

# Management of Post Harvest

## losses in maize

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**T**HE important post harvest on-farm losses occur during storage, when maize grain is being stored for food, animal feed or while the farmer awaits a selling opportunity or a rise in prices. Even though production of maize has been increasing, post harvest losses remain static at 10%. During storage farmers experience heavy damage and losses due to biotic factors such as insects, fungi, rodents and birds.

Post harvest losses during storage account for 6.58 per cent, and that insects alone account for 2 to 4.2 per cent which constitute a major share of food grain loss. Insect being good fliers move from storage to field and

infest the standing crop. As a result, harvested produce contain immature stages of insects that complete their development during storage, thus these fields carry over population and form the potential source of inoculum. The most economically important post harvest pests of maize are rice weevil *Sitophilus oryzae* L. (Coleoptera: Curculionidae), Angoumois grain moth *Sitotroga cerealella* (Oliv.) (Lepidoptera: Gelechiidae), rice moth *Corcyra cephalonica* Stainton (Lepidoptera: Pyralidae), red flour beetle *Tribolium castaneum* (Herbst.) (Lepidoptera: Tenebrionidae) causing both quantitative and qualitative (chemical

changes, seed viability, contamination, nutritional) losses by feeding the grain. Today, losses from storage pests cannot be measured only by the amount of food or seeds destroyed by insects. The mere presence of insect fragments in food is objectionable to the consumers. The losses due to insect pests is dependent upon storage time, moisture content of grain, insect population density and proper storage structures. A loss in stored maize has been reported from 1.96 to 10.63 per cent after 9 months of storage. Also it is reported that maize infestations start in farm fields and follow a typical pattern in rural storage where the build-up tends to be slow in the first month after harvest and expand exponentially thereafter.

The losses are directly measurable in economic, quantitative and qualitative (nutritional) terms. Economic loss is the reduction in monetary value of maize grain as a result of physical loss. Quantitative maize loss involves reduction in weight and therefore can be defined and valued. Qualitative loss although difficult to assess because it is

**Table 1.** Different stages of post harvest maize grain losses

Stage at which losses can occur	Causes of grain losses
<b>Pre harvest</b>	Delayed planting and harvesting Lines susceptible to diseases and pests
<b>During Harvesting</b>	Poor supervision during de-husking Poor transportation to the stores Poor drying before storing in storage structures
<b>During storage in stores</b>	Pests (weevils, rodents and birds)
<b>During shelling</b>	Poor shelling leading to breakages of grains
<b>Drying and storage</b>	Temperatures too high during drying Storage pests and fungi Insufficient drying before storage Moisture in storage structures which cause rotting and discoloration Poor storage bags that give sub-optimal aeration

*The post harvest losses of food grains in India are estimated to be around 10 per cent from farm to market level causing considerable losses during threshing (1.68%), transporting (0.15%), processing (0.92%), and at storage by rodents (2.50%), birds (0.85%), insects (2.55%), moisture (0.68%). According to FAO estimates, about 10-25% of the world harvested food is destroyed by insect pests and rodents. Post harvest losses of maize at farm level was estimated to be 3.02 kg/quintal in which 0.68 kg of maize was lost per quintal at storage, 0.49kg was lost during drying, 0.44 kg at transportation, 0.34 kg at threshing, 0.15 kg at packaging and 0.10 kg at cleaning.*

frequently based on subjective judgments which can be described by comparison with locally accepted quality standards. Moreover, the metabolic activity of insects cause increase in moisture content and temperature of infested grain making the grains more suitable for infestation by other secondary pests and microorganisms. Contamination by moulds is mainly determined by the temperature of the grain and the availability of water and oxygen. Moulds can grow over a wide range of temperatures, but the rate of growth is lower at lower temperature and less water availability. Maize can be stored for one year at a moisture level of 15 per cent and a temperature of 15°C. However, the same maize stored at 30°C will be substantially damaged by moulds within three months.

### Sources of Infestation

**Field infestation:** Some of the insects like *S. oryzae*, *S. cerealella* infest seed crops at reproductive stage in the field. They come along with the harvested produce and multiply during pre-storage or storage period. The infestation is normally detected at the time of emergence of adults.

**Godowns itself:** Insects or its stage(s) hiding in the cracks and crevices, electrical fittings etc. are the major source of infestation in the godowns.

**Old gunny bags/containers etc:** Insects or its stage(s) hide in the weavings or corners and infest the seed when stored in such bags/containers.

**Vehicles:** Vehicles also become sources of infestation when in regular use. Insects remain in the cracks and crevices in dormant stages and when agricultural produce is transported in this vehicle, infestation occurs by insect pests already present in the vehicle. Such vehicle needs thorough cleaning and treatment to kill insects hiding in it.

**Others:** Other sources of grain infestation may be non dis-infested courtyards, grain cleaning machines, crates, laboratory equipment, etc. In the most common case, crops are contaminated by equipments used in storage, harvesting, handling or

storing or buy the remains of grains from previous years.

### Factors Influencing Pre-harvest Infestation of Maize

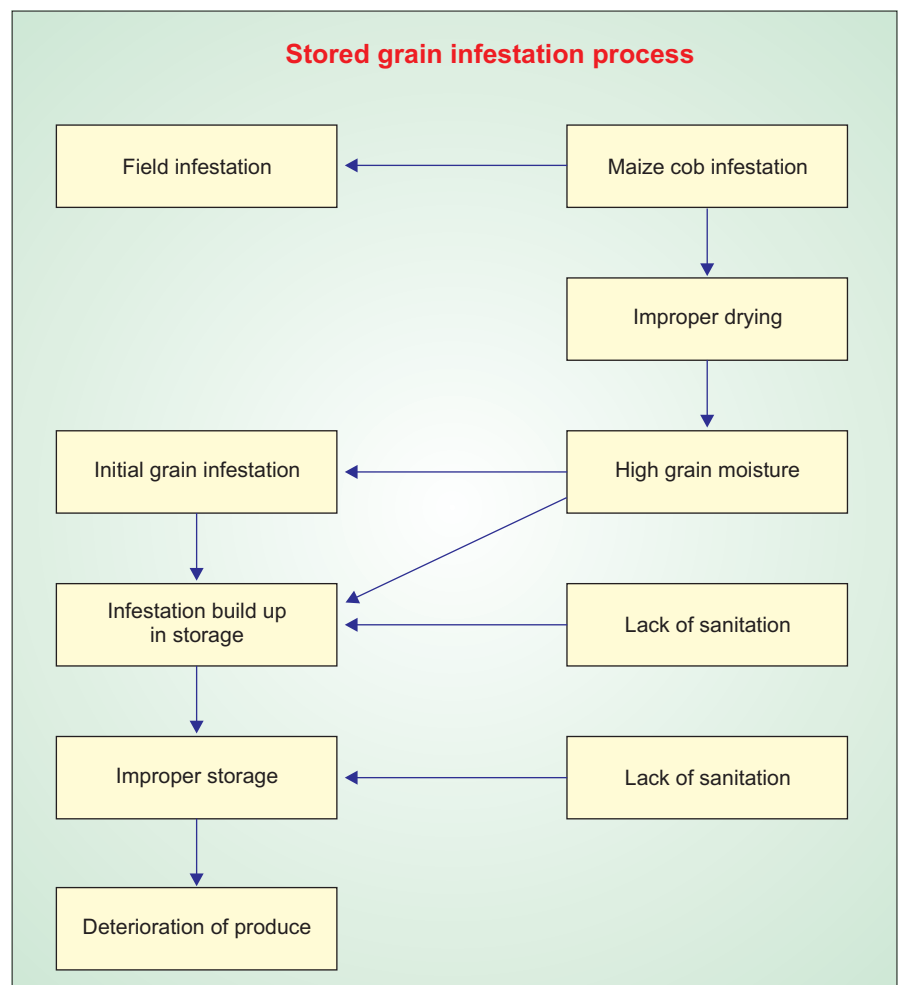
- **Maturity of maize grain:** Storage pests seem to infest grain only when moisture content reached to certain level (around 30%).
- **Husk cover:** Both length and tightness of husk leaves around the ear will affect infestation by weevils. A tight long husk cover has been shown to reduce weevil penetration and thus grain damage. Damage to husks and silks by lepidopteran field pests and by birds will increase the chances of damage by storage pests.
- **Time of harvest:** Proximity of infested maize stores to the crop in the field has been suggested as a factor influencing weevil infestation before harvest. Infested stores are the main source of rice weevil and thus their dispersal behaviour is one of the most

important factors determining pre harvest infestation.

### Factors Influencing Post-harvest Infestation of Maize

**Storage form:** Shelled grain suffer more damage by pests like rice weevil, lesser grain borer and red flour beetle. Shelled grain will result in faster population increase of weevils than maize stored in the cobs with husks.

**Temperature:** Temperature is an important factor for the growth, development and general behaviour and distribution of pests. At higher (> 20°C) temperature, most of the microbes, mites and insects, multiply and infest seed affecting its health. Each species of insects is active only within a certain temperature range which limits the zone of effective temperature. When food is abundant and the humidity of stored seed is sufficient, the development of stored seeds pests may be catastrophic unless checked by temperature. While storing seeds, it is very important not



to allow major temperature fluctuations in the seed. It has been established that the optimum temperature range for the development of most of stored seed pests is from 18 to 32°C. Temperature below 16°C considerably restrict the reproduction of these pests.

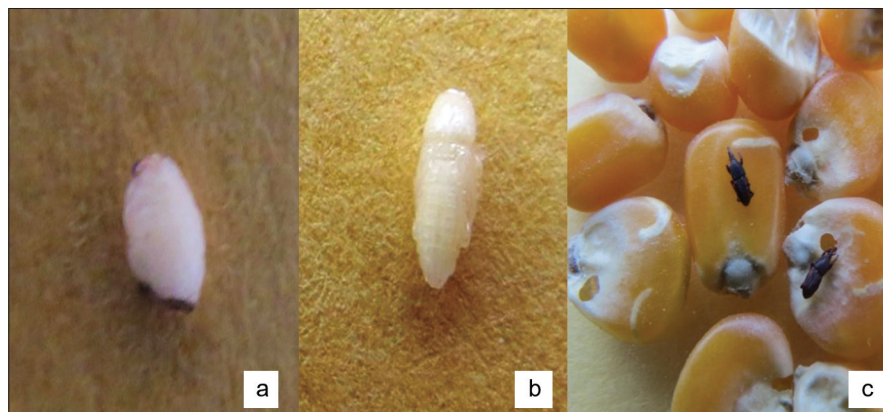
**Humidity:** Humidity is an important ecological factor which affects pest activity. Most of the seed under tropical environment deteriorates quickly due to high humidity and high temperature.

**Grain moisture content:** Maize stored at high moisture levels (30-35%) deteriorates rapidly. Moisture level of 9-10% considered as safe for storage where *S.oryzae* is the main insect pest. Farmers use many methods to dry the maize spreading it for sun drying, smoking the crib etc.

**Oxygen availability:** Oxygen content in the atmosphere is most important in the development of insects. Each insect species requires a particular minimum concentration of oxygen for its survival and multiplication, and they cannot survive when the oxygen content goes below that level. This clearly indicates the requirement of oxygen for survival and multiplication of storage insect pests.

**Condition of the storage place:** Dirty infested stores are the main source of infestation to the fresh insect free produce when kept at the same place.

**Infestation before harvest:** Insect population initially develop much faster in maize with higher levels of pre harvest infestation than in maize with low field infestation levels. This



Life stages of *Sitophilus oryzae* (a) Pupa (b) Larva (c) Adults infesting grains

difference becomes less as the storage period becomes longer.

### INSECT PESTS OF STORED MAIZE

#### Rice weevil *Sitophilus oryzae* L. (Coleoptera : Curculionidae)

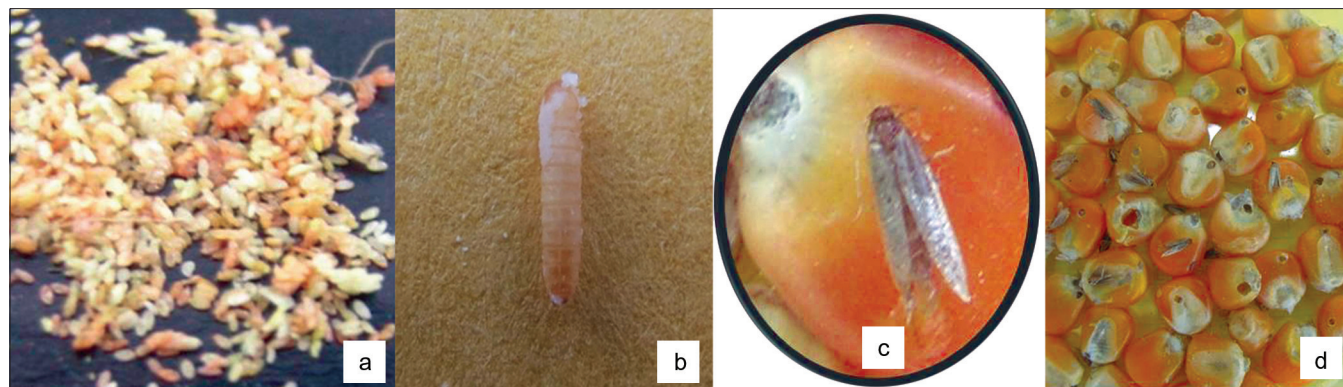
This pest is widely distributed in tropical and sub tropical regions of the world. Alternate hosts are paddy, wheat, sorghum and barley. Adult is tiny weevil about 2.5 mm long, dark brown or reddish brown in colour. Females lay about 150-300 eggs that hatch in about 3 days. The grub is short, stout "C" shaped that is creamy white, translucent, yellow or brown head with biting jaws. The larvae feed inside the grain kernel for 18 – 20 days. The pupa is naked and the pupal stage lasts for 6 -7 days. Adults live for 4-5 months. The new adult will remain in the seed for 3 to 4 days while it hardens and matures. As it is an internal feeder both adults and larvae attack the grains and feed voraciously. In case of heavy infestation only pericarp of the kernel is left behind, while rest of the mass is eaten. The insect can infest crop

at maturing stage in the field.

#### Angoumois Grain Moth [*Sitotroga cerealella* (Oliv.) (Lepidoptera : Gelechiidae)]

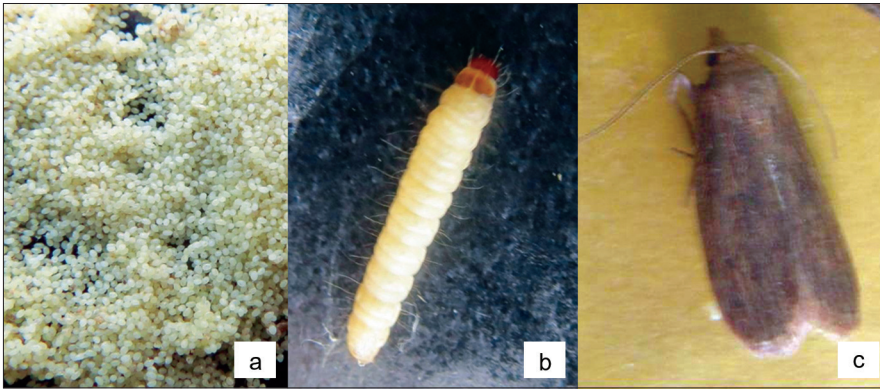
Alternate hosts are paddy, wheat, sorghum and bajra. Eggs are cylindrical, cigar shaped laid singly or in small clusters on the surface of the grain which look white at early stage but later changes to bright red. Caterpillar is white in colour with yellow head. Larva undergoes 4 instars after about six days each at optimum temperature. Adult moth measures 8-10 mm with buff coloured front wings. Hind wings are margined with long hairs, their tips are elongated. Life cycle is completed in 30-32 days.

Only larvae damage grains, adults being harmless. Larva after hatching begins to feed on endosperm. As a result grains are hollowed out resulting into loss of viability. On damaged grains circular hole with characteristic flap or trap door appears. Pest attack is in both fields and stores. In stored bulk grain infestation remains confined to upper 30 cms depth only.



Life stages of *Sitotroga cerealella* (a) Egg (b) Larva (c) Adult (d) Damaged grains





Life stages of *Corcyra cephalonica* (a) Eggs (b) Larva (c) Adult

**Rice Moth *Corcyra cephalonica* Stainton (Lepidoptera : Pyralidae)**

Alternate hosts are rice, jowar, barley, millets, soybean and oilseeds. The rice moth has a wingspan of 12-15 mm, with greyish brown forewings. The female lays up to 150 eggs within a few days of emergence. Young larva is creamy white with prominent light brownish yellow head. The adults live for 1-2 weeks and drop their eggs in the produce. At maturity, they construct white silken cocoons for pupation. Pupal period lasts for 7-9 days. Adult lives for 7-15 days. Young larva feeds on the broken grains, make webbings resulting in grain pollution with large quantities of frass and silken cocoons.

**Red Flour Beetle *Tribolium castaneum* (Coleoptera : Tenebrionidae)**

Alternate hosts are cereals, millets, flour, starchy material, nuts and processed cereal foods. Adults are flat brown 5-6 mm in length and reddish brown in colour. Eggs are wheatish colour, sticky and are laid on the grain/ debris of grains. They



Adult of *Tribolium castaneum*

are small, cylindrical in shape, rounded at both ends. Larvae are very active, cylindrical and pupate after 3-4 weeks. Pupal stage lasts for 5-9 days. Adult has 4-5 months longevity and feeds throughout the life. Life cycle is completed in 3-4 weeks. Feed on broken grains and result in dust formation. Infested flour emits sour and pungent smell which is due to secretions of beetles. The presence of larval stage, dead and live adults and odour represent damaged material.

**Lesser Grain Borer *Rhyzopertha dominica* (Fab) (Coleoptera : Bostrichidae)**

Alternate hosts are wheat and rice. Full grown larva is dirty white with light brown head and curved abdomen covered with tiny hairs. Larval period varies from 25-28 days. Pupal stage lasts for 7-8 days. The adult is very small (3mm) cylindrical shaped beetle that is dark brown in colour and somewhat shiny in appearance. It completes its life cycle in 6-8 weeks. Heavily attacked grains become hollowed out and only thin shell remains. After severe infestation



Adult of *Rhyzopertha dominica*

adults produce frass and spoil more than what they eat. Profuse powdery substance is the characteristic of its damage.

**Khapra Beetle *Trogoderma granerium* (Everts.) (Coleoptera : Dermestidae)**

Alternate Hosts are wheat, barley, oats, cotton seed and dry fruits. The larva is brownish white in colour, body covered with bundles of long reddish brown movable and erectile hairs on the posterior segments and forming a sort of tail in the posterior end. Larval period extends up to 20-25 days. Pupal life is for 4-8 days. Adult is approximately 1.6 to 3.0 mm long and 0.9 to 1.7 mm wide and is covered with hair. Life cycle completes in 33-45 days.

**Management Strategies of Storage Pests of Maize**

Preventing insect infestations of stored commodities requires an integrated management approach that combines engineering, biological, ecological and economic principles.

**Preventive Measures**

- Cleanliness and sanitation is the most important and the first step towards prevention of insect infestation. Dusts, grain and chaffs should be removed from transport system, storage area as well as threshing yard before using them for new produce after harvest.
- Time and frequency of harvesting of crop is important to control storage insects. Crop should be harvested at proper time to prevent egg laying. Field



Adult of *Trogoderma granerium*

infestation occurred in case of *S. oryzae* and *S. cerealella* by adults migrating from infested grains in godowns to maturing crops.

- As the infestation starts in the field itself and is carried to store houses, sun drying on a raised platform is the most effective treatment to kill various stages of insect. Proper drying not only kills the insects, germs and fungi but also reduces grain moisture to the limits of storage grains.
- The filled seed bags should always be stacked on wooden pallet (platform). This prevents seed from picking up moisture from the floor, facilitates proper cleaning and circulation of fumigant or fresh air. Avoid using steel hook for seed bags as it damages bags and causes spilling of seeds. Alley (moving) space should be left between seed-stacks and walls for inspection or sampling. In fact only 50% to 60% space is utilised for proper storage of seeds.
- The packaging material during storage and transport should be strong and free from insect infestation. Gunny bags, HDPE bags are best suited for these purposes.

## CURATIVE MEASURES

### Inert Dusts

Use of inert dusts is an ancient and traditional method to protect grain. Inert dusts are fine powders, chemically inactive but cause considerable insecticidal activity by mechanical abraising and physical absorption of moisture proofing layers of insect integument. Some common inert dusts are ashes, clays, gypsum, lime, magnesite, Nakki, silica, talc, phosphates, diatomaceous earth. It was reported that though most of the dust proved effective and convenient to use but it is difficult to remove it and clean as it goes inside the infested and damaged grains. The dust can only kill larvae and adults moving in between the grains. Magnesium carbonate, crystalline silica talc, amorphous silica, walnut ash, cow dung ash, diatomaceous earth @ 5g/ kg seed have been found to be effective.

### Botanicals

Bio insecticides of plant origin often show selectivity to insect species, they are biodegradable and therefore have higher chances of acceptability. Plants are considered the best source of newer chemical structures for development of new, ecofriendly, safer insect control agents. Many plant products and their essential oils have been shown to exhibit insecticidal activity against stored product insect pests. In India, mixing of any synthetic insecticide with stored grain is not permitted. Due to environmental concerns and human health hazards, several chemical insecticides have either been banned or their use is restricted. Further, due to the problem of resistance to insecticides, there is an urgent need for safer alternatives particularly from natural sources to conventional chemical insecticides for the protection of grain against insect infestation. Leaves of neem (*Azadirachta indica*), its seed powder and oils were used to get protection from storage insects since early days. Pongamia (*Pongamia pinnata*) also possess various types of bioactivity including antifeedant, oviposition deterrent and toxic effects. Medicinal plants such as *Ageratum conyzoides*, *Albizia lebbek*, *Cissus quadrangularis*, *Vitex negundo*, *Adathoda vasica* were found to contain insecticidal activity at the rate of 20g/kg seed against *S. oryzae*. Turmeric, garlic, Glyricidia, castor, *Aristolochia sp*, ginger, *Agave americana*, custard apple, *Datura sp*, *Calotropis sp*, *Ipomoea sp.* and coriander are some of the other widely used botanicals to control and repel crop pests. Fumigation with phyto oils is also giving good results to control storage insects. Vegetable oil obtained from groundnut, mustard, rapeseed, soybean, cotton seed, neem, palm, sesame, safflower, castor, karanj, coconut oils gave better results in comparison to purified oils and non edible oils. The oil smear on the grain surface results in prevention of egg laying or reducing oviposition higher adult mortality, reduction in egg hatching, interference with larvae development and eventually reduced adult progeny.

The oil coating is believed to block the oxygen supply to the embryo and interfere with the normal respiration resulting in suffocation and finally cause insect death. Oil treatment do not generally adversely effect the viability of seeds, palatability, cooking quality and physical appearance of the grain. Aromatic spices and herbs contain volatile compounds which are known to possess insecticidal activity. Contact as well as fumigants insecticidal activity of plant essential oil is also reported against storage pests such as Acorus oil, clove oil, turmeric oil, sweet flag oil, jatrophia oil, ocimum oil and eucalyptus oil etc. Most of the essential oil constituents are monoterpenoids which are secondary plant chemicals. The essential oil of *Ocimum basilicum* and *Eucalyptus globulus* at concentration of 0.4% showed insecticidal activities against *S. oryzae* and *T. castaneum*.

### Chemical Methods

The effective management of storage pests may be ensured by drying the grains properly before storage, storing new grains in the clean godowns or receptacles and plugging all cracks, crevices and holes in the godowns thoroughly. If infestation of grain has already taken place or it is imminent on account of a peculiar situation in which the grain is stored then application of chemicals become necessary. Insecticidal treatment is very common to control insects. Spinosad and Malathion has high toxicity to insects and comparatively low toxicity to mammals. Apart from them pirimiphos methyl and dichlorvos is widely used to control storage insects. After this synthetic pyrethroids were emerged with good potential for storage insects. Deltamethrin proved to be effective against storage pests. Recently cyfluthrin and bifenthrin are also giving good control against storage insects.

### Surface Treatment

The grains are kept in jute, markin and polypropylene bags. The grains can be protected by spraying insecticides on the surface of the



stacks. The godowns are disinfected before storing the grain and new infestation can be prevented by surface treatment. Old gunny bags can be disinfected by dipping them in insecticides and then get it dried. But this is not popular due to residue and resistance problems. Insecticidal spray is recommended on floors, walls, containers and storage facilities.

Dose for organophosphates as per malathion- 150mg/ m<sup>2</sup>.

Dose for synthetic pyrethroids as per deltamethrin- 30 mg/ m<sup>2</sup>.

### Seed Treatment

Mixing of insecticides is another method to control storage pests. Grain meant for seeds can be protected by mixing malathion 0.5% dust @ 1.6 kg/tonne 50 EC. Newer eco friendly insecticide Spinosad (1mg/kg seed) is effective in killing adults of storage pests such as *S.oryzae*, *S.cerealella*, *T.castaneum*. Spinosad is an appealing stored grain protectant because of its persistence on grain for a period of one year with out loss of insecticidal activity and its low mammalian toxicity. Treated seeds must be kept in cool and dry places. The moisture content of the seed should not be above 10%. Otherwise insecticides impair viability and vigour of the treated seeds.

- Mixing of organophosphates @ 20mg/ kg seed
- Mixing of synthetic pyrethroids @ 1 mg/ kg seed

To store the grain/seed for household purposes storage receptacles are very important. Generally grains are stored in jute bags, plastic bags, polypropylene bags and can be treated with any of the protectants at recommended dose.

### Fumigation

Fumigation is the most widely used procedure to control stored product pests to prevent economic and quality losses by providing various application methods and penetration capability into the treated commodity. Methyl bromide (MB), according to Montreal Protocol, is scheduled to be phased out worldwide by 2015. Sulphuryl

fluoride (SF) is known to have limited efficiency on egg stages of insects. It is known to contribute to the greenhouse effects, which may jeopardize its future use. Currently, phosphine (PH<sub>3</sub>) is the most widely used fumigant worldwide due to its low cost and ease of application, though resistance observed in major pest species threatens the continued use of PH<sub>3</sub>. In fumigation, structure should be properly sealed for better effect which is not practical always. Fumigation can control the existing infestation but cannot restrict the cross infestation of insects. Fumigation with periodical prophylactic treatment with insecticides is very useful. Dosage of Aluminium phosphide tablets : 3 tablets/ tonne.

### Insect Growth Regulators

Insect growth regulators restrict development of insects by producing super numerary larvae, abnormal larval/ pupal intermediated, abnormal pupa and adults. These compounds have low mammalian toxicity thus can be used in storage. Methoprene, Fenoxycarb, diflubenzuron, etc. have been evaluated against storage pests by different workers.

### Pheromones

In storage pheromones may be used either for monitoring or suppression of insect pests. Suppression can be achieved through mass trapping by luring insects to source with chemosterilants or pathogen or disrupting mating in storage by permeating them with sex pheromone.

### Hermetic Control

It is an ancient practice, simple cheap and effective method of insect management. The natural respiration of insects and grains result in depleted oxygen level and increase of carbon dioxide. Complete air tightness of storage structure is very important. Storage structures Pusa bin, Pusa Kothar, bins with thatched roofs or brick roofs and ferro-cement bins based on air tight principles serve the purpose of insect control. In hermetic control, metabolic activities of insects and microflora act as

biogenerators that reduce the oxygen and increase carbon dioxide composition of intergranular atmosphere so that insect development is arrested. It must be stressed that to kill all insects by hermetic storage takes place in a long time.

PCI recently introduced a **hermetic** (air-tight) storage system in India in association with **GrainPro, Inc. USA** under the trade name Grain Pro Super grain bags. This **storage system** can be used for medium and long term storage needs and eliminate the use of fumigants or chemicals. This system can be used to control insect infestation and humidity.

### Modified Atmosphere

Disinfestations of stored grain using modified atmosphere involves the alternation of the composition of intergranular storage gases (O<sub>2</sub>, N<sub>2</sub>, CO<sub>2</sub>). Modified atmosphere may be achieved in several ways adding CO<sub>2</sub> or N<sub>2</sub> or reducing O<sub>2</sub> and leave no residue on food. Modified atmosphere which is lethal to insects can be obtained using nitrogen provided a hypoxic atmosphere of <1% can be maintained whereas flushing with CO<sub>2</sub> insects are under stress of both hypercarbia and hypoxia. They may provide alternative to phosphine but not to methyl bromide due to comparatively longer exposure. However quick action treatment can be achieved with application of CO<sub>2</sub> under pressure. The efficacy of CO<sub>2</sub> with temperature and decreases with increase of humidity.

### Rodents

Among the biotic factors vertebrate pests such as rodents also contribute significantly to post-harvest losses. Rodents not only feed on grains but also contaminate 20 times more than what they consume with their droppings, urine, hair and sometimes with their dead bodies. Three species are found throughout the world: the house mouse (*Mus musculus*), the black rat (*Rattus rattus*) and the brown rat (*Rattus norvegicus*) while a few other species are important in Asia.

## Management Strategies

Before undertaking any control measures, a thorough inspection should be carried out in and around the premises that has to be treated. The object of this inspection is to identify the species and assess the size and extent of the rodent population. This information helps in achieving good control and arriving at proper and complete proofing measures to prevent entry and movement.

### Rat Proofing

It checks the entry of rats and mice into or outside the house, farm, storage and other building. For this purpose, all small and large openings are closed and sealed. The edges of all doors, windows and other inlets and outlets are covered with metal sheets. Concrete walls and shallow foundations should be constructed. Devices should be installed to keep the door closed. Food grains and other materials may be kept in metallic container or boxes.

### Cleanliness

The heaps of trash, garbage and sweepings should not be allowed for a longer period near the houses and godowns. The food materials should not be kept in the open containers. It is very essential to launch cleanup programme in the rat infested areas so that rats may not harbour themselves in the want of food and shelter. In this way rat population can be minimized.

### Traps

The traps are employed in the places where rat infestation is small and chemical control like poison baiting, fumigation is impractical. There are many types of traps viz., cage traps, wooden traps, wire traps, snap traps and bamboo traps which are commonly used in the country. Bandicoot trap, double mouth sure success trap and union trap etc., are more efficient for trapping of rats. The traps should be cleaned by water after each installation and fresh and

attractive bait materials like breads, fruits, etc. should be used.

### Poison Baiting and Fumigants

This group is generally used to kill the rats with various rodenticides. The rodenticides can be divided in to two groups

*Single dose poison:* This group comprises acute poison which kill the rats by single exposure to poison baits, eg: zinc phosphide.

*Multiple dose poison:* These chemicals are effective only after the multiple feeding of poison baits by rats, because their cumulative effects lead the death of animals. eg. warfarin, ratanfin, rodafirin etc.

*Some newer rodenticides:* Vacor (RH-782), silmurin and bromadiolone are of very recent origin. They are found to be most effective against rats. Their single dose of poison baits kills the rats. No bait shyness reflex build up by the use of these poisons. They are safer to human beings and domestic animals.

Pre baiting: 980 g cereal + 20 g oil mix thoroughly with bare hands

*Poison baiting:* 960 g cereal + 20 g oil + 20-25 g  $Zn_3P_2$  powder mixed with the help of any stick (Source: Technical bulletin on "Rodent management in Arid Zone" Published by Project Coordinator, AICNP on Rodent Management, Jodhpur.)

### Microorganisms

Maize grain is a good substrate for mold infection and production of potentially dangerous mycotoxins harmful to both humans and animals. A large number of fungi are associated with grain moldiness, but the most common are *Aspergillus flavus*, *A. parasiticus*, *Fusarium graminearum*, *F. moniliforme*, *Penicillium* sp. and *Diplodia maydis*. These fungi produce different types of mycotoxins, consumption of which can even lead to death in acute cases.

## Management of Aflatoxins in Maize

*Pre harvest contamination:* The *Aflotoxin flavus* fungus present in soil and air can infect maize at any stage from preharvest to post harvest. Corn can be infected by air borne spores in the field during grain filling, growth cracks, mechanical injury and damage by pests to the plant parts or seeds lead to the infestation by fungi. Toxins are produced under high temperature, drought and terminal water stress prior to harvest.

*Post harvest contamination:* Fungi continue to grow and produce aflatoxins under high moisture and warm temperatures. This process is enhanced if drying is delayed. Damage by insects or rats can also facilitate mild invasion and toxin production during storage. For management, avoid mechanical damage during harvest, drying and storage.

Rapidly dry grains to 13.5% moisture content and store the seed. Use cleaned grain bags/storage structures before putting the new produce. Stock cobs or grains bags on wooden plank and store them in well aerated water proof area.

The maximum tolerance level for human/poultry consumption is 20ppb while it is 100 ppb for breeding cattle.

## SUMMARY

Heavy damage and post harvest losses are experienced by farmers during storage of maize. A large number of biotic factors are responsible for these losses such as, insects, fungi, rodents and birds. The insects alone account for 2 to 4.2 per cent of major food grain loss. Maize infestations start in fields and follow a typical pattern in rural storage where the build-up tends to be slow in the first month after harvest and expands exponentially thereafter.

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## A FACT

Most historians believe maize was domesticated in the Tehuacan Valley of Mexico. The Olmec and Mayans cultivated it in numerous varieties throughout Mesoamerica, cooked, ground or processed through nixtamalization. Beginning about 2500 BC, the crop spread through much of the Americas. The region developed a trade network based on surplus and varieties of maize crops. After European contact with the Americas in the late 15th and early 16th centuries, explorers and traders carried maize back to Europe and introduced it to other countries. Maize spread to the rest of the world because of its ability to grow in diverse climates.