Review Article مراجعة علمية

The State of Post-Harvest Problems and Stored Products Pest Control at Farmer and Central Level: Identification and Approach for Problem Solving

Laborius, G.A. and R. Harnisch

Deutsche Gesellschaft fur Technische Zusammenarbeit (GTZ),

Eschborn, F.R.G.

Abstract

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Storing food grain is one approach of solving world nutritional problems. This paper discuss storage constraints of food grains, and analyses storage systems which facilitates the identification of specific problems. Issues such as lack of information on proper storage conditions, how to protect stored grains, methods of estimating losses, sanitation and management of stores, and recommended pesticides were discussed. Special attention was given to pest control as a component of the integrated storage system. The need for better pest control methods, more coordinated research and improved extension services to improve the understanding control of stored grains pests were also stressed.

1. Introduction

Increased agricultural production for the national food supply is the priority of government planning. Surprisingly, there seems to be a lack of awareness that it is often more economic to conserve what has been produced than to increase production in order to compensate for losses. The relationship between the imput in form of appropriate storage systems and the output in form of indirect production increase is often not recognized.

Due to the relative lack of experience and the delayed political interest many countries are only now beginning to notice the clear need for developing an interdisciplinary post-harvest system approach to join in an examination of the situation.

Ryland (1986) has discussed the interdependencies among storage, drying, transport and marketing activities in the post-harvest sector and has highlighted the need to be analysed simultaneously in order to provide sufficient incentives and impact for the formulation of a national post-harvest policy.

Post-harvest Loss Assessment

No one knows precisely how much food is lost. An early review by Adams (1977) of the available information on post-harvest losses showed that many of the data on the extent and types of losses were not meaningful and appear rather speculative.

Experts figure the losses in tropical areas anywhere from 5 to 30% for cereal grains whereby losses on a commercial level are generally seen as more crucial than on farm level.

There has been considerable activity in post-harvest loss assessment in the last 10 years. In order to improve and standardise the methodology for loss assessments, Harris and Lindblad (1978) published a manual where both techniques for the measurement of grain losses during threshing, drying, storage and milling and the causes including insects, molds and rodents were presented.

Recently Boxall (1986) has undertaken a critical review of the methodology for assessing farm level grain losses, stating that the methods are extremely variable from commodity to commodity and from country to country and that the methodology must be described for each situation to meet local constraints.

The objective is to measure the efficiency of a post-harvest system rather than weight losses alone.

For a rapid assessment of losses due to insect infestation the count and weigh method at present seems the easiest to undertake and appears to be the most appropriate (Pantenius, 1988).

Damage and Losses as Basis for Action

Lipton (1982) as well as Boxall and Gillet (1984) give examples showing that the opinion of high losses in on-farm storage systems in Asian countries is incorrect and losses between harvest and consumption are typically 5 - 8% of grain production and very rarely above 10 - 12%.

Similar figures were obtained from field studies during a 6 to 9 month storage period conducted in African countries (Lepigre and Pointel, 1975, Golob, 1981, Pantenius, 1987). However, there is a danger in underestimating the losses in the different parts (harvesting, threshing, drying, storing,

selling, processing) of the post-harvest system. The loss in each part may be relatively small and uneconomic to reduce. When combined they will be more important and may result in a total loss of 15 - 20%. This is also the case when the introduction of high yield varieties have overtaxed the ability of traditional handling, drying and storage to cope with larger quantities and susceptibility of those varieties and oblige farmers to sell their produce early in order to minimize their storage problems.

On the basis of estimates that between 70 and 90% food grain in tropical areas is held at farm level, the benefit of loss prevention programmes seem to be greatest in this sector. However, in view of the difficulties in introducing improved storage practices at farm level it may perhaps be worthwhile to make more use of the available resources upon the commercial level, as results in this sector can be achieved more easily and quickly and because of the urgent need to pay greater attention to this high loss storage sector.

2. Analysis of the Post-harvest System

Harvest

In the period before the new crop, the stores are generally empty, particularly those small farmers operating on a subsistence level, so that pests are only able to feed on small amounts of remaining grain, or on waste of the previous harvest. Strict hygiene measures taken during this period are thus particularly effective in further reducing the already strongly decimated pest population.

Species which are able to fly, such as *Sitophilus* spp., *Sitotroga cerealella* and *Prostephanus truncatus,* settle in the grain ripening in the fields Schwettmann (1987) discovered in the Philippines that depending on climatic data and the corn growth, 6% - 93% of the cobs were already infected by *S. zeamais* in the field. Infestation commenced 4 - 5 weeks before the harvest and clearly increased as the grain ripened.

Drying

In traditional farming in Africa, the store is also designed to enable the stored produce to dry. This needs open storage systems which do not afford any protection against flying pests of rodents.

Sun drying is the most common method used by farmers in humid tropical regions. The crop is spread out on a smooth and clean surface and turned from time to time, thus enabling it to dry evenly and preventing it from becoming too hot. This system has had to be changed in areas where, for example, the cultivation of hybrid rice varieties allows several crops a year and where one crop is harvested during the rainy season. Under those conditions, drying is now performed by large mill plants or storage companies with mechanical drying systems at their disposal.

In arid regions moisture problems will occur under the following circumstances:

- Grain imported from moderate climatic zones with a moisture content of around 14% is in danger of being ruined if condensation takes place. Condensation is especially likely to occur in closed storage systems if the grain has a relatively high moisture content, if there are significant fluctuations between day and night-time temperatures and if the storage area is not aired. This is typically the case with grain stored in silo units.
- It is not uncommon for damage to occur from water in arid tropical regions as a result of insufficient protection from rain. Damaged rooves, inadequate drainage systems or unsatisfactory covering in open-air storage are commonly-found faults.

Marketing of Grain

In a large number of African countries, a clear lack of variety is to be seen in the marketing institutions. Apart from farm storage, there is usually only a single state organization responsible for the storage and marketing of grain in the larger towns and cities. There are generally no comparable private institutions. In addition, standards of quality for grain only exist in very few countries. Prices are fixed by the government. They are not determined on the basis of supply and demand, and only rarely do they take the production imput into account.

Shortage of competition, the lack of quality standards and fixed prices do not as a rule provide any incentive for an increase in production, or for more effective pest control as a result. They typically lead to an increase in the need for imported foodstuffs and the migration of the rural population to urban areas.

Providing support for agriculture in many tropical countries also means raising prices for basic food. An awareness for more effective pest control will also grow as a result.

Storage

The storage of grain by farmers. There are numerous types and forms of traditional stores designed to suit the climatic conditions, the available construction material and the duration of storage. A great number of these stores have been adapted over the centuries to follow the requirements and they correspond to the particular, technical and socioeconomic needs.

A rough distinction may be made between open and closed systems. Open systems are more commonly found in the humid tropical regions. They enable the grain to continue drying while in storage. Closed systems are more prevalent in the arid zones. All types offer either no or only partial protection against infestation with insects or rodents. Freedom from infestation is only possible in very well closed storage bins as eg. oil barrels. The reduction in the oxygen content and the rise in the carbon- dioxide content leads to the destruction of living insects. It is however, important that the barrels are not subjected to any fluctuations in temperature in order to prevent condensation.

Insecticides are not generally used in traditional storage systems. Farmers accept losses as coming from the hand of fate. A certain change of attitude is now able to be observed in the regions in Africa which have become infested with *Prostephanus truncatus*, a pest coming from Central America and new to Africa. The losses to corn caused by this beetle

are so high (up to 50%) that the farmers are forced to take action. Effective use of insecticides is, however, only possible here if a change is made from the traditional method of storing cobs to storing loose corn. Improvements in farm storage are generally only effective by means of well-adapted, non- sophisticated innovations which improve the traditional system step by step.

Warehouse storage. In keeping with the percentage of the population living in the agricultural sector, 70 - 90% of the total amount of grain in most tropical countries is stored by the farmers (Cook, 1988). The remainder is generally divided up between large-scale state storage and the ususally very rudimentary private grain trade. The prevalent large-scale storage systems in tropical countries are:

- bag storage in warehouse;
- bulk storage in silos;
- open-air storage of bags under trapaulins.

As mentioned earlier losses in large-scale stores are generally greater than those in farm stores. There are various reasons for this. In a number of cases, The construction of the warehouses is unsuitable for safe storage of grain. Typical, commonly- found faults are:

- either no or only inadequate airing facilities
- faults in the drainage system.
- too many corners or angles in the warehouses.
- inadequate protection against insects or rodents entering the store.
- rough, cracked walls and floors.
- insufficient storage capacity.

Also noticeable are:

- shortcomings in the necessary storage hygiene in the stores themselves and their surroundings.
- poor storage technology, such as stacking bags against walls or directly on the floor without any pallets being used.
- either no or only inadequate pest control.
- poor management.

Silo storage. In cases where quick intake or rapid turnover of large amounts of loose grain are necessary, such as in ports, the use of silos is justified. This type of storage involves high construction and running costs which are only warranted by regular turnover. In countries with silo storage, the bulk handling chain should stretch to the final consumer or the processing company. Changing from bags to bulk storage and then back to bags is not practical and leads to increased losses (Bramall, 1987).

Long-term storage in silos repeatedly leads to moisture damage as a result of condensation, and to moldiness. A ventilation unit is absolutely necessary in such circumstances.

Storage in bags is preferable to silo storage in most tropical regions for the reasons stated.

Open-air storage. In countries with insufficient storage capacity open-air storage is practiced. This is the worst form of grain storage and should only be tolerated in cases of emergency for short periods. Damaged covering and generally high rodent attack leads to massive losses. Insect control is exceptionally difficult. Fumigation is of little effect when the bags are stacked on permeable, unsealed ground.

Pest Management

For the control of stored products pests, suitably adapted storage structures, storage hygiene and storage technology are basic prerequisites, all of which are in need of considerable improvement. The same applies to active control using insecticides and fumigants. In order to prevent any danger to humans, animals or to the environment, careful selection and licensing of the products used is necessary. The index issued by the FAO /WHO provides good guidelines. If the recommended dosages and the relevant application techniques are adhered to, the admissible residue levels should not be exceeded.

The selection of the active ingredients should be based on the spectrum of the existing pests, whereby the most important species in economical and quantitative terms should be decisive in making the decision.

Particularly in African countries there is often no guarantee that the best possible active ingredient will be available.

Additionally products are often out of date and thus less effective. Having once applied an insecticide of this kind with little success, it will be difficult to convince in subsequent years of the sense of taking any further control measures.

In recent years, the resistance of pests to all kinds of active ingredients has increased in importance (Champ and Dyte, 1976). This particularly affects the commonly- used Malathion and in some cases Pirimiphos- methyl (Sayaboc and Amoranto, 1986).

The occurrence of pest species which are resistant to phosphine, the most important fumigant world-wide, is a source of increasing worry (Taylor and Halliday, 1986), as there are no alternative products available.

Attention was again drawn to the importance of an effective quarantine service in connection with the introduction of the pest *Prostephanus truncatus* into Africa. Countries which are threatened and which no possibilities for quarantine inspections of imports to date have thus imposed a ban on importing corn from infested countries, which has led to considerable drawbacks in free world trade (Lugg and Ndibalema, 1988).

3. Objectives, Approaches to Solutions

Management, Storage Technology and Storage Hygiene

The key of improving post harvest control lies in acknowledging the present realities and in passing on knowledge through training and extension.

Before accepting grain, the following fundamental criteria should be checked:

- moisture content
- purity
- pest infestation
- quality control and grading.

If the goods are accepted, drying, cleaning or pest control must be carried out in accordance with the condition estab-

lished. Only then should the grain be taken into the cleaned store. Regular cleaning of the storage space and surroundings are essential prerequisites for freedom from any pests. There is no such thing as too much storage hygiene. Regular controls, made at daily, weekly or monthly intervals, and records kept of them ensure that any changes in the warehouse are registered immediately. Measures should then be taken directly to deal with any negative developments and a record kept of them. Job descriptions should be drawn up to clearly define the specific tasks of each individual member of staff, thus making areas of responsibility clear.

As losses increase both in terms of quantity and quality with the duration of storage, the mangement must ensure that regular rotation of stock takes place.

The«first-in, first-out» rule should be used as a basis for this. The monthly report is intended as a means of self-control and by way of information for the storage company.

Pest control

Alongside numerous traditional methods on the farm level, the most important direct means of pest control is the use of insecticides and fumigants.

The traditional insect control is based on methods of avoiding infestation removing infested lots or the pests themselves. The destruction of pests by means of chemicals is not really wide-spread. Methods which are relatively successful are:

- cleaning and smoking out the bin before storage.
- use of heat and light (effect of the sun) to drive pests away.
- cleaning the commodities by winnowing, sieving or picking out, e.g. infested corn cobs.
- application of a controlled atmosphere, e.g. in barrels or underground storage.
- use of ashes for small storage amounts, e.g. seeds
- use of vegetable oils for storage of pulses, e.g. neem oil (5 ml /kg cowpeas).

Care should be taken when using insecticides that only active ingredients and formulations approved by the FAP /WHO or the responsible national authority are used in pest control. A large number of criteria are of importance in selecting the correct substance. Only a few of them are listed here:

- toxicity to warm-blooded animals.
- desired duration of effect (persistence).
- composition of the spectrum of pests being dealt with.
- temperature and moisture conditions.
- direct treatment of the stored products or surface treatment of the storage space and the stacks of bags.

Only insecticides from the pyrethroid group, for example, have proved themselves to be of value in controlling pests of the family of Bostrichidae (e.g. *Rhizopertha dominica, Prostephanus truncatus)* (Bengston et al., 1975; Desmarchelier, 1977; Laborius et al., 1979; Wohlgemuth et al., 1987). They are, however, less effective in use against other storage pest species. The effect of organophosphorous compounds is just the opposite.

It is important that the active ingredients are regularly changed and that the technical application of the prescribed dosages is correctly performed in order to prevent the pests from forming any resistance.

The following requirements are important for use by farmers:

- small package sizes.
- availability at the right places and at the right time.
- shelf life is not exceeded.
- appropriate formulations.

The application of fumigants, in particular phosphine, is only recommended in large-scale sotrage by trained staff. The use of gas is the only possibility when dealing with insect infestation inside the kernel and in large bag stacks. It should be applied under gas-tight covers or foils. The greatest current problem is hermetically sealing of the stored goods. Widescale training is necessary here.

The fumigation of entire stores is only possible in exceptional cases.

Applied Research

The application of the known techniques is of importance for general practice. Research should be practice-related in order to be able to provide simple suggestions for solutions in line with the current state of development in tropical countries.

Complicated procedures hardly have any chance of being used in the long term. Special emphasis should be placed on the development of pest management strategies. This also includes further instructional work on all biological facts about kinds of pests and their overall ecological relevance.

Training and Extension

The emphasis on the application of present knowledge also includes the demand for more intensive training and extension. This should be conducted especially by means of practice-oriented seminars and workshops and be combined with the provision of easily-comprehensible documentation, with contents adapted to suit the relevant target group.

A constant exchange of information between farmers and extension workers and between extension workers and researchers is necessary for the development of such adapted technologies as are required.

Evaluation and Follow-Up

Post harvest control programmes require repeated evaluation once they have been introduced. Only in this way it is possible to make further progress and clearly establish any possible reasons for rejection by practicians. This affords the possibility of making specific corrections before the procedural knowledge is lost entirely.

This procedure naturally also includes follow-up with the extension workers and supplying them with revised information material. Evaluation and follow-up are intended as a means of guaranteeing the success of the programme and preventing the target group from returing to the old inadequate procedures as a result of any slight shortcomings in the system.

4. Plan for Action

To launch a national grain-saving programme requires an analysis of the present system indicating weakness and strengths of each segment from harvest to marketing. Loss assessment studies-as we have seen-allow the diagnosis of the problems and constraints of post-harvest loss reduction in order to detect the «best-solution» components from a range of alternatives.

Strategies

In discussing strategies for advances in post-development one must remember that food losses are related as much to social as to physical and biological factors. Any strategy to be applied has to consider how to make the people concerned aware of post-harvest problems so that they realize the urgent need for food handling and storage measures. Additionally the strategy must provide the necessary stimulation and incentives with which farmers and storekeepers can understand the relationship between the imput of appropriate storage methods and the output of more grain.

Implementation of the Post-harvest Programme

Many countries are only now beginning to realize the need for developing a system approach to grain storage and handling, to marketing, research and to extension and training in order to run nationwide post-harvest programmes.

Little general information about storage combined with the lack of awareness about post-harvest problems has led to a critical shortage of qualified personnel. Additionally many government organizations and institutions fail to develop programmes that address food losses. This should be overcome through training programmes for extension workers and administrative personnel where the accent has to be placed on practical aspects.

Compounding such shortage of staff are poor cooperation and co-ordination between the rural and government sector. Because of the complex interrelationships between farmer, extension agent, researcher, trader and marketing board the importance of co-operative planning within the post-harvest system must be stressed. That implies that all parts must be related to each other and that the incorporation of a national storage programme must involve representations from all parts.

There is a need to generate more information about the different operations within the system. Governments have the obligation to develop, design and promote appropriate extension methods for post-harvest knowledge transfer which can encourage the target groups in adopting improved practices. Extension workers should be able to establish and communicate post-harvest training programmes, teaching farmers in sound storage methods and demonstrating their use.

Whenever recommendations are given they must be economically justified as farmers will only accept them when benefits are clearly visible.

The lack of financial incentives through grades and standards have suppressed any attempts to induce the utilization of appropriate storage and pest control techniques.

There is some evidence that farmers «sell» their storage problems to the commercial or government sector, often because marketing regulations and price incentives do not reward careful grain storage. Unless premiums are given for higher quality as well as demonstrating the cost-effectiveness of appropriate storage practices any real improvement in the conservation of stored commodities will not meet with any great success.

Insignificant attention has been given to research into improving existing post-harvest systems. Research is one starting point to show possibilities and to set priorities for change in storage practices. Action-oriented research to ensure that innovations are technically sound as well as socially acceptable and economically justifiable is seen as essential.

Monitoring and evaluation is an important ingredient of every part of the implementation process. Evaluation is the feed-back system that enables corrections or adjustments to be made. Particular attention should be given to the process of «follow up» as many examples have shown that a lack of assistance after the implementation phase is a crucial point and often responsible for programme failure.

Priority for Action

According to these recommendations an institutional framework needs to be built up which indentifies the nature and magnitude of the storage problems and investigates ways and means to develop, test and implement the most appropriate post-harvest technology to produce the best possible results. This post-harvest protection body should additionally provide decision-makers with realistic options, so that national storage programmes can be designed.

In conclusion it would be appropriate to mention that politicians and decision-makers must give the post-harvest sector the attention and importance it deserves.

الملخص

لابوريوس، ج. آ. ور. هارنش. 1989. الحالة الراهنة لمشكلات التخزين ومكافحة آفات المواد المخزونة على مستوى المزارع ومستوى التخزين المركزي: تعريف بالمشكلة ومحاولة إيجاد حلول لها. مجلة وقاية النبات العربية 7: 184 - 189.

ينظر إلى تخزين المواد الغذائية على أنه أحد السبل الرئيسة لحل مشكلات العالم الغذائية. ويستعرض الباحثان معوقات التخزين الأمين للحبوب. وأجريا تحليلاً لنظام التخزين يمكّن من التعرف على أهم المشكلات الخاصة به. ومن المشكلات التي تناقشها المقالة، تلك المتعلقة بجهل أوضاع التخزين والافتقار إلى تقنيات وخطط مناسبة لوقاية المواد المخزونة،

وإلى طرائق تقدير الخسائر، ونظافة المخازن وإداراتها، ولمبيدات الآفات التي يوصى باستخدامها. كما ركزا على وقاية النبات كجزء متكامل لنظام التخزين. وأظهرا مقدار الحاجة إلى طرائق مكافحة أكثر، وإلى مزيد من الجهد لتنسيق البحوث وزيادة فعالية أجهزة الارشاد كي تصبح ركائز يستند عليها في نقل المعرفة وتفهم المشكلات وحلها بشكل أفضل.

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