CHEMICAL INTERVENTION ON ALL STAGES AND ON ALL SCALES OF TROPICAL STORAGE PRACTICE

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ABSTRACT: Grain protection has been in practice for centuries in the tropics. Earlier protection included use of materials such as ash and dry neem leaves, which probably acted as an abrasive and repellent respectively. In the late 1940's, the concept of synthetic chemical control was established and spread during the 1950's. It gradually transformed from mixing of BHC anu DDT dust to approved products such as application of malathion and phosphine. During this period research on relative efficacy of various chemicals and fumigants under tropical storage conditions was also conducted. Grains need protection at all stages from field to consumption. In the tropics field to storage infestation by stored grain pests is common. Inadequate storage methods immediately after harvest and before processing add to the problem of field to storage infestation. The process of infestation and more so of multiplication of insects continues during processing, transportation, and long term or seasonal storage before the grain is finally consumed. A wide range of yield losses during these various stages are estimated. An overall yield loss of 30%, as estimated by some workers, may not be an exaggerated estimate. Storage practices in the tropics vary a great deal due to factors such as climate, product, availability of local material, transportation, length of time to be stored. There has been a great deal of change in the storage practices at government level, where large scale storage is practiced, but comparatively little change has come at the level of the tropical subsistence farmer.

INTRODUCTION: Stored grain protection has been practiced for centuries in the tropics due to crop growing seasons, where in the off season a subsistence farmer could utilize his product. Large scale storage for varying lengths of time by government or semi-government agencies is practiced as a strategic reserve to guard against crop failures and also to a limited extent to control the grain prices in the off season. There has been a great deal of change in chemical control practices where large scale storage is practiced, but comparatively little change has come at the level of the tropical subsistence farmer. Probably 60 to 70 percent of the grain in the tropics is stored by the subsistence farmer for his own consumption. He may also store grain for a shorter period due to lack of good marketing and transport and for sociological reasons. Yet at this level there is little insecticide used because of the lack of funds by the farmers for purchase of pesticide and poor storage facilities. A government subsidized program could help the protection of grain by chemicals at this level. Easy storage protection included mixing of materials such as cow dung ash and dry neem leaves, which probably acted as an abrasive and repellent respectively, with the grain. Khare[1] reported that mixing of cow dung ash provides an additional method of checking infestation to some extent in storage at the farmers level where a small quantity of grain in stored.

PREHARVEST INFESTATION AND INTERVENTION: Grains need protection from stored grain pests at all stages from field to consumption. In the tropics field to storage infestation by stored grain pests is common. *Sitotroga cerealella* and *Sitophilus oryzae* both are primary stored grain pests of rice and they commonly infest paddy in the field before harvest. Similarly *Sitophilus zeamais* infests maize, *Rhizopertha dominica* infests wheat and other cereals and *Callosobruchus maculatus* infests cowpeas. All these are major stored grain pests. The initial field infestation is carried over to drying and storage. Grains harvested in semi-humid tropics have high moisture level. Maize may have up to 30 percent moisture at harvest at Ibadan, Nigeria. Usually with the subsistence farmer, grains are left near the field for sun drying. During this process insect infestation continues to build up. Cribs made of plant material are used for storing husked and unhusked maize. These materials provide aeration facilities to avoid mould, but at the same time facilitate infestation from surrounding areas. Infestation during drying in cribs and structures is best avoided by cleaning these storage places and dusting with about 1.0 percent lindane dust applied at 10 to 12 ppm. This method is practiced in Africa to a limited extent by subsistence farmers in the case of maize drying and storage. This method is inexpensive but the farmer has to wait 6 to 8 weeks before consumption. Lindane dust is easily available to the farmers. Le Pelley and Kockum[2] recorded that after shelling the lindane residue in maize was reduced to a level of 1 ppm or less when applied as a 1 percent dust at 12 ppm to ears of maize and sorghum. This treatment was found particularly effective in killing and preventing successful egg laying by *Sitophilus* spp. and *Sitotroga cerealella* (Ashman[3]). However resistance to lindane has recently been reported from Malawi and Zambia for *Tribolium castaneum* and *Sitophilus zeamais* by Pieterse and Schulten[4]. Due to reports on lindane resistance, considerable research has been initiated to find out suitable replacements. Iodofenphos, Gardona, fenitrothion, pirimiphosmethyl, phoxim and bromophos are being tested at several field stations in the tropics. These compounds have created lots of interest, but further assessments are necessary for conclusive results.

POST HARVEST INFESTATION AND INTERVENTION: Farmers Level - The process of infestation of stored grain and more so the multiplication of pests continues during processing, transportation and storage. The dirty, infested crib is one of the greatest sources of infestation before and after harvest. Grain is stored by a farmer in the tropics only from one season to another. A subsistence farmer has a traditional type of storage structure that has hardly undergone any change through several years. The common storage structures include an open type without any cover and various permanent to semipermanent covered structures. Unhusked maize cobs, panicles of rice and millet are hung in bundles or stored on vertical racks near the farmer's house which is often in the vicinity of the farm. This method is still practiced in parts of Africa and Indonesia. Covered structures vary a great deal due to climatic factors, time of harvest, availability of local raw material and type of grain. Length of storage required and local customs also influence the choice of storage methods. The different covered structures commonly found are covered by thatched roof, from grass or any locally available plant material. These are constructed on different heights of platform. Mud structures either above or below ground level, large grass baskets, storage bins made of plant material and cribs are also used. Different existing storage structures have been described elsewhere in detail by Dela-sus and Pointel[3], Hall[5] and Ashman[6]. There has been little improvement over the traditional structures by utilizing local raw material. An attempt was made in India by Pradhan, Mookherjee and Sharma[7] to obtain safe storage of dry wheat (7.5 percent moisture content) for a period of over 16 months by constructing a mud bin that incorporated a polythene film in the wall called a Pusa bin. An improvement in this type of structure, the Pantnagar Kuthla, has been introduced by Khare [1]. Steel bins have also been introduced in India but they are expensive and have problems of heating if not located under shade. Wheatley[8] described the new types of containers now available to farmers in Africa, which are being adopted by some farmers. They are modified, corrugated, galvanized iron water tanks, metal oil drums and polythene sacks. Caswell[9] improved polythene sack storage for cowpeas by providing a cotton cloth sack inside the polythene sack. These improved structures are gradually being introduced by progressive farmers.

Bindra et al[10] developed a simple grain treating machine that could be conveniently fabricated at a low price with locally available material and advocated mixing of malathion with wheat in India for control of *Sitophilus* spp., *Rhizopertha dominica* and *Trogoderma granarium*. Mookherji et al[11] observed that malathion dust at 16 ppm sufficiently protected the wheat grain up to a period of 4 months against *Tribolium castaneum*. Srivastava and Dadhick[12] reported malathion as a good protectant against *Callosobruchus* spp. in grain for a long period. In Africa malathion is most commonly mixed with grains at 4 oz of 1.0 percent a.i./200 lbs grain (Wheatley[8]). There are a variety of insecticides that can be used but malathion is considered both cheap and safe. The recommendation of malathion as an admixture may also avoid mixing of dangerous insecticides in food grain, which is common in developing countries at the small traders level. However, resistance to malathion of certain stored grain pests has been reported. It is not clear from these reports if malathion resistant strains have developed in the tropics at the farmer storage level or if it is due to the unstable malathion formulations marketed by local companies as reported by Wheatley [8].

Delassus and Pointel[6] developed a simple and effective technique for storing cowpeas in African countries. This method involves treating about 50 kg cowpeas in a 3-mil polythene bag with an 18 g carbon tetrachloride capsule. They reported effective control of cowpea pests for a long period. Ethylene dibromide capsules containing 5 cm^3 of the fumigant in liquid form have been advocated for treatment of 100 kg of maize in special jute bags having polythene liner in Ghana[13]. In recent years, phosphine tablets are becoming more popular due to high efficacy against stored grain pests. The major disadvantage for recommendation to a subsistence farmer is that it has high mammalian toxicity and the pellets or tablets are still not available in smaller individual packets for the use at this level. Benazet [14] found that 2 pellets (i.e. 0.4 gr. of phosphine) gave excellent control of maize insects in a hermetically sealed drum containing 65 kg of maize. Cornes et al[15] observed Phostoxin^R at a dosage of 2 pellets per bag gave good control of *S. zeamais* and *T. castaneum* and penetration of phosphine was much superior to that of ethylene dibromide treatment.

Large Scale Storage - Large scale storage by traders, cooperatives and governments, for different quantities and lengths of time varies greatly and depends on a number of factors. Traders and cooperatives may store grain for a short time. Government storage may last for more than a year as a strategic reserve against crop failures. Storage with traders is generally better than with the farmers. Silos, metal cylinders, bags or bulk storage is common. Government warehouses are found in most countries in large towns and at ports. Reasonably good buildings have been constructed to suit the climate and quantity of grain to be stored for the length of time. Protection of grain at the large-scale storage level has undergone considerable change and is not entirely unsatisfactory. This has been due to the influence of pesticide industries and national and international organizations. Grain is stored on a large scale either in bags stacked one on top of another or in bulk storage. The different contact insecticides and fumigants used in the tropics are lindane, malathion, pyrethrum, methyl bromide, Phostoxin^R and ethylene dibromide. Empty warehouses are cleaned before new stocks are brought in and treated with lindane or malathion. The dispensable powder formulations give results superior to emulsifiable concentrates. Usually malathion or lindane are applied at the rate of 1 gr. a.i. per m^2 in 50 ml. of water. Incorporation of pyrethrum has given superior control. Lindane or DDT smokes are also used but they are less effective. Pyrethrin or dichlorvos fogging is effective especially for moth pests but needs careful handling.

Grain bags in large scale storage are treated by several different methods. If the storage structure is not well protected, application of lindane or malathion is made at each layer of bags during construction of a bag stack. The insecticides commonly recommended are 2 percent malathion dust or 0.5 percent lindane dust. One of the most popular methods of treating the bags is by spraying wettable powder formulations to the four sides and the top surface of a bag stack. An automatic dichlorvos sprayer developed by Ashman[16] has also been introduced both in bulk and bag stack storage. It has been found especially effective against storage moths.

Extensive research on grain storage protection in the tropics both at the farmers level and large scale storage level is being conducted at several national and international research laboratories. In India at least two institutes, Indian Grain Storage Institute at Hapur and Central Food Technological Research Institute at Mysore are actively persuading research on storage. In West Africa, the Nigerian Stored Products Research Institute at Ibadan, Nigeria and the Crops Research Institute in Accra, Ghana and in East Africa, at Nairobi, Malawi and Zambia, research units on grain storage are active under the agriculture ministries. The Tropical Products Institute in London, has conducted extensive research through the Tropical Stored Products Centre (Slough) in many parts of Africa and have made concrete recommendations and helped many countries to establish grain storage research laboratories. The Institut de Recherches Agronomiques Tropicales et des Cultures Vivrietes (IRAT), Paris, working closely with various African countries - Cameroun, Dahomey, Upper Volta, Niger, Senegal and Togo - has recommended improved methods of protecting harvested crops in rural environment with the aim to improve and modernize storage in the traditional African environment. A FAO scheme to study and improve African Rural Storage with its center at the International Institute of Tropical Agriculture, Ibadan, Nigeria was established in 1973. Through this study improvement in rural storage structures and evaluation of readily available insecticide and fumigants is conducted.

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