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The Rodents (Mammalia: Rodentia) – Gnawing Away on Stored Grains and Options for the Integrated Pest Management in Stores

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Abstract

Rodents mainly rats and mice are some of the most troublesome and damaging pests in the world. They live and thrive in a wide variety of climates and conditions, and are often found in and around homes, buildings, farms, gardens, open fields and storages. They eat and contaminate food, damage structures and property, and transmit parasites and diseases to the animals and humans. Rodents specially house rat *Rattus rattus* (Gray) and house mouse *Mus musculus* Linnaeus can cause damage to grains intended for human's consumption, and by contamination with faeces and urine. Their presence can be detected due to squeaking and scratching noises, odour, droppings, urine marks, burrows, damage as torn bags, spoiled grains, chewed window and door sills, feet and tail marks on dusty floors, shelves or table tops, and grease like marks. The management of grains in storage to prevent rodents damage is just as important, or more so, than managing the crop while it is growing in the field. There is no way to get rid of rodents completely, however, they can be controlled through a program of prevention (keeping food in rat-proof containers, keeping left-over food in bins with tightly fitted lids, and do not pile rubbish, timber or bricks near grain stores) and destruction (remigration, trapping and poisoning). For preventing losses from rodents feeding, growers should implement a sound integrated pest management (IPM) program in their grain bins. An integrated rodent management program involves, removing of potential harbourages, preventing rodent entry by effective structural proofing, responding immediately to signs of their activity, grain bin sanitation, periodic grain monitoring, residual pesticides treatment for long-term storage, grain fumigation, using small amounts of poison bait at various locations as a last resort and protecting non-target animals from baits consumption.

Keywords

Rodents, Damage, Storage, Stored Grain, Pest, Control, Rat, Mouse

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1. Introduction

Stored grains are stored in storages for short or longer period by producers or commercial grain buyers to continue regularly supply to the consumers. Stored grains can be heavily damaged by certain species of pests if they are not properly conditioned and protected. All the pests may be a problem by their presence either alive or dead in grains that are to be processed for food. Pest's infestations and direct feeding may cause contamination, odour and mould problems; reduce grain weight, nutritional value and germination of stored grain; and reduce the quality and quality of the grain that can make it unfit for processing into food for humans or animals, and ultimately contaminated grains may pay a reduced price (Sarwar, 1998; Siddiqui and Sarwar, 2002; Sarwar, 2004; Sarwar, 2013 a; Sarwar et al., 2003; Sarwar et al., 2004). Rodents are creatures that have continually growing incisor teeth and process no canine teeth. All rodents have a pair of incisor teeth in their upper and lower jaws. These teeth continue to grow throughout their life to make

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more damage caused by gnawing. There are more than 6,000 different kinds of rodents, and nearly 600 of these belong to the genus *Rattus* and are called rats, though many other rodent species are also commonly referred to as rats. The term mouse is applied to smaller rodents particularly in the genus *Mus*. Rodents cause structural damage to buildings by burrowing and gnawing to the fabric of buildings. They undermine building foundations and slabs, and effect settling in roads and railroad track beds. Rodents also may gnaw on electrical wires or water pipes, either in structures or below ground. They damage structures further by gnawing openings through doors, window sills, walls, ceilings and floors. Considerable damage to insulated structures can occur as a result of rodents burrowing and nesting in walls and attics. They also cause problems by gnawing on electric wiring, plumbing and wooden structures such as windows, ledges, corners, wall material, and tear up of insulation and ceilings for nesting (Sarwar, 1989; Sarwar et al., 2011). The other and often overlooked impact is on the health of smallholder farmers as rodents are carriers of at least 20 severely debilitating human diseases. Some commensal rodent species are also responsible for spreading a number of diseases to man and their livestock. Among the diseases, rodents may transmit to humans or livestock the pathogens of murine typhus, leptospirosis, trichinosis, salmonellosis (food poisoning) and rat bite fever. Plague is a disease that can be carried by a variety of rodents, but it is more commonly associated with roof rats (*Rattus rattus*) than by other rats (Meerburg et al., 2009).

Rodents have two major impacts on crops; the first is the substantial damage they can cause at any stage of the growing crops, and damage to the banks of irrigation canals and levees. They may damage crops in fields prior to and during harvest, and during processing. The second is the losses they cause at post-harvest to stored grains and vegetables. Rodent pests threaten stored grains through feeding, contamination and structural damage. Rodents also consume, damage and contaminate food foodstuffs and animal feed. Loss of stored grains due to rodents is a serious problem experienced throughout the world and almost every type of food commodity is subject to rodent's attack. Rats and mice also damage containers and packaging materials in which foods and feed are stored in storages. Grain contamination is the main risk from rodent's infestations. One rat can eat approximately 20 to 40 pounds (9 to 18 kg) of feed per year and probably contaminate 10 times more than that amount with its urine and droppings. Each rat produces around 15,000 droppings and 6 litre of urine in a year. And mouse typically produces around 30,000 droppings and a litre of urine per head per year (Bayer Crop Science, 2013). The present article therefore treats with the rodents that inhabit damage to the stored grains and presents some efforts of controlling of pests.

2. Key Characteristics of Rodent Pests

Proper pest identification is requisite for any good pest control operation, because accurate and correct identification of pest species and a practical knowledge of pest behaviour can determine the source and the target area for control. It is very important to know, which species of rat or mouse is present in store in order to choose effective control strategies. The most troublesome rat species in store is the roof rat or the house rat *Rattus rattus rufescens* (Gray) and the other is house mouse *Mus musculus* Linnaeus.

2.1. Roof Rat or the House Rat *Rattus rattus* (Gray)

This is also known as ship rat, its general appearance is sleek, graceful, muzzle pointed, and ears can be pulled over eyes. Colour of belly is uniform, all white, all buff or all gray, body weight is 150 to 250 gm, and hind foot length is 3.5 cm. Probably, the most easily recognized characteristic that differentiates the roof rat from native rats is the tail, wich is more than 11 cm in length. Roof rat's tail is hairless, black fine scales, and longer than the combined length of its head and body, and extends at least to snout. Roof rat's droppings are black, banana-shaped and about 1/4-1/2 inch long. However, identifying rat species from droppings alone is difficult and often can misleading. Females produce 5 to 8 pups per litter with a possible 4 to 5 litters per year and number of teats on female is 10.

It is a cosmopolitan species and has spread through international trade; purely it is an indoor species in Pakistan and is mostly confined to the towns and villages throughout the country (Roberts, 1997). Ahmad et al., (1995) estimated the sizes of rat populations at 5 wholesale grain markets in four major cities (Faisalabad, Lahore, Multan and Rawalpindi) of Punjab Province of Pakistan. Population estimates ranged from 5 rats/ grain shop in the new grain market in Faisalabad to 61 rats/ grain shop at Lahore. Surveys of rat populations in 13 out of 40 other smaller city and town markets in Punjab, confirmed that these are rat-infested, with six ranked as severe, three as medium, and four as having little problems. Rice is the main commodity stored in these grain shops, and in laboratory, an average adult roof rat can eat 12.7 gm of rice nightly. The annual grain losses per shop due to rodent consumption, contamination, spillage and wastage are estimated to be 740 kg. There are about 5500 shops in the major and minor markets and the annual losses would approximate 4000 mt/ year, or about 0-3% of the

estimated 1.225 million mt that move through the markets yearly. Dietary habits of the house rat are studied in the urban areas trapped from general stores and human dwellings of various localities of Rawalpindi city by analysing the stomach contents (grains and cereals). The results show that wheat is the most frequently consumed cereal; it is followed by chickpea, millet, barley, lentils, maize, sorghum and peanut. There is a non-significant difference in the winter and summer diets of rats (Syeda et al., 2013).

The roof rat *R. rattus* poses both of health and safety hazards. It is implicated in the transmission of a number of diseases to humans, including murine typhus, leptospirosis, salmonellosis, rat-bite fever and plague. It is also capable of transmitting a number of diseases to domestic animals and is suspected in the transference of ectoparasites from one place to another. In addition to consuming and contaminating stored food and feedstuffs, roof rats can gnaw on wiring (posing a fire hazard), and tear up insulation to use it for nesting material. The rats can feed on the fruit and vegetative portions of many landscape and garden plants including the bark of trees. Their feeding and gnawing may completely girdle young trees. Roof rats can often eat the pulp from oranges while the fruit is still hanging on the tree, leaving only the empty rind. In food processing and storage facilities, they feed on nearly all food items. The rats may also feed on stored food and livestock feed and contaminate much more than they actually eat. Roof rats are also food hoarders, and hideaway supplies of food such as seeds and nuts. The most significant behavioural difference between the species, which has implications for control methods, is the aerial nature of roof rats. Roof rats prefer to forage for food above ground in elevated areas indoors and outdoors. They are agile climbers and travel through trees and along vines, wires, rafters, and rooftops. They often use trees and utility lines to reach food and to enter buildings, but can also be found foraging in dense ground cover. Roof rats can swim and may use sewerage systems to disperse to new areas. They prefer to nest in secluded areas above ground in such places as attics, overhead garage storage, in the vine cover of fences or buildings, and in wood piles or other stored materials where harbourage can be found. They favour dense non-deciduous trees or trees with hollow cavities and the crowns of palm trees, especially when old fronds are not removed. Roof rats sometime burrow in the ground especially in hot and dry environments. In these areas, they may use trees, materials stored on the ground, concrete slabs and sidewalks to support shallow burrows (Pryde et al., 2005; Vernes and Mcgrath, 2009; Lawrence, 2014).

2.2. House Mouse *Mus musculus* Linnaeus

House mice *Mus musculus* are from 65 to 95 mm long starting from the tip of their nose to the end of body, range from 12 to 30 gm in weight (young weighs about 1 gm at birth) and their tails are 60 to 105 mm long. The tail bears very little fur and has circular rows of scales. House mice tend to have longer tails and darker fur when living closely with humans. Their fur ranges in colour from light brown to black, and they generally have white or buffy bellies. House mice are able to reproduce throughout the year, often having 5-10 litters each year when conditions are favourable. Pregnancy lasts for 19 to 21 days and 5 to 6 young are born per litter, though there can be as many as 12 individuals, and young reaches to adulthood in 5 to 7 weeks.

House mice generally live close to humans in places like houses and barns; they generally live in cracks or in walls or make underground tunnels. Their homes usually have several rooms for nesting and storage (gather and then store their food for later use), and three or four exit holes. House mice make nest in roofs, in woodpiles, storage areas or any hidden spot near a source of food. They make their nests from rags, paper or other soft substances. House mice can eat many kinds of plant matter, including seeds, roots, leaves, and stems, while in house they can eat any human food that is available as well as glue, soap, and other household materials. House mice are generally most active at night, although some are active during the day time. House mice are quick runners, good climbers, jumpers and also can swim well. House mice have excellent vision and hearing, a keen sense of smell, and use their whiskers to feel air movements and surface textures (Sage et al., 1993; Prager et al., 1998; Frynta et al., 2005; Indik et al., 2005). House mice often squeak to each other in the nest and use pheromones and other smells to communicate with each other about social dominance, family composition, and reproductive readiness. The males sing when they smell females who are ready to mate, which might can attract to females. It is recently discovered that male mice produce complex ultrasonic songs in response to female sex pheromones (Holy and Guo, 2005).

2.3. Damage by Rodents

Large amount of stored grains in highly accessible barns are a magnet for rats and mice. As their external food sources are depleted and once the disturbance of harvest subsides, rats increasingly come from the fields to forage in and around grain stores. In contrast to rats which live in external burrows and only visit grain stores to feed, mice establish colonies within the buildings themselves and may never venture outside. Whole wheat, which has been partly eaten by mice, has a kibbled appearance, while whole grains partly eaten by rats bear a cut or chopped appearance.

Accurate data on rat's damage, control and their cost is difficult to obtain. Estimates of losses of foodstuffs, structural damage and the amount of labour and materials

expended to control rats are usually only educated guesses. One study found that a small colony of rats (10 to 26 animals), when given access to a ton of sacked wheat, would contaminate 70% of the grain after 12 to 28 weeks. The sacks have been heavily damaged as well. Total damage equalled to 18.2% of the total value of the wheat and the sacks. In most cases, the cost of rat control particularly when it is done in a timely fashion is far less than the economic loss caused by rat damage (Marsh, 1994; Timm, 2011; Sarwar, 2015 a; 2015 b).

3. Identification for Presence of Rodent's Signs

The rodents have the ability to migrate from adjacent sites to stores and this can involve their movement over considerable distances. The peoples often do not see rats, but signs of their presence are easy to detect. The following evidence and signs can be used to identify the presence, species and location of both mice and rats:-

3.1. Observing of Droppings

The shape and size of droppings can help to identify the rodent species. The rat's droppings are approximately 10-12 mm long, up to 5 mm in diameter and spindle shaped. The droppings produced by mice are approximately 4 mm long and much thinner at around 1 mm. If droppings are soft and glistening, this may tell that live rodents are still present. The presence of large droppings (from adults) and small droppings (from young) indicates a breeding population. If droppings are well distributed (scattered or in groups), this can indicate the species and whether the rodents are moving extensively. For example, few rats regularly use latrine areas to deposit droppings. If there are fresh droppings, this will indicate the size of the infestation and rodents are still present. Notably, rats produce about 40 droppings each day and mice about 80 pellets.

3.2. Live / Dead Rodents

Rats and mice are mainly the nocturnal, if live rodents are seen during the daytime, then there can be short of food, or there is a heavy infestation or a harbourage has been disturbed. Large numbers of rodents, particularly mice, have a characteristic smell to indicate their presence.

3.3. Smears

The smears left by rodents are formed when the animal's fur deposits a dark and greasy film on surfaces with which it makes regular contact. In heavy infestations, grease from the body, combined with dirt and urine may even build up into "urine pillars". These may remain on surfaces indefinitely and may not indicate a current infestation.

3.4. Tracks Footprints and Tail Swipes

The tracks footprints and tail swipes can be found in deposits of dust or flour and in soft mud. Apart from size there is necessity to distinguish between rat and mouse footprints. The size and appearance of the footprints may not allow an accurate assessment to be made of current infestation. Footprints and tail marks may remain visible for many months in undisturbed dust and it can be difficult to distinguish between fresh tracks and old ones.

3.5. Gnawing Damage

The damage to wood may be caused by both rats and mice when trying to gain access to a building. They can also gnaw as a means of keeping their continuously growing incisors worn down and sharp. Freshly-gnawed wood is generally light in colour and damage to recently stacked goods can give information on the duration and size of an infestation. Paper including labels is often shredded by mice for nesting purposes. Gnawing may be visible on doors, ledges, in corners, in wall material, on stored materials or other surfaces wherever rats are present. Fresh accumulations of wood shavings, insulation and other gnawed material indicate active infestations. Size of entry holes often 4 cm in diameter or less for mice, and 5 cm or larger for rats, or tooth marks can be used to distinguish rat from mouse gnawing.

3.6. Tracks and Burrows

Rats may feed within a building and live outside; rats memorize pathways and use the same routes habitually, so run ways or burrows may be found next to walls, along fences, next to buildings or under bushes and debris. Frequently used run ways can be seen where they are traveling between areas. These run ways may terminate in a hole or often with a fresh soil heap outside. Dust and cobwebs over the entrance or to a harbourage show that it is un-used by rodents.

3.7. Sounds

Sounds such as gnawing, climbing on walls, clawing, various squeaks and fighting noises are common where rats are present, particularly at times of the day when they are most active. When looking for rats in structures, search thoroughly on premises, attics and basements, around foundations, crawl spaces, and behind and under stored materials.

Rat sign and visual sightings are of limited value in accurately estimating rat numbers, but they are the simplest and often the only practical method available. If there is no sign, there are no rats or few present, and if only a few rats are present they may have invaded an area only recently. Old

droppings and gnawing, one or more rats seen by flashlight at night, or no rats observed in daytime then their medium numbers may be present. Fresh droppings, tracks and gnawing present, three or more rats seen at night, or rats seen in daytime then large numbers are present. Since rats are normally nocturnal and somewhat wary of humans, and usually many more rats are present then they may be seen in the daytime. Under certain conditions, rats may become quite bold in the presence of humans, and then a high percentage of the population may be visible. A conservative estimate of rat numbers can be made from measuring their food consumption, this can be done by feeding the rats for a while on finely ground grain, and then uneaten food may be carried off. After this, divide the total amount of food eaten per day by 15 gm to have a conservative estimate of rat numbers.

4. Damage Prevention and Control Methods of Rodents

The initial response for rodents controlling should be to identify the location, size and scope of the infestation, using mechanical or sticky traps and bait stations. Using fine powder, such as clay powder, locate the pathways within the building and place traps or baits accordingly. Determine the route of entry, the cause and remedial action to prevent further infestation. Chemical treatments are used only in a crisis situation, threatening rapid losses and when pests succumb to use more conservative methods. Early control, with a cycle of baiting soon after harvest, is vital to stop rats and mouse populations to get establishing in and around grain stores. The following more specific guidelines may serve as a starting point in the design of a plan of action:-

4.1. Non-chemical Control Methods

During certain situations, the use of chemical methods in controlling pests is not permitted or not advisable. Sometimes the sites or producers holding an organic accreditation are restricted to use the types of approved pesticides for pest control. Occasionally, the use of pesticides, particularly in food production areas may present a risk of product contamination or sabotage (Sarwar, 2010; Sarwar and Sattar, 2012; Sarwar et al., 2013; Sarwar 2015 c; 2015 d).

4.1.1. Monitoring and Exclusion Traps

It is important to know about the pests entering in the building and the traps can be used to determine which rodent species are found in a locality, where they live and what is the size of their populations. Blunder traps, sticky board and box traps are readily available through commercial outlets and are effective against small rodents, while mechanical traps and cages are more suitable for larger rodents problem. The installed traps should be checked regularly and if the population is small they can act as a control as well as a monitoring mechanism.

In areas where there are protected species of animal or plant life, the use of physical methods of control may be selected in preference to pesticides. Mammal traps, which are designed to kill the rodent, as well as live traps, are available for rats and mice. Sticky or glue board traps are also available for both rats and mice in sensitive food production areas. Spring traps may be used for killing and taking of animals. Such traps must be used in accordance with their conditions of approval in order to meet legal requirements and avoid risks to non-target wildlife and persons, particularly children. Break-back traps are commonly used for the destruction of rats and mice, while live catch traps are available in either single or multi catch versions. They can be used as an alternative to toxic baits in high risk/ production areas, although the presence of a bait attractant may pose a contamination risk. Cage traps which catch the target animal live are of limited use as a control measure, but may be employed when there is a risk to protected species from other methods. Any animal caught in traps should be dispatched humanely and non-target species must be released unharmed. As a general rule, it is considered good practice to all traps at least once in every 24 hour period. Where traps are placed outdoors, this may need to increase inspecting to at least twice in every 24 hour period.

4.1.2. Sanitation

Sanitation is fundamental in rats control that must be continuous, and if sanitation measures are not properly maintained, the benefits of other measures may be lost and rats can quickly return. Good housekeeping in and around buildings can reduce the available shelter and food sources for rats and mice. Careful, removing of ground storage of pipes, lumber, firewood, crates, boxes, gardening equipment and other household goods can help to reduce the suitability of the area for rodents and also make their detection easier. Collect garbage, trash and garden debris frequently, and ensure all garbage receptacles have tight-fitting covers. Where pets are kept and fed outdoors, rats can become a problem if there is a ready supply of food, always feed only the amount of food to a pet that can eat at a feeding, and store pet's food in rodent-proof containers. For roof rats in particular, thinning of dense vegetation can make the habitat less desirable, climbing hedges on fences or buildings are conducive to roof rat infestations and should be thinned. Separate the canopy of densely growing plants from one another and from buildings by a distance of 2 feet or more to make it more difficult for rats to move between them.

4.1.3. Store Construction for Rodent Proofing

Physical barriers can prevent rats from gaining entry to

structures where food and shelter are available. It is a relatively permanent form of rodent control that prevents damage from occurring. To exclude rats, seal all holes and openings larger than 1.3 cm across in a building. Rodent-proofing should be done with heavy materials that can resist to rodent's gnawing. These include concrete mortar, galvanized sheet metal and heavy-gauge hardware cloth. The most successful and long-lasting form of rat control in structures is exclusion, seal cracks and openings in building foundations and any other openings for water pipes, electric wires, sewerage pipes, drain spouts, and vents. No hole larger than 1/4 inch should be left unsealed, in order to exclude both rats and mice. Make sure that doors, windows and screens fit tightly, and their edges can be covered with sheet metal if gnawing is a problem. Coarse steel wool, wire screen and light weight sheet metal are excellent materials for plugging of gaps and holes because rodents are likely to gnaw away plastic sheeting, wood, caulking and other less sturdy materials. Because rats and mice are excellent climbers, openings above ground level must also be plugged. Roof rats often enter buildings at the roofline, so be sure that all access points in the roof are sealed.

Rodent proofing is an important and often neglected aspect of rat control. It further include repairing or replacing of damaged ventilation screen around the foundation and under the eaves; providing a tight-fitting cover for the crawl space; seal all openings around pipes, cables and wires that enter through walls or the foundation; be sure all windows that can be opened are screened and that the screens are in good condition; covering of all chimneys with a spark arrester; make sure that internal screens on roof and air vents are in good repairing; covering rooftop plumbing vent pipes in excess of 2 inches in diameter with screens; and make sure that all exterior doors are tight fitting and weather proof at the bottom.

4.2. Chemical Control Methods

The use of pesticides can present a risk of product contamination, risk to the health of users and risk to the environment. For these reasons the use of pesticides should be a last resort and their utilization ought to be strictly adhering to the requirements of current known legislations to prevent rodenticide hazards to wildlife and pets, and to reduce accidental exposure to human population.

4.2.1. Rodenticides (Toxic Baits)

The trapping is generally recommended for controlling rats indoors, but when the number of rats around a store is high, it might need to use toxic baits safely to achieve an adequate control, especially if there is a continuous re-infestation from surrounding areas. Baits to control rodents are formulated with an attractant (generally food) and a rodenticide (toxin). The professional pest control personnel are able to obtain different types of rodenticides in various formulations, which are registered for use. Anticoagulants are blood-thinning rodenticides that cause an animal's blood to lose the ability to clot, damaging capillaries and resulting in internal bleeding that is fatal. These active ingredients are used at very low levels and the onset of symptoms is delayed for several days, so the rodent does not avoid the bait because of its taste or the onset of illness. When prepared with good quality cereals and other ingredients, anticoagulant baits provide good to excellent control if baits are fresh and when placed in suitable locations so as to attract rats. The various anticoagulants fall into two groups, the older "first-generation" compounds such as warfarin, chlorophacinone and diphacinone, which require a rodent to consume in multiple doses over a period of several days; and the newer "second-generation" compounds such as brodifacoum, bromadiolone, difenacoum and difethialone, which can be fatal after a single feeding. The other active ingredients used as rodenticides to control rats and mice are bromethalin, cholecalciferol and zinc phosphide. Zinc phosphide differs in that it is an acute toxicant that causes death of a rodent within several hours after a lethal dose is ingested (Richards, 1988; Salmon et al., 2006).

4.2.2. Bait Placement and Bait Stations

The recommended strategy of bait application, which is often needed for optimum rodent control, is that all rodenticide baits must be used carefully according to the label directions, which have become more specific and more restrictive. Some baits must be contained within bait stations for all outdoor and above-ground applications. In addition to increase the safety of the bait, bait stations also help the rats to feel secure while feeding. Place all bait stations in rat travel ways or near their burrows and harbourage or suspected nest sites. For roof rats, place baits in elevated locations, such as in the crotch of a tree, on top of a fence or high in a vine. If bait stations are placed above ground level, it is necessary to take care that they are securely fastened and would not fall to the ground where children or pets could find them. Where it is impossible to exclude rodents from structures, rat control can be accomplished by establishing permanent bait stations in buildings and around the perimeters of store. Other baits or bait stations may also be used around the periphery of structures or within 50 feet of a structure. Because rats may not travel far from their shelter to find food, many product labels suggest of making bait placements at 10-30 foot intervals. Remove and properly dispose of all uneaten baits at the end of a control program. In addition, it is wise to collect and properly dispose of any dead rodents found during the course of a rodenticide application. A person can pick them up using a sturdy plastic bag inverted on one's hand, seal

them in the bag for disposal with household garbage, or bury them in a location where pets or scavengers may not easily dig them up (Salmon and Gorenzel, 2010).

Smoke or gas cartridges used for controlling of burrowing rodents, when are placed into the burrows and ignited, these cartridges produce toxic and suffocating smoke, and gases. Nevertheless, it is important that safety procedures should be rigidly enforced wherever the operations for controlling of burrowing are conducted, always approved rodenticides may be used when needed and care must be taken that non-target animals cannot access the poisons (Sarwar, 2015 e).

5. Integrated Pest Management

Integrated pest management (IPM) uses a range of preventive measures to control pests. It significantly reduces the need to use chemicals, but provides the same or better level of protection for stored commodities. Research indicates that commonly used chemicals produce adverse effects on archive materials and the peoples who use them. This knowledge combined with chemical resistance in pests and environmental concerns, has led to move away from chemical intervention to control rodent's infestation. Integrated pest control is cost-effective and the acceptable use of practicable measures to minimize the losses caused by pests in a particular management system. The measures may be simple or complex, but they must suit to the system objectives and its technical capabilities. Furthermore, in this context, cost-effectiveness requires that all costs and benefits, including sociological and environmental effects, should have been taken into account. Preparing of the grain bin to receive grain is one of the most important steps in an IPM program to prevent losses from pests. In grain storage, as with other durable agricultural products, there should be good commodity management and good storage management, which are the major prerequisites (Corrigan, 2011; Sarwar, 2013 b). A successful rat control strategy therefore typically includes three elements, sanitation measures, proper building construction and rodent proofing, and population control if necessary. For this purpose, the information gathering can be divided into two parts:- 1) Information on the pests such as species present, location, numbers, extent of infestation, risk to food safety, and proposed control methods like fumigation should be needed only rarely. 2) Information on the premises like potential entry routes of pests, exclusion recommendations, hygiene and housekeeping requirements, storage and stock rotation processes, and risk assessments (Sarwar, 2015 f).

6. Conclusion

Rodents such as rats and mice inflict damage to grains, covers, bags and the store itself (cables, doors). As a consequence, bags leak grain when rodents bite holes in them, bag stacks can collapse when rodents bite on the supporting frames, sparks from short circuits can cause a fire when rodents bite on electrical wires, silos and warehouses may sink or even fall down as a result of being undermined by rodent tunnels, and drainage canals around a store can get damaged. The bottom line management approach for rodents when to build a new storage is to think about the ways for keeping them out of storage. Pay attention to doors, ventilation openings, brickwork and the connections between the roof and the walls. Repair any damage to the store immediately and this applies especially to the doors. Keep the store very clean, remove any fallen grain immediately, and store any empty or old bags and fumigation sheets on pallets or if possible in separate stores. Store bags in tidy stacks set up on pallets, ensuring that there is a space of 1 meter all round each stack. Keep the store free of garbage in order not to provide the pests with places to hide or nest. Burn or bury garbage and keep the area around the storage free of tall weeds. Keep the area around the storage free of any stagnant water and make sure that rainwater is drained away as the rodents might use this as drinking water. However, effective and sustainable ecologically-based rodent management therefore requires communities to become involved.

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