in the same storage. This infestation is also called cross infestation.

3. After storing, insects infest grains from surfaces of the storage containers/ bags where the insect's egg or larvae or adult would be harbored and is called as latent infestation.

4. A number of coleopteran beetles and weevils are also capable of migrating upward or downward among the grain bulk irrespective of the pressure. Thus infestation commenced on the top of the bulk grains may migrate to bottom and vice versa, known as vertical infestation.

Factors responsible for insect damage in stored grains:

Main factors responsible for enhancement of insect damage in stored grains are:

1. Higher grain moisture content in the grains. The safe moisture levels are 14% for paddy, 13% for milled rice, 12 % for wheat and 10% for oilseeds and 9% for pulses.
2. Less fluctuations in diurnal and seasonal temperatures.
3. Unscientifically fabricated/ constructed traditional storage structures, which are generally neither moisture proof not can prevent cross infestation of the insects.

Protection of stored commodities

This can be achieved by various methods. The control methods may be hygienic, physical, or chemical.

<u>Hygienic Control measures</u>:

The most efficient methods of preventing damage is to keep the stores as clean as possible.

The small size of insects makes cleanliness a most important aspect of control measures. Practical hygienic control measures vary with different kinds of storage. Through cleaning of store rooms, warehouse or mills at periods when they can be emptied, and careful inspection of all material when brought in for storage or processing reduce to a minimum the residual insect populations which persist in store house etc. In warehouses, granaries and flourmills cleaning can be done by using vacuum cleaners. These allow ledges to be efficiently cleaned. It is important to clean all accumulations of cocoons and webbing.

Physical control measures

The dependence of insects on physical conditions within grain stores makes them susceptible to control by modifying their environment.

a) Cold: The storage of material at temperatures below 13°C is effective in preventing insect infestation. Temperature of about 15°C and below inhibits the breeding of saw-toothed Grain Beetle, *O. surinamensis*. All stages of C. maculates were killed when subjected to temperatures of 0° C or less for 32 days, eggs being more susceptible than other stages. This technique is not appropriate for the tropics due to the high cost of achieving low temperatures.

(b) Heat: Heat treatment has given good results for treating retail stores and storerooms. In mills, temperature from 40°C to 54°C in all parts of the mill for a period of ten to twelve hours can kill all the insects. Heat is not satisfactory for the treatment of nuts and dried fruits. Grains can also be passed through special machines at temperatures of 54°C to 60°C for 30 minutes, to kill any insect infestation. High temperature through solar radiation may kill the developing larvae of insect pests (e.g. C. maculatus).

(c) Gamma irradiation: Much attention has been focused recently on the possibility of using gamma irradiation to control insects in stored grain and grain product. Dosage of 25 kilorads of gamma radiation could be effectively used to eradicate the immature stages of C. cephalonica.

Chemical control measures

More than one method may be used to protect stored food commodities from insects, the use of chemicals is most common. However, the insects have developed resistance insecticides. At present conventional insecticide management of stored product insect pests is common in the tropics**.** Conventional insecticides used in insect pest management include permethrin, lindane, pirimiphos- methyl, phostoxin (aluminium phosphide, which evolves phosphine), methyl bromide and iodfenphos (jodfenphos) (table 3). The types of fumigations are as follows.

(a) Fumigation under sheets: The development of methyl bromide fumigation under-gas proof systems for products such as grain, groundnuts and cocoa beans is commonly praticed. This kills all the insects present and the sheets are then left out on the stacks to prevent the uptake of atmospheric moisture and re-infestation by insects. Methyl bromide fumigation and the storage of various commodities under vapour-proof sheets are two techniques, they are phosphine fumigation and gas discharge to disinfest stored food commodities. Phosphine is supplied in various forms: pellets and tablets, and bags /sachets. The use of this gas serves the immediate need to control the insect pests of grain in storage quickly and effectively.

(b) Spot fumigation: Fumigants used for this include ethylene dibromide, ethylene dichloride and carbon tetrachloride. The fumigant is contained in small sachets and the rate of application is 5 cc for each bags of 50 kg.

Control by use of plant materials

The control of stored products using plant materials is a common practice among small-scale farmers For example, neem kernel powder effectively preserved cowpea for eight months against C. maculatus. Piper guineense and Capsicum spp. caused adult mortality in C. maculatus. Many plant derivatives have insecticidal, ovicidal and larvicidal properties. Crushed Chromolaena odorata leaves repel insects. The effects of various neem (A. indica) products with copra oil, palm kernel oil and 0.25% diazinon dust for protection against S. zeamais were found to be affective. The extracts were more effective as suppressants of C. maculatus than S. oryzae and there was no effect on C. puncticollis. Both neem leaves and neem seeds powders mixed at the rate of 3% (w/w), gave from 85 to 90% mortality in C. maculatus adults after 72 hours. Powders obtained from Eucalyptus, Melia azedarach and Crofton gratissimus were found to have some insecticidal activity against. C. maculatus

<u>a. Vegetable oils:</u> The practice of adding a small quantity of vegetable oil (1-15 ml per kg seed) to the grains of legumes to protect them against insects is common. The vegetable oils tested were the African palm, cotton seed, Maize, groundnut, rice bran oil, soyabean, coconut, jatropha curcas L., Pongamia glabra neem (A indica), Bassia longifolia, Bassia trifolia, mint (Mentha spp) etc. Crude oils seem to perform better than purified oils and non-edible oils better than edible oils. The main effect of the oil coating is on the ability to prevent hatch of the bruchid eggs, the oil acting as an ovicide.

<u>b. Ashes:</u> Ashes of the three plant species *Afzelia africana, Parkia africana and Ceiba pentandra* provided effective control of *C. maculatus* in cowpea. However, a large quantity of ash (ash volume equal to that of grain) was required. It has been suggested that free movement of the adults for oviposition is prevented by the wood ash filling the inter-granular spaces.

<u>Resistant varieties:</u> A number of factors such as high protein content, seed, texture, and a pod wall factor have been linked to resistance of cowpea varieties to *C. maculatus*

Types of treatments

a. <u>Prophylactic treatment:</u> To prevent the cross infestation of insects, synthetic insecticides should not be sprayed directly on the food grains especially earmarked for consumption. However, these can be used for seed treatment. Some of the insecticides and their concentrations recommended for prophylactic treatment of jute bags storing grains are given in Table 4.

<u>b). Curative treatment:</u> In spite of regular prophylactic treatment, infestation develops due to latent or cross infestations. This can be controlled by insecticides and fumigants. These compounds can be classified as;

i) Knock-down insecticides: The chemicals capable of quick immobilizing or killing insects are usually aimed against flying insects, this can also kill the insects on surfaces as well in the cracks and cervices. Such chemicals are pyrethrin spray, lindane smoke generator or fumigant traps.

ii) Grain protectants: Mixing of chemical dusts with food grains is not recommended. However, these can be mixed with grains meant only for seed purposes. Pyrethrum dust, malathion, deltamethrin and BHC dusts are normally used as seed protectants against storage insects.

iii) Fumigants: A fumigant is a chemical, which at required temperature and pressure can exist in gaseous state in sufficient concentrations to be lethal to a given organism. A number of fumigants explored and used for control of storage insects are as follows:

a) Ethylene dibromide (EDB): it is highly toxic liquid filled in glass ampoules with sealed nozzles, suitable for fumigation of foodgrains stored in reasonably airtight structures.

b) EDB+: It is a mixture of EDB and carbon tetrachloride in a ratio of 1:8 w/w and has a greater penetration power and hence can be used for bagged storage under gas proof covers. It is equally effective in rural storage structures.

c) Ethylene dichloride carbon tetrachloride (EDCT): It is mixture of ethylene dichloride and used for large scale fumigation in both bulk and bag storages of foodgrains except milled product. After storage structure is made fairly airtight, the fumigant is poured through the openings on the bundle of gunny bags kept on the grain lot and openings are sealed immediately. Stocks are left undisturbed for 36-48 hrs depending upon the temperature and nature of infestation.

d) Aluminium phosphide (ALP): It is a solid fumigant available in the market in the form of tablets of 3 gm each packed in sealed tubes. It is one of the very potent fumigants used practically on all kinds of foodgrains, milled products etc. Phosphine gas is its active ingredient, which is an active poison liberates when comes in contact with atmospheric moisture. Phosphine being highly toxic should be handled with care and by trained staff only.

Methyl bromide, carbon tetrachloride, carbon disulphide, ethylene dioxide and chloropicrin etc are some other exploited fumigants not in use these days.

a) Insect pest management in rural storages: In rural sector foodgrains are generally stored in unscientific traditionally fabricated bulk storage structures, which are neither moisture proof nor can prevent the infestation of insects. Insect pest management in rural storages includes 3 main activities or actions, which should be taken care by the farmers in sequence, are as follows:

1. Appropriate drying of the harvested crops and threshed grains,
2. Dis-infestation of storage containers or structures or stores.
3. Use of grain protectants.

Conclusion.

Post-harvest losses are larger than pre-harvest losses in all agricultural commodities. This has led to the designing of various storage structures from ancient times. Modern methods of grain handling and management is through large storage systems like ware house and silos.in ware houses the grains are handled in bags and in silos they are handled in bulk. Number of insects infest the grains. This can be controlled by physical, chemical and sanitation methods. The present methods involve a combination of all the methods.

Table 1. Post-harvest losses caused by insect pests to major cereals, pulses, cassava and dried fish.

Commodity	Insect species	Country estimates for % weight loss
Maize	Sitotroga cerealella (Oliv.) Ephestia cautella (Wlk.) Prostephanus truncates (Horn)	4-5 - Kenya 9-12 - Zambia 6-14 - Malawi 5-70 - Nigeria 9-34 - Tanzania
Wheat	Rhyzopertha dominica (F.) Ephestia cautella (Wlk.)	10 - Zimbabwe 6-12 - Sudan
Rice	Sitophilus oryzae (L.) Sitotroga cerealella (Oliv.)	10 - Sierra Leone 2 - Egypt
Millet	Sitophilus oryzae (L.) Sitotroga cerealella (Oliv.)	2-5 - Mali 17 - Sudan 10 - Zambia
Beans	Acanthoscelides obtectus (Say)	7-45 - Ghana
Cowpeas or peas	Callosobruchus maculatus (F.) Callosobruchus chinensis (L.)	5.4 - Nigeria 40 - Zambia

Groundnut	Caryedon serratus (Oliv.) Tribolium castaneum (Herbst)	4.5 - Nigeria 5 - Zimbabwe
Cassava	Prostephanus truncates (Horn)	50-70 - Tanzania

Table 2. Insect associated with stored grains

Taxonomic status	Common name	Infesting stored products
A. Coleopterans Rhyzopertha dominica Fabr. (Bostrichidae)	Lesser grain borer	Rice, maize, wheat
Sitophilus oryzae Linn. (Curculuinidae)	Rice weevil	Cereals and their products
Sitophilus granarius Linn (Curculuinidae)	Granary weevil	Cereals, wheat
Sitophilus-zeamaize Motsch (Curculuinidae)	Maize weevil	Cereals maize
Trogoderma granarium Everts (Dermestidue)	Khapra beetle	Wheat, maize, oat, dryfruits
Tribolium castaneum Herbst. (Tenebrionidae)	Red flour beetle	Cereals and their products
Tribolium confusum Jac. Du Val (Tenebrionidae)	Confused flour beetle	Cereals and their products
Tenebrio molitor Linn. (Tenebrionidae)	Yellow meal worm	Cereals and their products
Tenebriodes manuritanicus Linn. (Togostidae)	Cadelle beetle	Cereals and their products
Laemophloeus minutus Oliv. (Cucujidae)	Flat grain beetle	Cereals and their products
Crytolestes pusillus Schon (Cucujidae)	Falt grain beetle	Grain stores and flour mills
Cryptolestes ferrugineus Stephens (Cucujidae)	Rust red grain beetle	Cereals flour, dry fruits etc
Oryzaephilus surinamensis Linn. (Silvanidae)	Saw-toothed grain beetle	Cereals, cookies, dry fruits
Oryzaephilus mercator Fauvet (Silvanidae)	Merchant grain beetle	Cereals, cookies, dry fruits
Gibbium spylloides Czenpinski (Ptinidae)	Hump spider beetle	Broken grains, wheat, gram
Callosobruchus chinensis Linn. (Bruchidae)	Azuki bean weevil	Pulses
Callosobruchus analis Fabr. (Bruchidae)	Pulse beetle	Pulses
Callosobruchus maculatus Fabr. (Bruchidae)	Spotted cowpea beetle	Pulses
Bruchus lentis Froel (Bruchidae)	Lentil beetle	Pulses and beans
Bruchus pisorium Linn. (Bruchidae)	Pea beetle	Pea
Lara (=Bruchus) affinis Frol. (Bruchidae)	Pea bruchid	Pea
Ahasverus advena Waltle (Silvanidae)	Foreign grain beetle	Cereals, oilseeds, dried fruits
Lasioderma serricorne Fabr. (Anobiidae)	Cigrette beetle	Spices, tabocco, mustard etc
Caryedon serratus Oliv. (Bruchidae)	Groundnut beetle	Groundnut, tamarind pod;
Zabrotes subfaciatus Boheman (Bruchidae)	Mexican bean beetle	Phaseolus beans, cowpea etc

Steegobium paniceum Linn. (Anobiidae)	Drugstore beetle	Tobacco, spices, drugs etc.
Araecerus fasciculatus Deeer (Anthribidae)	Coffee bean weevil	Nutmegs, coffee beans etc
B. Lepidopterans Sitotroga cerealla Oliv. (Gelechiidae)	Angoumois grain moth	Cereals
Corcyra cephalonica Staint. (Galleriinae)	Rice moth	Cereals, legumes, copra
Ephestia (Cadra) cautella Walk (Phycitidae)	The almond moth	Wheat and other cereals
Ephestia (Cadra) kuhniella Zell. (Phycitidae)	Mediterranean flour moth	Flour, maida, suji etc.
Ephestia (Cadra) calidella Guen. (Phycitidae)	Dried fruit moth	Dry fruits, milled cereals
Plodia interpunctella Hubn. (Phycitidae)	Indian meal moth	Cereal products, nuts etc.
Phthorimaea operculella Zell (Gelechiidae)	Potato tuber moth	Potato, tobacco, tomato etc.
C. Psocopterans Liposcelis bostrychophilus Badonnel (Liposcelidae)	Cereal psocid	Milled rice and other cereals

Table 3. Insecticides, fumigants and inert dusts recommended for stored product insect control or as grain protectants.

Products	Dose (ml or g/t)		Application
Pirimiphos methyl	12 ml/t	30	Conveyor belt
Fenitrothion	15 ml/t	14	Conveyor belt
Deltamethrin	14 ml/t	30	Conveyor belt
Pirimiphos methyl + permethrin	10-18 cm^3	180	Conveyor belt
Chlorpyrifos +deltamethrin	15-20 cm^3	180	Conveyor belt
Fenitrothion + permethrin	5-10 cm^3	180	Conveyor belt Grain surface
Deltamethrin + fenitrothion	12-20 ml/t	180	Conveyor belt
Phosphine	3-9 g/t	4	Grain mass Conveyor belt
Methyl bromide	$20cm^3/m^3$	2	Grain mass
Inert dusts (Diatomaceous earth)	0.5-1.0 kg/t	None (They are considered as safe)	Conveyor belt, structure, aeration

Table 4. Insecticides recommended for the treatment as snacked paddy bags

Insecticide	Conc. Of spray (%)	Preparation and Dose	Frequency of treatment (days)
Malathion 50 EC	0.50	1:100@3Lit/100M²	60
Primiphos methyl 50 EC	0.50	1:100@3Lit/100M²	60
Pyrethrum with 2% pyrethrin EC	0.02	1:100@3Lit/100M²	60
Deltmethrin 2.5 EC/ WP	0.025	1:100@3Lit/100M²	60

Fig 1. Large scale storage structures known as Silo.