STORED-PRODUCTS PROTECTION IN WARM CLIMATES

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Abstract

An introduction is given on the topics to be discussed in the session: "Stored-Products Protection in Warm Climates." In addition the author has commented on this topic in general. It is questioned if the Working Conferences give enough attention to training, extension and regional/international cooperation in the field of post-harvest protection. The availability of pesticides and fumigation techniques is briefly reviewed. It is concluded that due to pesticide resistance, the number of available pesticides may be drastically reduced in the near future if no appropriate action is taken now.

With respect to natural or botanical pesticides, attention is drawn to the lack of data on their effectiveness in the real farmer situation. The problems in setting maximum residue limits for botanicals and insecticide mixtures are indicated. The need to implement the International Code of Conduct on the Distribution and Use of Pesticides is stressed. Integrated pest management is discussed within the context of bag storage and inherent susceptibility of grains to insect attack. Some views are given on the role of loss assessment in post-harvest protection. FAO's experiences in containing and controlling the Larger Grain Borer in Tanzania are discussed and a plea is made for regional cooperation in dealing with the problems created by this introduced pest.

Introduction

The objective of this Conference is to review the state of the art in storage technology for parts of the world. The information circular expressed the hope for a fruitful exchange between specialists from developed and developing countries. The Conference should also identify "constraints", and now follows my interpretation of the circular "for preventing or reducing losses in quantity and quality due to arthropod pests".

I believe we all agree that this is a very worthwhile but practically impossible task. Storage situations and related pest problems ranging from subsistence to large-scale storage, differ between commodities and the magnitude of the problem, and consequently the costs which can be incurred to prevent losses depend on the prevailing socio-economic situation of the owner of the produce and the final use of the produce. In addition, the susceptibility for insect attack depends on the condition of the commodity which itself changes or can be changed in the different components of the post-harvest system.

The conclusion of this Conference could be that for a better loss prevention and/or reduction in humid climates more effective control methods have to be developed to meet particular needs. There is no doubt that the available protection technology needs continuous improvement. The question should be raised however if lack of technology is the major constraint. I believe that lack of information at all levels on available technology and its proper use is, in large parts of the tropical world, the main cause of losses in quantity and quality. Insecticides and fumigants are more and more applied by persons who have not been trained in how to use them properly. This not only leads to inadequate protection and a waste of effort and resources but also endangers human and animal life and promotes the development of resistance to pesticides. The Working Conferences have given some attention to training and extension in post-harvest loss prevention and international cooperation in this field. It may be questioned if enough attention is given to these important aspects. The importance of regional cooperation, harmonization of regulations, standards and codes of practice to implement the research results have hardly been touched.

In introducing the session: "Stored Products Protection in Warm Climates", I will try to give my views on topics to be discussed as understood from the preliminary programme and within the limitations of a biologist. However, I will also give my views in general on this important topic.

Insecticides and fumigants

Man has always tried to protect his harvested produce against arthropod pests as is demonstrated by the many traditional storage practices and protection methods which are still in use throughout the tropical world. When new grain varieties were introduced, the quantities handled and stored increased, and grain marketing expanded and, consequently, there was a need for better protectants. These became available after the Second World War and are used on an ever-increasing scale in the tropics.

Hall (1970) compiled at that time available information on handling and storage of food grains. With respect to grain protectants, he mentions 7 insecticides - carbaryl, DDT, diazinon, dichlorvos, lindane, malathion and pyrethrins. Since then the experience on their use has increased enormously. Snelson (1987) was able to review extensive information of 22 grain protectants, a dozen of which are widely used in the tropics. Mixtures of grain protectants, in particular organophosphate/pyrethroid mixtures, are more and more used to control bostrychids and other storage pests. However, the increased availability and use has led to resistance development which is likely to cause a reduction of available grain protectants that can be used in the near future.

With respect to fumigants, the situation is rather critical. Bond (1969) gives treatment schedules for grain with 8 fumigants or fumigant mixtures. Of these, some have been banned in most countries and in practice only methyl bromide and, in particular, phosphine are used in the tropics. Resistance to phosphine is however spreading fast (Taylor 1986) due to improper fumigation practices (Friendship et al., 1986).

A global survey on pesticide resistance in stored product pests was conducted by Champ and Dyte (1976), showing the presence of resistance in a number of storage pests. Since then, relatively little additional information has been collected (c.f. Champ, 1986), especially in developing countries. For an effective use of the presently available pesticides and, if necessary, to develop pesticide resistance management strategies, pesticide resistance at national level should be monitored, but this is hardly ever done.

An obvious reason for this neglect is the lack of human and financial resources. On the other hand, it could well be that where post-harvest research is conducted, the priorities are not set correctly. Champ (1986) has made a strong plea for resistance monitoring which should be given serious consideration. The development of resistance under laboratory conditions in the Larger Grain Borer, Prostephanus truncatus, against permethrin as reported at this Conference stresses the need for field monitoring of resistance.

Because of resistance development, changing handling and storage practices, ever higher demands for quality produce and tighter residue restrictions, there is a need for new insecticides and fumigants. Much work in this field is being conducted (Shebal, 1980; Ripp et al., 1984; GASGA, 1986; Annis and van S. Graver, 1986; Snelson, 1987; Bengston, 1987). I hope that at this Conference a complete overview can be obtained on the ongoing activities and expected time frame when practical results can be expected. Of much importance is an early identification of the potential users of new products or technologies. It seems that new insecticides and the new fumigation technologies which are presently being developed will be used in the first place for large-scale storage, in particular in developed countries like Australia or certain Southeast Asian countries. It is time to ask ourselves if there is also a place for these new technologies in Africa, Latin America and the Near East and if so how to introduce them.

In most storage situations, however, the presently available pesticides and well established techniques have to be used as long as possible.

Research has been ongoing for many years in various countries on "traditional" or botanical insecticides and the results are interesting. Information on practical application however, insofar as available, is mostly anecdotical. Large-scale field demonstrations showing the effectiveness in a quantitative way of the botanicals versus non-treatment or synthetic insecticides apparently have not been done.

The main constraints in the use of synthetic insecticides, beside costs, are quality control, packaging, sales, distribution and extension in its proper use. This also applies for botanicals but this is never taken into consideration. There is an obvious need to have a closer look at field efficiency and practical application of botanicals. It is often assumed that insecticides of natural origin are safe and can be used in one form or another to protect grains without risks for the consumer. This however is not necessarily true. It is up to the individual countries to allow their use as grain protectants. To set international standards on acceptable maximum limits for "natural pesticide" residues in food or feed commodities, according to procedures followed by the Codex Alimentarius Commission, seems very remote. Rules presently in force require among other prerequisites that the pesticide is registered at least in one country and that ample toxicological information is provided including results of long term feeding studies. The crucial problem is who will provide for the funds to collect the necessary data.

In this context attention is drawn to a similar problem relating to insecticide mixtures. International standards on acceptable maximum residues for insecticide mixtures cannot be set because of lack of data. In countries where these mixtures are used, the maximum residue levels for the individual compounds have therefore to be used as a guideline.

Many developing countries do not have a well defined and effective pesticide registration process and a governmental infrastructure to enforce laws on pesticide control schemes. Therefore most pesticide-importing countries rely heavily on the pesticide industry to promote the safe and proper distribution and use of pesticides. In these circumstances, foreign manufacturers, exporters and importers, as well as local formulators, distributors, re-packers, administrators and users, must accept a share of the responsibility for safety and efficiency in distribution and use.

In order to promote the sharing of responsibilities between the parties involved and to address the need for a cooperative effort, FAO has prepared a Code of Conduct on the Distribution and Use of Pesticides. This "Code" was approved by all FAO Member Nations in 1985. The "Code" is supported by a number of internationally approved technical guidelines (testing and management of pesticides, health hazards, distribution and use, labelling, advertising, etc.). The "Code" is also supported by the International Group of National Associations of Manufacturers of Agrochemical Products (GIFAP).

To stress its importance, the following paragraph is included in all FAO project documents which relate to the protection of stored produce:

"Based on the Articles of the FAO International Code of Conduct on the Distribution and Use of Pesticides, unanimously approved by Member Countries, emphasis should be placed on the proper selection, handling, application and control of pesticides. By observing the Code it would be possible to minimize risks to human health and would also help to control pesticide residues in grains, vegetables and other food products, and reduce environmental contamination and other potential adverse effects of pesticides."

The implementation of the "Code" should and will have an impact on pesticide use for the protection of harvested produce.

Integrated Pest Management

Stored-product entomologists probably have always emphasized the need for a package of measures like drying, hygiene, warehouse management, spraying of the storage structure, spraying of the bags, fumigation, etc. Nowadays, however, a pest control based only on regular fumigations with phosphine is conducted in many tropical countries. If such fumigations are conducted in non-gas proof situations, resistance development is likely to occur.

In pre-harvest crop protection, integrated pest management is considered "the" strategy for pest control. The need for an integrated approach in post-harvest protection has been stressed by several authors (Adkisson 1983, Bengston 1986, 1988) and well defined strategies have been developed and are implemented for bulk storage in Australia and certain Southeast Asian countries.

However, in particular with respect to bag storage, the integrated approach seems in many countries to be more and more forgotten. Spraying of bags to prevent reinfestation after fumigation has become more the exception than the rule. Webley (1986) in a review on fabric spraying for pest control in grain storage concluded that total store fumigation with phosphine is probably the most attractive of all options, in particular with respect to bulk storage. If this practice is also introduced for bag storage, he stresses the need for store design and sealing specifications. Most bag stores in the tropics are not built gas tight and cannot be sealed. There is an obvious need to assess the present status of integrated pest management in bag stores and to identify priorities for action. Due consideration however should also be given to the use of carbon dixoide and sealed storage to control pests in stored grain (cf. Annis and van S. Graver, 1986).

An example of an integrated approach for the protection of grains stored at farm level in Africa will be discussed at the end of this paper.

The development and introduction of varieties tolerant or resistant to pests and diseases is one of the cornerstones of integrated pest management. Also in post-harvest protection, due attention is given to host plant resistance (Dobie, 1987). However, the actual breeding for tolerance/resistance for better protection against storage pests has received little response from plant breeders and this is unlikely to change in the near future.

The collected information on susceptibility is however very valuable, but it may be asked how much use is made of it. Extension messages on storage protection mostly do not have specific recommendations for pest susceptible and tolerant varieties. It is therefore strongly recommended that more attention is given to the formulation of practical extension messages, making use of the availability of data on host plant susceptibility.

Loss assessment

In the seventies and early eighties, much attention has been given to the assessment of post-harvest losses in particular in rural storage situations. Existing methods were refined, new methods were developed, and experience gained with the various methodologies was reported and commented on (Harris and Lindblad, 1978; Boxall, 1986; Schulten, 1982, 1988). Information about post-harvest losses was and still is required in order firstly to provide a justification for intervention and the allocation of resources (staff, equipment, budget), secondly to continue to promote increased national and international awareness and, thirdly, as a basis for choosing which type of intervention is appropriate in a given situation. Implicit herein is the recognition that such data are necessary for determination of the cost-effectiveness of the loss reduction methods proposed. Several methodologies are now available for detailed loss assessment and each has built on biases and limitations which need to be considered in the light of local conditions and the nature of the intervention tested.

Experience with loss assessment methods has shown that the conduct of a statistically valid survey is, in general, too time consuming and too costly. This basic truth has to be understood also by economists and agricultural planners.

Post-harvest losses are location- and time-specific. There is a need for rapid appraisal techniques which can be derived from existing methodologies but improvements are certainly required. In comparative studies to assess progress in relation to an earlier established base line the error or bias will be similar in both cases, thus differences are likely to be valid although absolute figures may be slightly erroneous. Essential for better understanding of reported loss data and their correct use, is a detailed description on how the data were collected and interpreted. It should be kept in mind however that there are many other justifications for post-harvest interventions than directly observed qualitative or quantitative losses. When production practices change, forcibly post-production practices have to change also. Socio-economic changes such as a reduction of the timely availability of labour, the need to reduce the workload for women, etc. are also valid justifications for post-harvest interventions.

Training

A major constraint for effective and safe loss prevention is the lack of trained personnel. Therefore besides describing and discussing improved technologies, the Working Conferences need also give due attention to methodologies for transfer of technology and to results obtained using certain approaches.

Much training in stored product protection is provided throughout the world at national level and within the framework of technical cooperation. For example, FAO (1990a) lists 16 short courses for international participation which are largely devoted to pest control in stored produce. This represents 11% of the identified short courses in the field of plant protection. It seems that all training provided aims at increasing the technical knowledge of the participants. Apparently it is expected that the trainees themselves make use of their acquired skills or transmit them to others. However very little attention, if at all, is given to training in extension methodology and in the organization of extension campaigns for specific target groups like farmers, storekeepers, etc.

Essential for a successful training is the correct identification of the training needs. Data should be available on current practices for post-harvest protection and their effectiveness, but, as mentioned by Wright (1985), such information is difficult to find.

FAO, with funds provided by Japan has organized a training programme at Centreinar in Brazil for about 40 trainers from Latin America and Caribbean countries. The training not only focuses on post-harvest technology **per se** but also on how to plan and implement national training programmes. A second phase is foreseen envisaging the essential multiplier effect using the trainers trained in phase I to conduct a series of training courses in their home countries.

Regional/International Cooperation

Developing countries need to define their own technical requirements through applied and adaptive research. Due to financial constraints and insufficient human resources, most countries fall short in developing and adopting adequate post-harvest practices, including the protection of produce at standards required today. A system of inter-country cooperation and an intensive exchange of experiences would assist these countries in optimizing their resources, reduce duplication and make better use of their existing institutions and infrastructures. Such cooperation can be fostered by the creation of a network to ensure better utilization of existing national institutes. The Regional Network on Food Grain Post-Harvest Technology (REGNET) in Asia has demonstrated the need for and effectiveness of networking (Semple and Toet, 1988; FAO, 1990b).

Such a network approach would also be very useful in East and West Africa to deal with the post-harvest problems created by the accidental introduction of the Larger Grain Borer, *P. truncatus*.

Cooperation between developing and developed countries and international organizations is a must and should be strengthened.

Due to limitations in time it is not possible to discuss this important aspect in further detail. The seminars organized by the ASEAN Grains Post-Harvest Programme (AGPHP), the Australian Centre of International Agricultural Research (ACIAR) and Inter-Country Cooperation in Post-harvest Technology and Quality Control for Food Grains (RAS/86/189) should be mentioned. These seminars have laid a sound knowledge basis for post-harvest protection for the Asian region and created much motivation at national level for stored product protection.

The development of a code of practice for the safe and effective fumigation of grains which was developed for the Asean Region by the ASIAN Food Handling Bureau and ACIAR is a major contribution towards better pest control. Similar initiatives need to be developed for other regions.

Lack of information is one of the serious constraints for post-harvest protection. The organization by the Group for Assistance on Systems for Grains After-Harvest (GASGA) of a workshop on postharvest information management was timely and has contributed to a better understanding as to how the flow of information on post-harvest can be improved (Schenck-Hamlin, 1989).

The Larger Grain Borer, **P. truncatus** in Africa

Since 1981, the ability of the United Republic of Tanzania to achieve self-sufficiency in food production has been threatened by the storage insect pest P. truncatus, the Larger Grain Borer (LGB), which was accidentally introduced. The LGB is a primary pest of maize and dried cassava. Its original area of distribution was Meso-America. Maize is infested by the beetle before harvest after the crop has matured and during storage. Egg laying occurs mainly in the kernels of grain, and the larvae then feed on them. Dried cassava is infested in the store.

The country's environmental conditions and the general practice of storing maize on the cob with the sheathing leaves intact favour the development of the beetle within infested stores. Weight losses of stored maize have been recorded that are as much as five times higher than those usually found in the absence of the LGB.

From Tanzania the LGB has spread to Burundi and Kenya. Another infestation was found in Togo in 1984 from where it has spread to Ghana and Benin and recently to Guinea (Laborius, personal communication). Also in this area, maize is stored on the cob. Losses are similar to those found in Tanzania, but storage periods are shorter. For further information on the LGB problem in Africa and activities undertaken for its containment and control, see Schulten and Toet, 1988 and Herren and Markham, 1990.

Since 1984, FAO is assisting the Government of Tanzania with containment and control. The experiences obtained will be briefly discussed because they show clearly the complexity of post-harvest loss prevention programmes and underline the points raised earlier.

PHASE I: 1984-1987. An integrated approach was chosen and all efforts were directed towards field application. Farmers were recommended to dry the maize, to shell it and to mix it thoroughly with permethrin and at a later stage with a permethrin/pirimiphos methyl dust mixture (100 gm mixture of 0.3% permethrin and 1.6% pirimiphosmethyl per 90 kg of maize). The use of this mixture is necessary to achieve control of LGB and of other storage pests, in particular Sitophilus. The treated maize was to be stored in a slightly modified traditional store. Much emphasis was put on store hygiene, such as cleaning of stores, destruction of old crop residues, etc.

A distribution and selling system for insecticides was set up. Surveys were conducted to establish the distribution of LGB.

No movement of untreated maize was allowed. The Plant Protection Act was amended to enforce this regulation. Efforts were made to eradicate isolated outbreaks.

A massive training programme was launched to train produce inspectors and extension personnel in LGB control and containment techniques and in post-harvest protection in general.

Progress of the adoption of the new techniques was regularly monitored.

The results of the first phase can be summarized as follows:

- The Plant Protection Department was strengthened with vehicles, motorcycles and equipment;
- Produce inspectors and extension personnel were trained;
- Farmers were trained in LGB control;
- Approximately 410 tonnes of insecticide dust were distributed and sold;
- The Southern highlands, an important maize producing area, remained still largely free from LGB.

The cost of this phase was in the order of 1.8 million US$ which was covered by contributions from The Netherlands, Australia, Canada, FAO, EEC and the Government of Tanzania.

Constraints. The availability of the insecticide mixture in small units was a major constraint. Initially the insecticide was sold by personnel of the Ministry of Agriculture and Livestock Development. At the end of Phase I, it was expected that the cooperatives would sell the insecticide but this failed. Involvement of private enterprise in the distribution and sale was attempted but in vain.

The legislation ("all maize being moved has to be treated"), although admittedly being the appropriate strategy, was found difficult to implement. Main constraints were:

- shortage of insecticides;
- high costs to farmers and/or traders especially when large quantities of maize are involved;
- reluctance by farmers and traders to comply with the legislation when there is no obvious LGB infestation;
- difficulty to check compliance with the regulations nationwide due to lack of funds and trained manpower.

The limitations have become more acute in view of the increases in the amount of maize being produced in recent years for Tanzania as a whole.

Because of LGB, export of maize became a problem. Potential importing countries on the African continent could not be convinced that LGB in export maize could be effectively controlled by fumigation. Therefore large quantities of maize had to be stored which called for training of warehouse personnel.

Phase II: 1987 - 1991. This phase is essentially a continuation of Phase I but now many more trained and experienced national personnel are available.

The timely distribution of insecticides became however more and more difficult, and therefore the strategy of so-called "intensive campaigns" is more often followed. In such campaigns all farm stores in defined areas are sprayed by personnel of the Plant Protection Division, while the farmers shell the maize and mix the grains with the insecticide mixture. The advantage of this approach is that the overall population in a given area is lowered. Disadvantages are that many plant protection personnel are fully occupied in these campaigns, costs although small per farmer are rather high because of the large number of farmers, and the time needed to treat the whole country stretches over many years.

The effectiveness of intensive campaigns is presently being assessed and a better monitoring system for LGB presence has been developed. It seems that the spread of LGB is slower than expected. LGB is reported from less than 50% of the villages while the Southern Highlands are still largely free of LGB. This may be the result of the control and containment activities or due to some ecological factors which are presently unknown.

Research. The Tanzania/FAO LGB Programme is not involved in research, but in the implementation of known control and containment strategies. Much research on LGB has and is conducted by international organizations like the Natural Resources Institute (UK) and the Gesellschaft für technische Zusammenarbeit (FRG) which have collaborative programmes with other countries and home-based research. Based on the experiences in Tanzania, the following research priorities can be identified:

- Monitoring for resistance development;
- Evaluation of alternative insecticides in case of resistance development;
- Field evaluation of pheromone traps;
- Ecological studies on LGB, in particular its natural spread, development and breeding outside grain or cassava stores;
- In-field evaluation of effectiveness of biological control;
- Verification of effectiveness of phosphine fumigations, in particular at temperatures occurring in the highlands in the cold season;
- Development of protection methods for stored dry cassava.

International cooperation. Notwithstanding all efforts made to contain the LGB, experience in East and West Africa shows that it is gradually spreading. An enormous effort will be required to develop and implement control strategies for the many different storage systems in Africa. Problem-oriented research has to be conducted and duplication of efforts has to be prevented. There is already effective cooperation between affected countries and international research institutes. This needs to be maintained and further strengthened.

The presence of LGB in Tanzania has become a major obstacle for the export of surplus maize, because importing countries fear to become infested by LGB as well.

I am of the opinion that the disinfestation of LGB-infested maize creates no major problem as long as adequate fumigation practices are followed, and appropriate prophylactic measures are taken to prevent re-infestation before transport/shipment.

The technical capability of countries concerned in fumigation should be strengthened by training personnel and provision of equipment. This, however, is not enough to remove trade barriers because of LGB. Regional organizations such as the Inter-African Phytosanitary Council, the Economic Commission for Africa (ECA), the Preferential Trade Area (PTA) should play an active role in this respect. The development and adoption of a code of practice for fumigation of produce liable to infestation by LGB is considered an essential step in promoting the inter-African maize trade.

Concluding Remarks

To achieve sustainable pest control in hot climates, in particular developing countries, the main constraints are:

- Lack of trained manpower;
- Lack of information on available technologies;
- Lack of proper use of available technologies;
- Insufficient problem oriented research;

Solutions to alleviate identified constraints are:

- Strengthening of national structures (extension, training, research) working in the field of post harvest loss prevention;
- Better dissemination of available information on post-harvest loss prevention;
- Better identification at national level of priorities for action and allocation of resources;
- Intercountry/interregional cooperation;
- International cooperation.

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PROTECTION DES PRODUITS STOCKES DANS LES PAYS CHAUDS

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Résumé

Depuis le début des années 60, une attention toujours croissante a été apportée à la protection des grains, en particulier à ceux stockés dans les pays tropicaux et sub-tropicaux. Il existe actuellement une pléthore de parutions sur les nombreux aspects des différentes sortes de protections. En outre, le nombre de pesticides est en augmentation croissante et un personnel en nombre grandissant a été formé à leur utilisation courante.

Plusieurs projets sont, ou ont été, exécutés dans pratiquement tous les pays concernés, bénéficiant souvent d'une assistance bi ou multi-latérale.

Au cours de cette conférence de travail, nous devrions nous demander ce que nous avons bien pu accomplir avec nos recherches et nos projets. Utilisons-nous vraiment pleinement les connaissances acquises pour fabriquer plus et de meilleurs produits réservés à la consommation humaine et adaptés aux exigences du marché ? Les priorités que nous nous sommes imposées respectent-elles les buts assignés par les bailleurs de fonds, le personnel de recherche et d'exécution ? Quels efforts faisons-nous afin de promouvoir les échanges d'informations et éviter le double-emploi ? Avons-nous une idée claire des futurs besoins de la recherche, de la formation et de l'exécution ?

Les différentes questions mentionnées plus haut sont discutées dans cette présentation. Ces questions ainsi soulevées sont valables, en particulier pour l'Afrique, où l'introduction accidentelle du grand capucin du maïs exige une protection accrue des stocks de maïs et de cassave séchée. L'engagement de la FAO dans la lutte et l'élimination du grand capucin du maïs est également abordé.