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Prospects of traditional seed storage strategies against insect infestation adopted by two ethnic communities of Tamil Nadu, southern peninsular India

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Abstract

Post harvest grain storage is intended to save grains and other commodities, which would otherwise be destroyed mainly by insect pests. Post harvest storage techniques adopted by ethnic races are worth emulating. Seven different storage systems like *Thombai* (Bamboo bin), *Mankattai* (Mud house), *Kulukkai* (Earthen bin), *Addukkupaanai* (Earthen pot-pile), *Pathayam* (Wooden bin), *Thallpai* (Straw bin) and *Vattappetti* (Palmyra leaf bin), used by *Kanikars* of Kanyakumari District and *Hindu Malayali* of Thiruvannamalai District, Tamil Nadu, India are found to be scientifically based. The basic design, the type of materials used and the ingenuity of the storage systems have been elucidated with the view of modifying such a system to suit the present day storage needs.

Key words: Stored product pests, storehouses, post harvest activities, ethnic storage systems.

Introduction

Storage and upkeep of agricultural products are very important post harvest activities. Considerable amount of food grains is being spoiled after harvest due to lack of sufficient storage and processing facilities (Singh and Satapathy, 2003). An FAO estimate of worldwide annual losses in stored produce has been given as 10% of all stored grain. About 13 million tons of grain loss is due to 10 million tons to failure (Wolpert, 1966). Routine management of stored produce pest through fumigation (Page and Lubatti, 1963), chemical pesticides (Lemon, 1967) and plant based deterrents (Schmutterer, 1990), is intended to contain this loss.

Storage practices vary and there are small or big storehouses, indoor or outdoor, temporary or permanent and individual or community storage structures. The indoor storage is mainly for obtaining seed, whereas the grains for consumption are stored in separate structures that are constructed away from the residence (Jain *et al.*, 2004).

Storage of food grains by the indigenous people groups of the tropics and subtropics is mainly traditional. The traditional methods have been used for many years with little or no modification and are successful because of the application of scientific principles, though unawares. The selection of a traditional storage system by an ethnic group is often related to climate, but local natural resources and customs also influence the choice of the storage methods (Hall, 1970).

Recent exploration of certain ethnic pockets in the Indian sub-continent revealed the development and use of a number of foolproof storage systems that protected stored produce from insect infestation for considerably longer periods. *Kanikars* of Kanyakumari District (lies between 8°03′ and 8°35′ of the northern latitude and 77°05′ to 77°36′ of the eastern longitudes) and *Hindu Malayali* of Thiruvannamalai District (lies between 12°00′ and 12°49′ of the northern latitude and 78°38′ to 79°45′ of the eastern longitudes) Tamil Nadu, India are two ethnic races with age-old customs and practices related to food, medicines, agriculture and other topics. In this study, the strategies and tools adopted by these two ethnic groups for preserving stored produce have been exclusively studied.

Materials and methods

The two localities were visited along with guides from the same ethnic groups and information was collected about the prevalent storage practices. Photographs of the storage structures were taken and the basic scientific plan behind the design was established for most of the structures. The grains or other products stored in these structures were personally observed and their quality was ascertained.

Results

Thombai (Bamboo bin)

It is a chief storage structure made from *Bambusa arundinacea* (Retzius) Roxburg (Bamboo) (figure 1) splits which are closely intertwined in such a way that a bamboo skeletal structure is formed with a narrow opening at the top. This structure is placed over a foundation of boulders and covered over on all sides by clay and allowed to dry. The interior of the structure is lime washed while the exterior is fortified with cow dung. When the structure is fully dried the major grain to be stored is put in to the interior. Any additional material to be stored is taken in separate gunny bags or pots. A large *Thombai* can hold about 30 tons of grains. A small pothole alone is left at the top and this too is closed by a large roof of *Cymbopogan* sp. Hackel (Ginger grass)

Figure 1. *Thombai* (Bamboo bin), 3 m height, 1 m radius, capacity > 500 Kg.

Figure 3. *Kulukkai* (Earthen bin), 2 m height, 0.5 m radius (at the broadest place).

which prevents rainwater from damaging the structure. The top of the *Thombai* is in the form of spire and the roof is conical in structure similar to a pyramid (figure 1).

Mankattai (Mud house)

This is the variant of *Thombai*, and it is normally kept indoors. Here, there is no bamboo skeleton and the walls are made of mud bricks and plastered over with a primary layer of mud. There is no spire, and the top is covered over with wooden planks after storing the grains inside. The whole structure along with the wooden planks, is plastered over with clay and cow dung, allowed to dry and then it is lime-washed (figure 2).

The size of the *Mankattai* is determined by the farmer based on his need. Mostly it is used to store larger quantities of the same commodity.

Figure 2. *Mankattai* (Mud house), 1.5 m height, 1.5 m width, 2 m length, capacity > 500 Kg.

Kulukkai (Earthen bin)

This is another popular storage structure for storing lesser quantities of grains (< 200 Kg). The structure has a unique shape with a smaller base and a broader top with a constricted mouth for pouring in grains (figure 3). The base of the structure is trenched in the soil, normally inside a protected house and there is a basal vent for removing the stored grains closed by coconut shell (*Cocos nusifera* L.). When grains are stored for longer periods, the door or vent is sealed with clay. The mouth at the top is covered over by an earthen plate that exactly fits into the opening and the lip is sealed with mud. This earthen structure provides a storage time of about two years and it has proved to be very successful in storing paddy, black gram and millet. It is a common practice to top up the *Kulukkai* with dried leaves of *Pongamia pinnata* (L.) Pierre and *Azadirachta indica* A. Jussieu.

Addukkupaanai (Earthen pot-pile)

A variant of the earthen bin is the earthen pot-pile (figure 4). Usually three pots are arranged one over another, the smallest being at the top, covered over by an earthen lid fastened by thick cloth. The pots fit exactly one over another in such a way that, there is no gap left. The lips are sealed with clay and cow dung to further ensure perfect alignment.

Pathayam (Wooden bin)

This is a wooden structure with a cubic capacity ranging from 2,000 to 10,000 litres. It is made up of wooden planks joined together by carpentry work (figure 5). The wooden planks are arranged in such a way that there is no gap left between any two planks since a third plank lies over the two planks along their junction. The only opening at the top is quite narrow (about 30 x 30 cm) (figure 5a) with a strong door which snugly fits

Figure 4. *Addukkupaanai* (Earthen pot-pile), capacity: bottom pot 30 Kg; middle pot 20 Kg; top pot 15 Kg.

Figure 5. *Pathayam* (Wooden bin), 1.5 m height, 1.5 width, 2 m length, capacity > 500 Kg.

Figure 5a. Door of *Pathayam* (Wooden bin).

into the opening. *Pathayam* is topped up with leaves of locally available plants like *A. indica*, *P. pinnata*, *Annona squamosa* L. and *Eucalyptus globulus* Labillardiere.

Thallpai (Straw bin)

This is an unusual storage structure made up of paddy straw for storing seed grains. This storage maintains the seed grains viable for about two years. Paddy straw is specially prepared for making this structure. The straw is kept straight and dried properly. The dried straw is twisted to form ropes and the ropes are concentrically arranged over a large area. Loose straw is placed over this concentric arrangement and peelings from the bark of *Erythrina indica* L. and *Erythrina variegata* L. are placed along with loose straw. The bark peelings form the base and wall of this straw bin (figure 6).

The grain to be stored in the straw bin is first mixed with sifted fly ash and placed over the straw structure. When sufficient quantities have been placed, the straw ropes are folded over the grains and a rounded structure is obtained. This structure is usually suspended from the roof rafters.

Figure 6. *Thallpai* (Straw bin), capacity: 100 Kg.

Figure 7. *Vattappetti* (Palmyra leaf bin) (small sized), 0.5 m height, 0.25 length, 0.25 width, capacity 10 Kg.

Vattappetti (Palmyra leaf bin)

This storage structure is normally used for short term storage of grains and exclusively designed to suit storage needs of an individual household (figure 7). The normal size (2.5-3 m height, 1 m width, 2 m length, capacity > 500 Kg) is mainly used as maize storage. Seasoned Palmyra leaf (*Borassus flabellifer* L.) is carefully woven to form a type of cylindrical basket. Usually double weaving is done to make the storage system more durable. The storage system is provided with a top cover made up of the same material and in traditional storage practices, leaves of plants like *Psidium guajava* L., *Vitex negundo* L., *A. indica*, and *P. pinnata* are used as the optional inner lining of the palm leaf bin.

Discussion

The ethnic strategies are time tested and have proved to be very successful in storing various commodities pest-free. Some of the structures are not commonly used (palmyra leaf bin and straw bin) because of the shifting agricultural practices of the ethnic groups which mainly depends on the climatic conditions. The scientific basis behind these structures is astounding, even though the ethnic groups do not have established scientific knowledge but only traditional wisdom. Most of their practices are worth simulating since many of them are eco-friendly and sustainable.

Thombai is a very successful storage structure which can be erected in any open space at a very low cost. The clay provides an impervious coating which will not allow even small insect pests. The ginger grass used in the top cover has insect deterrent action which prevents insects from settling down on the structure. Srivastava *et al*. (1988) reported that 0.2% (v/w) ginger grass oil on red gram prevented oviposition and F_1 emergence of *Callosobruchus chinensis* (L.) for a period of 45 days after initial release of adults. Rehm and Espig (1991) established the high geraniol content of gingergrass oil. Paranagama *et al*. (2003a) reported that grain damage was lower in *Cymbopogon citratus* Stapf and *Cymbopogon nardus* Rendle treated rice than in the control. *C. citratus* and *C. nardus* showed deleterious effects on oviposition and F1 adult emergence of cow pea bruchid, *Callosobruchus maculatus* (F.) compared to the control during no-choice tests (Paranagama *et al*. 2003b).

The grains to be stored are first sun dried by the tribes and this kills most pests. Lale (1998) reported decreased oviposition and increased adult mortality of *C. maculatus* in grains stored after exposure to sun. Lale and Vidal (2000) recorded 100% mortality of the eggs and first instar larvae of C. *maculatus* and first instar larvae of *Callosobruchus subinnotatus* (Pic) exposed to sunlight for 2 h in *Vigna subterranean* (L.). Exposure of *C. maculatus* and *C. subinnotatus* adults to solar heat decreases the oviposition, retards egg development and reduces survival rate of immature stages. At a temperature of 50 °C, both species laid significantly fewer eggs with lower hatching potential, than those maintained at 40 °C. In both the species, no adult progeny emerged from seeds harbouring first instar larvae, when exposed to a temperature of 50 °C for 2,4 or 6h (Lale and Vidal, 2003). Exposure to the sun (in different coloured polyethylene bags) for 24h killed *C. chinensis* eggs and grubs found in infested green gram. Complete egg mortality was recorded in coloured bags and complete grub mortality, only in black coloured bags (Singh and Sharma, 2003). Thus *Thombai* relies on the insect deterrent action of plants and the sterilizing effect of UV in solar radiation. *Thombai* could be successfully used in granaries where long term storage is required, even up to a period of more than two years. The same structure can be repeatedly used for storage and only roof replacement is required.

Post harvest technology followed by the ethnic groups for storing grains in *Mankattai* (Mud house) *Kulukkai* (Earthen bin) and *Addukkupanai* (Earthen pot-pile) is almost similar. These three storage systems are normally kept indoors and all of them are mainly made up of mud. The environment inside these storage systems remains almost the same.

It is a common practice to top up these three storage structures with dried leaves of *P. pinnata* and *A. indica*. These two plants have proven insecticidal activity (Jilani and Su, 1983). Petroleum ether extract of *A. indica* leaves (680 $\mu g/cm^2$) applied to a filter paper produced class III repellency (42%) against *Tribolium castaneum* (Herbst) eight weeks after treatment, compared with class V repellency (81.5%), one week after treatment. Babu *et al*. (1989) reported the inhibitory action of *P. pinnata* seed oil - 0.75% (v/w) - on adult emergence of *C. chinensis* in pigeon pea. Dunkel *et al*. (1991) showed that the extract of *A. indica* seeds (0.2% w/w) applied to wheat caused 50% mortality in adult *Sitophilus oryzae* (L.) and 15% mortality in *Rhyzopertha dominica* (F.) within three days and F_1 emergence was reduced by 98 and 94% respectively. Khaire *et al*. (1992) reported *P.*

pinnata seed oil (5ml/kg) applied to wheat held in a store for 12 months prevented natural infestations by insects. The pesticidal activity and insect deterrent action of *A. indica* and *P. glabra* had been well documented (Reddy *et al*. 1999) and the leaves of these two plants contain various bioactive compounds (Tare, 2001).

Addukkupannai (Earthen pot pile) is a small-scale storage system. Farmers use it for storing grains for their personal needs. Separate pots carry separate commodities. The *Addukkupanai* is topped up with dry sifted red soil, which does not allow any infestation to the grains stored underneath. Normally the red soil layer is about 2 to 3 cm thick. Experiments carried out in Kenya indicated that a diatomaceous earth of local origin served as a protectant when applied to maize stored in bags (Le Pelley and Kockum, 1954). Such mineral dusts scratch the thin water-proofing layer of wax which exists on the outside surface of the insect cuticle, allowing loss of water which leads to death as a result of desiccation.

Occasionally grains were mixed with fly ash and stored in the *Addukkupanai*. Hall (1970) reported the admixture of wood ash or sand with food grains in many areas, usually restricted to the storage of small quantities in earthenware pots for seed purposes. Hakbijl (2002) reported the use of ash from burnt cow dung as an insecticide against *T. castaneum*, *Sitophilus granarius* (L.) and *Cryptolestes ferrugineus* (Stephens) larvae. Ashes kill insects by desiccation or by filling the intergranular spaces, restricting insect movement and emergence.

Pathayam (Wooden bin) is used to store paddy for about six months. Before storage in the *pathayam*, the grains are sun dried. For more protection, it is also topped up with insect deterrent leaves and fly ash. The plants commonly used in the *Pathayam* are *A. indica*, *P. pinnata*, *A. squamosa* and *E. globulus*, which have proven insecticidal activity against stored product pests. Kotkar *et al*. (2001) isolated flavonoids from aqueous extracts of *A. squamosa* which showed 80% insecticidal activity against *C. chinensis* at a concentration of 0.07mg/ml. Patel and Patel (2002) reported that a mixture of *A. indica* and *E. globulus* leaf powder in mustard oil was highly effective against *Corcyra cephalonica* (Stainton) on stored rice. Acetone and petroleum extracts of *A. squamosa* leaves exhibited respectively, 12.5 and 5.0% reduction in oviposition of *C. cephalonica* (Dwivedi and Pareek, 2002).

The ethnic groups using *Thallpai* (straw bin) live in hilly areas where the rainfall is high and the humidity, excessive. But the straw bin protects the grains from moisture and preserves it as seed grain for the next season. In *Thallpai*, *E. indica* and *E. variegata* bark peelings are used as padding. Ito (1999) isolated five oxyerythrinan alkaloids with insecticidal properties, erythrinine, 11-hydroxyerysotrine, erysotramidine, erytharbine, crystamidine and a dibenz {d,f} azonine type alkaloid, erybidine, from *Erythrina* plants. Tanaka *et al*. (2000) isolated two new isoflavanoids, eryvarin A and eryvarin B from the wood of *E. variegata* and elucidated their spectroscopic structure.

In *Vattappetti* (Palmyra leaf bin), the architecture is such that the Palmyra leaves are closely superimposed preventing the entry of insects. The dried leaves used for making this storage system are seasoned to make them hard enough to resist the bite of mandibulate insects and insect larvae that may hatch out from the eggs laid on the external surface. The ruggedness of the leaf sheath is usually not lost even after a period of one year in indoor storage. The leaves of plants used as inner lining of Palmyra leaf bin are known to have insect deterrent action. *P. guajava*, *V. negundo* leaves admixed with freshly harvested paddy, field infested with *Sitotroga cerealella* (Oliver), significantly reduced the number of emerging F1 adults during four months of storage (Dakshinamurthy, 1988). The LD_{50} for *P. guajava* leaf powder admixed with rice assessed for *S. oryzae* and *S. granarius* at seven days was 2.25% and 2.28% (w/w) leaf powder, which prevented the production of F_1 adults of both species (Sharaby, 1989). Morallo-Rejesus *et al*. (1990) showed that leaves of *V. negundo* caused 80% mortality in adult *C. chinensis* within 48h and prevented egg laying in mung bean. Prakash *et al*. (1990) showed that Z-heptatriacontanone isolated from the leaves of *V. negundo*, when admixed with rice at 400 mg per Kg reduced oviposition in *S. cerealella*, *R. dominica*, *S. oryzae*.

The seven different types of storage structures used by the two ethnic groups are indicative of the scientific bias common to ethnic wisdom. All the storage structures are comparatively cheap, eco friendly, make use of locally available material, impart high shelf life to the stored commodities and are highly effective in preventing insect infestation. These systems could be applied in modern storage areas with very minor modifications and this could save food produce that would otherwise be ruined by insects.

Tribal and rural people have a wealth of knowledge on the conservation and utilization of natural resources. Even though chemical methods of management of stored produce pests are highly successful, they leave behind toxic residues. But traditional methods of storage are more sustainable and eco friendly. Conserving and promoting indigenous knowledge helps in the extension of traditional wisdom to future generations.

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