A GENERAL SURVEY OF PHYSICAL MEANS FOR CONTROL OF STORAGE PESTS

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ABSTRACT: Physical means of storage pest control is the oldest method known and is still one of the most important. This survey deals with the following topics: Correct agronomic practices as related to storage; physical exclusion of pests; addition of chemically-inert solids; modification of the storage atmosphere; modification of moisture and temperature; physical impact such as turning and use of the Entoleter; radiation such as sound, visible light, UV, IR, radiofrequency and ionizing radiation; host-plant resistance; integration and interactions of physical control methods with other methods; and the future prospects for physical control.

Increased demands for hygienic food supplies have stimulated intensified searches for a variety of safe and effective pest control methods. The subject of "physical" or "non-chemical" control of stored product pests is a very old and broad one. My assignment is to give a broad overview of the subject. Several specific aspects have already been discussed in this Conference and the 295 selected literature references listed at the end of this paper should lead interested persons further into the specialized areas.

While storage insect control by physical means is an ancient art, modern-day knowledge of the factors affecting storage has made it possible to apply advanced technology. It is unfortunate, however, that only a small fraction of this knowledge and technology has been applied in a practical way. Much more can and should be done to profitably utilize this valuable basic information.

Let us now examine physical control methods within the following arbitrary groupings:

MANAGEMENT AND SANITATION
ECOLOGICAL CONTROL
BIOLOGICAL CONTROL
RADIATION
MECHANICAL FORCES, PHYSICAL BARRIERS AND INERT DUSTS
INTERACTIONS OF PHYSICAL CONTROL WITH INSECTICIDAL PROTECTANTS
LEGISLATIVE CONTROL, INFORMATION EXCHANGE AND TRAINING

In considering this matter, we should keep in mind that control is any form depends primarily upon making the environment <u>un</u>favorable for the development of pest species.

MANAGEMENT AND SANITATION: No other factors are more important than sound management and good housekeeping. The following list highlights some of the key points.

Follow optimum seeding, cultural and harvesting practices.

When possible, plant cultivars and varieties which are least susceptible to insect attack and which mature in a synchronized manner to minimize the period between initiation and ripening of seeds.

Control field pests, for example those which damage the husks of maize.

Keep fields free from weeds. Certain weeds attract stored grain insects. Weeds also contribute to high moisture levels in grain at harvest.

Thoroughly clean and spray storage structures before filling.

Store only in well-built weatherproof structures located as far as practical from the fields.

Store new grain separate from old grain and keep market grain and seeds well separated from livestock feeds.

Thoroughly clean used bags and baskets and kill insects which are hidden in seams and crevices with dry heat, boiling water or fumigants before reusing the containers.

Store only dry grain (unless specifically equipped for high-moisture grain storage).

Avoid mechanical damage to seeds when harvesting, threshing and handling grain.

Inspect stored products regularly so that treatments can be applied promptly when infestations are found.

Although these are simple-sounding, elementary statements, we research and development workers tend to become so engrossed in our sophisticated, modern approaches to grain storage that we often fail to give sufficient emphasis to these fundamentals.

ECOLOGICAL CONTROL: Since stored product insects have rather specific moisture and temperature requirements, these parameters can be profitably exploited for storage pest control. Modification of the storage atmosphere as a means of pest control is also well known. This may be done by using airtight storage containers which allow natural depletion of O_2 and accumulation of CO_2; by storage in a partial vacuum; by introduction of inert gases; or by forced aeration.

The physical integrity of individual kernels of grain is another important factor. Kernels with mechanically damaged seed coats or broken seeds are much more susceptible to attack by most storage insect pest species than are sound, whole seeds.

BIOLOGICAL CONTROL: Some important aspects of biological control of storage pests include host resistance, insect diseases, parasites and predators, insect pheromones and manipulation of insect genetics.

Among these factors, work done in regard to host resistance (or reduced susceptibility) has made the most significant contribution. Much more practical work needs to be done on the application of biological control in conjunction with other control methods for the management of storage pests.

RADIATION: This broad subject includes sound waves, light (ultraviolet, visible and infrared), radio-frequency and ionizing radiations. Although the literature is replete with reports of basic and academic studies, practical applications are not common. Perhaps the greatest progress in this area of work has been with X-rays for detection of hidden infestation and with gamma rays for destruction of pests. The use of ultra-violet light for detection and monitoring of insect populations in storage buildings is also noteworthy.

MECHANICAL FORCES, PHYSICAL BARRIERS AND INERT DUSTS: Sifting is a standard method of removing insects and their eggs from flour and for reducing the populations of free-living insects in whole grain. The utility of grain sifting is often of limited value, however, because it does not remove the hidden infestation (internal forms), and the adult insects removed from the grain are often allowed to go free and reinfest the stores.

On the other hand, it is well known that impact stresses such as occur in turning grain or in an entoleter machine are effective in controlling storage insects. Commercial storage and milling operators have made practical use of such phenomena for many years.

Physical exclusion of storage insects is also widely practiced by use of impenetrable bins or packages.

In small-scale storage, some subsistence farmers mix fine-seeded grain such as millet with larger-seeded sorghum or maize. This limits the intergranular space, making it difficult for insects to move into the grain bulk and thereby affords a degree of protection for the more susceptible larger seeds. Others put layers of fine sand, sawdust or ashes on top of threshed grain to discourage insects from entering grain stored in clay pots or dried-mud bins.

The practical use of so-called "inert" dusts such as those made from silica aerogels, diatomaceous earth, talc, dolomite, marble, lime, chalk and kaolin and of certain food additives such as tricalcium phosphate has been demonstrated. The utility of such duts is limited by high humidity and by possible adverse respiratory effects on persons and abrasive effects on machinery when exposed to the dustry atmosphere. Other problems include reductions in grain flow rates and in grain test weight (which is associated with commercial grading and market value).

INTERACTIONS OF PHYSICAL CONTROL WITH INSECTICIDAL PROTECTANTS: In this era of "integrated pest control" and "pest management," we would be remiss if we failed to consider the interrelationships among the physical and chemical means of storage insect control. The effects of moisture, temperature, substrate particle size, etc. on fumigation are well known and will not be discussed here. To illustrate the importance of this topic I have included a few literature references which deal with the effects of various environmental factors on the efficacy of residual insecticidal protectants and bin sprays.

It has been shown that certain construction materials such as new concrete promote rapid degradation of organophosphorus insecticides. The high enzyme content in the epidermis of newly-harvested grain has also been implicated in rapid breakdown of protectants. Grain moisture contents above 12% contribute to insecticide degradation and at the same time favor insect development. High temperatures may produce opposing effects on the action of protectants, viz. a positive effect by increasing movement and feeding of insects and increasing the inherent toxicological action of the pesticide and a negative effect by accelerating pesticide degradation.

Much more work needs to be done to identify and quantify the many interactions among the various methods of control so that their combined effects can be optimized.

LEGISLATIVE CONTROL, INFORMATION EXCHANGE AND TRAINING: To conclude this brief survey, I call attention to a topic which, if given proper consideration, can do a great deal to rescue stored food from destruction and contamination by pests and make it available for hungry people.

Legislative control is valuable, especially in the more highly-developed countries. Its usefulness is severely limited, however, in situations where literacy is low, where trained personnel are few, and where enforcement of sophisticated rules and regulations is nearly impossible. Information exchange and training are far more productive.

Technical information kept in files and known only to a few scientists is almost worthless unless it is put to practical use. We researchers must do a better job of communicating our basic knowledge to the extension workers, the grain dealers, the food processing people, the transportation industry and the farmers. We must also learn as much as possible from these people who work in the real world of storage pest problems. In this protein-hungry world, the training of storage technicians and agricultural students in the elements of correct grain storage should receive top priority.

Finally, a great amount of unapplied basic information on physical control of storage pests exists. Let's put it to work.

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