JOURNAL OF GRAIN PROCESSING AND STORAGE
Journal homepage: www.jakraya.com/journal/jgps

REVIEW ARTICLE

Food Grain Storage Practices-A Review

Prashant Pandharinath Said and [a]Rama Chandra Pradhan*

Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi-221 005, India.
[a]Present address: Department of Food Process Engineering, National Institute of Technology (NIT), Rourkela, Odisha, India.

*Corresponding Author:

Rama Chandra Pradhan

Email: rcpradhan@bhu.ac.in

Received: 17/02/2014

Revised: 29/03/2014

Accepted: 02/04/2014

Abstract

The food grains production has increased all over the world over last decades. Now-a- days, the grains are stored using the improved methods such as in bags, silos, warehouses, containers and even in piles on the ground. These systems can be managed as man-made ecosystems, where deterioration of the stored grain is a result of interactions among physical, chemical, and biological factors. Stored grain insects and pests normally cause as much loss of grains in storage. A new approach to the use of pheromones is the monitoring of insects based on remote sensing electronic transmitters that are progressively integrated into control programs. An Integrated Pest Management program that might integrate insect monitoring, aeration, refrigerated storage, modified or controlled atmospheres, for insect control and for quality preservation of grain. The future requirement is to synthesize the status of knowledge and to provide directions in order to minimize the post-harvest losses of grains in different regions of the world.

Keywords: Storage; insect; food grains; storage structures.

Introduction

Food, *water* and *shelter* are three basic needs of human being. With population growth rate of 1.50% in the world, it is the most important concern of providing food grains to the population. This inevitable population growth will place increasing demands on the production of cereal and other food grains, which currently comprise 67-80% of human food supply and diet (Kendall and Pimentel, 1994; Dyson, 1999). Grain production has also been steadily increasing due to advancement in various technologies starting from genetically improvement to improved cultivation practices. But improper storage results in high loss of grains. Grain losses in the storage accounts 10 to 20% of overall production, and preliminary storage losses are due to inadequate storage capacities, insect and pest infestations (Phillips and Throne, 2010). According to World Bank Report, India is losing about 12-16 million metric tonnes of food grains each year. Grain is the essential consumer goods for human. Being the part of daily diet, it largely modulates economy. Hence is the basis of social existence and development. Therefore, food grain production is the key part of the economic and social development. Therefore, grain researchers from different countries try to work out advanced scientific grain storage techniques and facilities. A grain stored properly is equivalent to a grain produced. India produces about 259.32 million tonnes of food grains in annually (FAO, 2012). About 60-70 % of food grains are stored by the farmers for their own consumption. The Indian farmers prefer to store food grains in traditional ways using different types of storage structures made by locally available materials. While big farmers keep food grains in the storage facilities provided by government agencies like Food Corporation of India.

There are several factors which are responsible for losses of food grains such as environmental factors, type of storage structure used, length and purpose of storage, method of storing grains, etc. The environmental factors consist of temperature, moisture content of grains, pH, humidity, etc. Other biological factors are insects, pests, microorganisms and rodents. During storage, significant qualitative and quantitative losses occur due to those biological factors. Present article is review of in different storage practices in India. This includes various newly developed storage structures, advance methods of storage, advances in insects and pests controls and various grain protecting practices.

Advances in grain storage structures

The percentage of overall food crop production retained at the farm-level and the period of storage is largely a function of farm-size and yield per acre, family-size, consumption pattern, marketing pattern, form of labour payment, credit availability and future crop expectations (Greeley, 1978). Indigenous storage structures are generally preferred by the farmers in India at home level. The traditional storage structures have several disadvantages and limitations. Hence, the some modifications have been done in the traditional grain storage structures to offer better safety to the stored grains. For small-scale storage of grains the PAU bin, Pusa bin, Coal-Tar drum bin and Domestic Hapur tekka have been developed and demonstrated by the several scientists.

The name PAU bin, itself suggest that the bin has been developed by the Punjab Agricultural University. The bin is made up of a galvanized metal iron structure. The bin has moderate capacity varying from 1.5 to 15 quintals. The Pusa bin is also called as LDPE (low density polyethylene) sandwiched bin. This means that the storage structure is made of mud or bricks with a polythene film embedded within the walls like a sandwich. The developed bin has minimal moisture migration during storage because of the good insulating properties of LDPE. The coal-tar drum bin (200 kg) was developed at Central Institute of Agricultural Engineering (CIAE), Bhopal. It is a low cost bin and can be easily available at domestic level. The domestic Hapur tekka or bin has capacity 200 to 1000 kg. It is cylindrical in shape, made of galvanized iron and /or aluminum sheet, has a small hole in the bottom through which grain can be removed.

In addition to small scale storage, there are structures for large scale storage of food grains. Several agencies are having storage facilities for farmer on rental basis like Food Corporation of India, Central Warehousing Corporation, State Warehousing Corporation, grain marketing co-operatives and several state government agencies. The large scale grain storage is done in Cover and Plinth (CAP) and silos. CAP storage involves the construction of brick pillars to a height of 14’ from the ground, with grooves into which wooden crates are fixed for the stacking of bags of food grains. The stacks are covered with 250 micron LDPE sheets from the top and all four sides. Food grains such as wheet, maize, gram, paddy, and sorghum are generally stored in CAP storage for 6-12 month periods. It is the most economical storage structure and is being widely used by the FCI for bagged grains. The structure can be fabricated in less than 3 weeks. It is an economical way of storage on a large scale (India Agronet, 2009).

The silos are either metal or concrete. Concrete silos are typically cheaper than metal silos. In silos the grains in bulk are unloaded on the conveyor belts and, through mechanical operations, are carried to the storage structure. Galvanized silo storage systems have been a proven scientific system for storage of food grains in Europe and America. This system ensures zero wastage due to moisture, fungus and rodents etc. In India this system is adopted to some extent by private sector since 1990, but it is limited to the process industry rather than for storage of grain for longer period. The storage capacity of each of these silos is around 25,000 tonnes. Farming Co-operatives cannot afford to have such systems. The Food Corporation of India is the single largest agency which has a capacity of 26.62 million tonnes. The benefits of such bulk storage are (1) Low running costs, (2) Low labour requirements, (3) Rapid handling, (4) Low through spillage and rodents, (5) Efficient and effective fumigation operation, (6) Less land area requirement, (7) Complete control of aeration, (8) Possible to store the grain for longer periods, (9) Possible to mechanize all operations, and (10) Possible to store moist grain for short periods.

Advanced storage methods

Advanced storage technologies such as aeration, refrigerated storage, modified atmospheric storage, hermetic storage systems are already adopted in many developed countries and India is following the suit. Though hermetic storage system was in practice in the village level in small pockets in throughout India, its adaptation through some modernization is yet to catch up with the large holdings. Insect monitoring and dose control through modern interventions are some of the measures for preventing storage losses.

Grain aeration

Aeration is widely used for preservation of stored grain. Aeration can be defined as the forced movement of ambient air of suitable quality, or of suitably conditioned air, through a grain bulk for improvement of grain storability. It is an acceptable practice to reduce the commodity temperature and is done by using mechanical aeration by means of fans. This system is suitable for low humid environment. On commercial scale, forced aeration plays important and effective role to preserve grains (Navarro and Noyes, 2002).

Refrigerated storage

In this method, ambient air is cooled and then passed over the bulk grains via existing aeration system. Refrigerated aeration has been used for cooling dry grain in subtropical climates when ambient temperatures are too high for successful insect control by aeration with untreated air. The initial investment for refrigerated storage system is comparatively higher but together with the dehumidified air method, it could provide answers to the practicability of aeration for safe commercial storage in tropical climates (Navarro and Noyes, 2002).

Modified Atmosphere Technology

Several researchers have been studied various atmospheric compositions for the protection of grains (Adler *et al.,* 2000; Navarro, 2006). The airtight or hermetic storage have also been successfully used to maintain grain quality in India, South America (Argentina) and North Africa.

Modified atmospheres (MA) and controlled atmospheres (CA) offer alternative to the use of conventional residue producing chemical fumigants for controlling insect pests attacking stored grain, oilseeds, processed commodities, and some packaged foods. The CA system also prevents fungal growth and maintains product quality.

Hermetic storage

An airtight or sealed storage is termed as "hermetic storage" or "sacrificial sealed storage". The method enables insects and other aerobic organisms in the commodity or the commodity itself to generate the modified atmosphere by reducing oxygen (O_2) and increasing carbon dioxide (CO_2) concentrations through respiratory metabolism. Respiration activity of the living organisms creates an atmosphere containing about 1-2% oxygen and about 20% carbon dioxide (White and Jayas, 2003).

Insect control success due to the hermetic storage treatments is comparable to conventional fumigants (over 99.9% kill), and losses due to insect activity are minimal (0.15% loss in weight for a storage period of 15 months) (Navarro *et al.,* 1984; Varnava, 2002). Low O_2 and high CO_2 environment kills insect and mite pests, and prevents aerobic fungi from growing (Weinberg *et al.,* 2008). Elevated CO_2 and depleted O_2 levels will generally maintain stored grain quality for long period of time. Commodities including cereals, oilseed grains, pulses, cocoa and coffee can be stored safely for many months, maintaining high quality and limiting moulds and mycotoxins.

Advances in insect and pest management systems

Usually chemical fumigants, contact insecticides are used to control stored product pests. Increase awareness about health issues due to organic residues in food grains has enforced restrictions on use of chemical pesticides because of adverse effects of pesticide residues in grain and environment. This has resulted in imposition of strict limitations on pesticide registration by regulatory agencies. In addition, in many countries, insects in particular have been developing resistance to contact insecticides and to the conventionally used phosphine gas. Birational approach is being preferred over the conventional practice to tackle these issues.

The major pests of stored grains include beetles (*Callosobrunchus sp, Trogodermagranarium, Tribolium confusum*), weevils (*Acanthoscel idesobtectus*), moth (*Corcyra cephalonica*) and rodents. The preventive and curative are the two categories of treatments applied for controlling insect and pest infestation. The preventive treatment is that which is given before infestation in order to inhibit insect attack. The curative treatment involves use of fumigant aluminium phosphide to control infested stock or godown in airtight condition. For controlling rodents rat cages, poison baits and use of rat borrow fumigation is recommended (India Agronet, 2009). Stored-product insects are serious worldwide pests of dried, stored and other durable agricultural commodities (Phillips and Throne, 2010). The global losses in stored grain have been estimated at approximately 10% in developed countries, 20% and more, in developing countries. A biorational approach is preferable for controlling stored-product insects because of the phase-out of very effective insecticides (e.g. methyl bromide), insecticide resistance, and the problem of insecticide residues in food. Electronic monitoring systems are being developed and successfully practiced in different parts of the world for monitoring and applying suitable chemical pesticide or bio-fumigant doses.

A variety of traps developed with synthetic pheromones has been developed for use in monitoring programmes in food processing and storage facilities. The pheromone is incorporated into a plastic matrix from which it is slowly released during several weeks or months. Grain probe trap or pitfall-cone trap, are placed at or below the surface of grain masses and do not require the use of pheromones. These traps capture beetles that are simply walking through the holes of the probe shaft, drop through the void inside the probe and are directed by a funnel into a collection vial.

A recently developed technology for monitoring insects is a probe trap equipped with an electronic device to count insects that relay the counts to a computer (Shuman *et al.,* 1996). Probe traps installed in shelled and unshelled peanuts in a pilot plant experiment indicated no significant differences in the presence of *Tribolium castaneum* aggregation pheromone attractants in the probes. Phillips *et al.* (2000) found evidence suggesting that pheromones and food attractants should not be used in devices intended for monitoring insects in bulk-stored grain.

A special device containing a heater and a ventilator named "speedbox" (Jakob *et al.*, 2006) that was developed especially for use at low temperatures and shorter treatment time. The use of this device allowed optimizing the Phosphine fumigation by effective control of all developmental stages of major stored product insects at low temperatures and at decreased exposure time. Some essential oils are highly selective to insects, probably because they bind to the insect-selective octopaminergic receptor, a non-mammalian target (Kostyukovsky *et al.*, 2002). A screening of a large number of essential oils from aromatic plants was conducted to isolate effective oils for using as fumigants in grain bins for insect control. The authors reported on two effective essential oils that were examined under laboratory and field conditions with supplementation of CO_2 against *S. oryzae* and *C. maculates*. Their results are the basis for using essential oils as botanical fumigants and alternatives to the toxicant phosphine for controlling stored-product insects.

Correct grain handling, regular inspections and pest control strategic planning are important practice to be conducted by every farmer who stores food grains. One of the strategies is to assure that initial insect population is depressed and that the physical conditions in the storage bin are not contributory to insects due to preventative sanitation practices (storing clean grain, insect-free structures with clean surroundings) and drying grain before loading into storage to maintain a low moisture content (12-13 percent) which can reduce insect growth.

Hygienic practices

Hygiene of storage environment is major factor which contribute to growth of the insect and pests infestation. Insect control can be done through cooling; fumigation is applied wherever practicable. Thermal disinfestations of insect parasites and pathogens can be done through solar heat or treatment with traditional additives if sufficiently available

Sanitation in and around stored grain installations is the almost efficacious and profitable administration exercise to prevent insect infestations in stored grain. This is the most essential IPM practice for storing and protecting grain because a successful sanitation is 80 percent of an effective IPM program in stored grains. Before harvest and storage of new grain, cleaning equipments for handling grain like harvesters, vehicles, aeration fans, etc. is required. Taking off any grain or grain dust from inside the bins by cleaning empty bins and brushing down walls is essential. Getting rid of any spillage grain close to the external of the bin and storage installation is requisite. Cautiously examining storage bins and fastening or sealing of any gaps or openings which may be expected entry spots for rodents or insects is requisite.

Spinosad as a natural grain protectant

Spinosad is a reduced-risk insecticide derived by fermentation from the soil actinomycete, *Saccharopolyspora spinosa* (Mertz and Yao, 1993). The spinosad is growing as a grain protectant, awaiting final acceptance of international residue tolerances for spinosad by major grain importing and exporting countries (Nayak *et al.*, 2005). Spinosad effectively controls economically important beetle and moth pests associated with stored grain and is also effective against certain psocid species.

Conclusion

India produces about 259.32 million tonnes of food grain annually but the post production losses are also high. Major stock is stored at farmers' level (70%) and remaining at organizational level. The advancement in scientific design and development of low cost storage structures has been found effective as it has created interest and awareness among farmers and traders to preserve the food grains safely. The modified and improved structures provide safe and economical means of grain storage for long durations. Need of the hour is to strengthen traditional means of storage with modern inputs and to provide cheaper storage structures such as low cost bins to farmers so as prevent enormous storage losses. With the chemical insecticides being phased out due to their residual effect on human health; the need for the hour is to maintain hygienic practice in the storage systems. Maintenance of CA or hermetic storage environment for the control of insect growth is also very effective and is possible for bulk storage system. Precision monitoring system of insect population and application of control dose of insecticides are few such measures for ensuring grain safety and security.

References

Adler C, Corinth HG and Reichmuth C (2000). Modified atmospheres. In BH Subramanyam and DW Hagstrum (Eds), Alternatives to pesticides in stored-product IPM. *Kluwer Academic Publishing, Norwell, MA,* 5: 105-146.

Dyson T (1999). World food trends and prospects to 2025. *Proceedings of the National Academy of Sciences, USA,* 96: 1-13.

Greeley M (1978). Appropriate rural technology: Recent Indian experience with farm-level food grain storage research. *Food Policy,* 3(1): 39-49.

India Agronet (2009). http://www.indiaagronet.com /indiaagronet/Agri_marketing/contents/Storage%20and%20Warehousing.htm

Jakob G, Dierks-Lange H, Heck FW and Schmitt S (2006). The speedbox – an innovative application device for the Degesch plates. In Lorini I, Bacaltchuk B, Beckel H, Deckers D, Sundfeld, E., dos Santos JP, Biagi J.D., Celaro J.C., Faroni LRD'A, Bartolini L, de OF, Sartori MR, Elias MC, Guedes RNC, De-Fonseca, RG, Scussel VM (Eds), *Proceedings of the Ninth International Working Conference on Stored Product Protection, 15–18 October 2006, Sao Paulo, Brazil, Brazilian Post-harvest Association, Campinas, Brazil, pp. 564-566*.

Kendall HW and Pimentel D (1994). Constraints on the expansion of the global food supply. *Ambio,* 23: 198-205.

Kostyukovsky M, Rafaeli A, Gileadi C, Demchenko N and Shaaya E (2002). Activation of octopaminergic receptors by essential oil constituents isolated from aromatic plants: possible mode of activity against insect pests. *Pest Management Science,* 58: 1-6.

Mertz FP and Yao RC (1993). Amycolatopsis alba sp. nov., isolated from soil. *International Journal of Systematic Bacteriology,* 43(4): 715-720.

Navarro S (2006). Modified atmospheres for the control of stored-product insects and mites. In Heaps JW (Ed), Insect Management for Food Storage and Processing. *Second Edition, AACC International, St. Paul, MN*, 105-146.

Navarro S and Noyes R (Ed.) (2002). The Mechanics and Physics of Modern Grain Aeration Management. *CRC Press, Boca Raton*, FL, pp: 647.

Navarro S, Donahaye E, Kashanchi Y, Pisarev V and Bulbul O (1984). Airtight storage of wheat in a PVC covered bunker. In BE Ripp et al., (Eds.). Controlled Atmosphere and Fumigation in Grain Storages. *Amsterdam, Elsevier*, 601-614.

Nayak MK, Daglish GJ, and Byrne VS (2005). Effectiveness of spinosad as a grain protectant against resistant beetle and psocid pests of stored grain in Australia. *Journal of Stored Products Research*, 41(4): 455-467.

Phillips TW and Throne JE (2010). Biorational approaches to managing stored-product insects. *Annual Review of Entomology*, 55: 375-397.

Phillips TW, Cogan PM and Fadamiro HY (2000). Pheromones. In Subramanyam BH and Hagstrum DW (Eds.). Alternatives to Pesticides in Stored-product IPM, *Kluwer Academic Publishers, Boston*, 273-302.

Varnava A (2002). Hermetic storage of grain in Cyprus. In Batchelor TA, Bolivar JM (Eds). *Proc. Int. Conf. on Alternatives to Methyl Bromide, Sevilla, Spain, March* 5-8, 163-168.

Weinberg ZG, Yan Y, Chen Y, Finkelman S, Ashbell G and Navarro S (2008). The effect of moisture level on highmoisture maize (*Zea mays* L.) under hermetic storage conditions-in vitro studies. *Journal of Stored Products Research*, 44: 136-144.

White NDG and Jayas DS (2003). Quality changes in grain under controlled atmosphere storage. In: Navarro S; Donahaye E (Eds). *Proceedings of the International Conference on Controlled Atmosphere and Fumigation in Grain Storages. Caspit Press Limited, Jerusalem, Israel*, 205-214.