FUTURE NEEDS AND DEVELOPMENTS FOR CONTROL OF STORED PRODUCT INSECTS

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The impending shortage of food throughout the world has greatly increased the necessity for better methods of food storage and preservation. Although many new methods of handling and processing have been developed in recent years, greater improvements are still needed. Unfortunately the preservation of food during storage and processing is often given lower priority and less attention than is its production. In growing crops the farmer takes every precaution to assure maximum quality and yield and much research and development has been devoted to improvements in food production. However food products are often stored and shipped in facilities that allow considerable waste and it is not uncommon to see estimates for losses of food after harvest, particularly in the developing countries and in tropical climates, reach sizeable proportions. At a recent symposium in Ottawa a report on rice production from the Far East (Indochina, Indonesia, Thailand, the Philippines and West Malaysia) indicated that the wastage through processing and distribution amounted to 20-25 percent[1]. With the overall production of rice in this region amounting to 175 million metric tons the estimated loss would then be of the order of 35 - 45 million metric tons. Considering the great amount of research and development that has been done to increase crop production in recent years, e.g. the selection of disease resistant, high yielding varieties, the production and use of fertilizers and the development of effective pest control on crops it is incredible that the technology for storage and processing of food has not progressed to the point where high losses of the harvested product can be avoided. Since food after harvest has reached its maximum value in terms of expended human effort it seems quite evident that far more money and research should be directed towards efficient means for handling food after harvest and for prevention of destruction by insects and other pests.

The control of pests on stored food is dependent on a number of factors and perhaps the greatest need is for administrative systems that can coordinate the activities of all agencies concerned with food handling and preservation to prevent losses. Economic, engineering, biology, toxicology, nutrition and health sanitation are all directly related to food storage and processing and must be taken into account in designing any pest control program. Prevention of infestation is more logical and economical than is treatment after an infestation has occurred. In cases where infestation takes place in the field, fumigation or other

treatment may be necessary to prevent an infestation from developing. However, pesticides cannot be used as a substitute for good storage facilities and good housekeeping if effective and efficient control is expected. To solve pest control problems on stored products close liaison and cooperation should exist with all those involved with harvesting, storage, transportation, processing and distribution of food. In countries where harvested crops are stored on the farm the scientist and all others concerned with food preservation should ensure that the farmer is given essential information and assistance on storage methods. Losses at the farm level can be severe because of improper facilities for storage and lack of information on pest infestation. In other areas where food is handled and stored in large commercial facilities an effective system for supplying information is still needed. For example the manager who makes policy decisions should be aware of the biological aspects of pest infestation and control and he should take steps to avoid the problem with such pests. Many infestations could be prevented or reduced if matters regarding control were given high priority. Often in the past decisions have been based on immediate cost figures rather than on good sanitation practices and hence chronic infestations have persisted. Inadequate pest control measures will not only allow undesirable dispersal of insects to other places and commodities but may also hasten development of insecticide resistance.

Legislation which requires inspection of goods and facilities and treatment of infestations can serve as an effective method for controlling stored product insects. Many years ago the Canadian government instituted a program for inspection of empty cargo ships before loading with cargoes of food, to avoid the possibility of contamination from insects often found in the ships[2]. This program was eminently successful and subsequently the need for treatment of cargoes with pesticides declined accordingly. The development of organizations as the Australian Wheat Board and the Canadian Grain Commission to handle and market grain has allowed improvement of standards of sanitation to the point where grain free of living insects can be delivered to importers. Just recently the British Standards Institution[3] has outlined recommendations for freight containers to facilitate the prevention or control of pest infestation in the food commodities they carry. Although many governments and agencies have designed measures to reduce infestation and dispersal of insects there is a great need for universal regulations to prevent infestations from moving across the world. This need is more urgent when resistance to pesticides is occurring and unnecessary dispersal of resistant populations becomes a threat.

The architects and engineers who design and build storage and transportation facilities can make a great contribution to pest control by building equipment that will supply optimum conditions for food preservation. In the developing countries good storage facilities that can be easily made from local materials, along with adequate training programs in pest infestation control

are, perhaps, the most important requirements for food preservation. With intensive research, engineers and biologists, working together could develop facilities that would prevent high losses from insects and microorganisms. Even in more developed areas storage facilities could be considerably improved to avoid conditions conducive to pest development. Ledges and pockets where grain and debris can accumulate could be eliminated from structures and machinery handling food materials. In flour mills, for example, dust accumulating on high beams above eye level is often missed when the housekeeping program is inadequate and hence a chronic insect infestation may exist. Many potential conditions for insects could be obviated if close liaison existed amongst all concerned with the design, production and use of facilities.

The pesticide applicator is a key man in a food protection program when an infestation has developed and requires treatment. He should have some understanding of the biological system he is treating as well as knowing the properties of the pesticides and the best methods for using them most effectively. Liaison between the scientist and the pest control operator is promoted here in North America by pest control associations, by universities and by other agencies. All of these organizations do an admirable job in providing information but pesticide applicators continue to use pesticides somewhat haphazardly. They show little apparent concern for the toxicity of pesticides to themselves and many seem to have only a superficial knowledge of the underlying factors involved in control. Can we hope to overcome such complex problems as resistance if the man, applying the pesticide, has no real comprehension of the problem? It is up to us to improve our lines of communication so that essential information is passed on in a way that it is meaningful and convincing.

We must also communicate more effectively with the general public and convince the taxpayers that we are doing an effective job in controlling insects. The money for research and development comes from the public purse. At the present time the public is somewhat disenchanted with the scientist and research. Failure to communicate effectively and assure the public of our ability to improve methods of food preservation could cause funds for research to decline.

Although these aspects of food storage and preservation may seem remote to the subject of Pesticides, Toxicity and Insect Resistance there is a direct relationship. Many of the control problems we are concerned with are a direct result of decisions and practices of others in the industry; close cooperation with these people to understand their problems is essential. Considerable improvement in our ability to deal with pest infestations in the situations where they occur is also necessary. We must improve our standard of research and our ability to report the information we obtain. A survey of the literature on stored products suggests that, in general, some of our research has not always been of a high calibre; the depth and scope of the information produced has not been equal to the rates of publication. More care,

imagination and ingenuity in planning, conducting and subsequently in reporting research is required. Too often valuable research facilities and time have been used to do simple repetitive experiments that have yielded very little new or essential information, data have been collected and reported in ways that defy comparison with data from other laboratories and manuscripts have been submitted for publication in an unrefined state. We must be far more critical of our work so that the literature does not become encumbered with irrelevant or superficial information.

To develop the most effective means of controlling insects in stored food, research planners should make better use of the relevant information from other sciences. Even simple bioassay experiments are influenced by many complex factors; experimenters should be aware of these factors and take them into consideration in designing experiments and interpreting the results. For example the ordinary situation of applying a fumigant to control a population of insects involves an extensive and complex set of variable factors (Fig. 1). The scientist studying toxicity and designing control measures should be familiar with the factors involved in a treatment, take them into account in planning the experiment and where possible make use of current basic knowledge to understand and discuss the results obtained. Other fields of Science - Chemistry, Biochemistry, Pharmacology and Toxicology, Biophysics, etc.- as well as Biology have a great deal of information relevant to problems in pest control; this information should be utilized wherever possible to bring about a solution of problems concerning insect infestations.

A great deal more information on the properties and uses of existing pesticides is required for us to exploit them most effectively. While there is a pressing need for new pesticides to deal with some of our current control problems the possibilities of new compounds being discovered and developed are not great. We will likely have to rely on compounds already in use for most of our treatments. Straight forward analytical work on bioassay, methods of application, residues and phytotoxicity will always be in demand. In assessing toxicity we should determine the response of all stages of a pest, particularly the most tolerant to a pesticide. Often the most convenient state (usually adult or larva) is studied while other stages, which are less amenable to the methods used in experimentation but often are more tolerant to pesticides, are left untested. Information on the relationship of resistance to stage of development of the insect, rates of selection in different stages and the importance of delayed mortality, altered viability and longevity in control is badly needed.

In addition more basic information on the toxicology of pesticides, the response of the pest to treatment, persistence and degradation of pesticides and formation of residues is needed. We must know more about the materials we are using and the way pests respond to them so that the pesticide can be directed to the most vulnerable point of the organisms life cycle and biochemistry. Information on mode of action is required to understand and deal

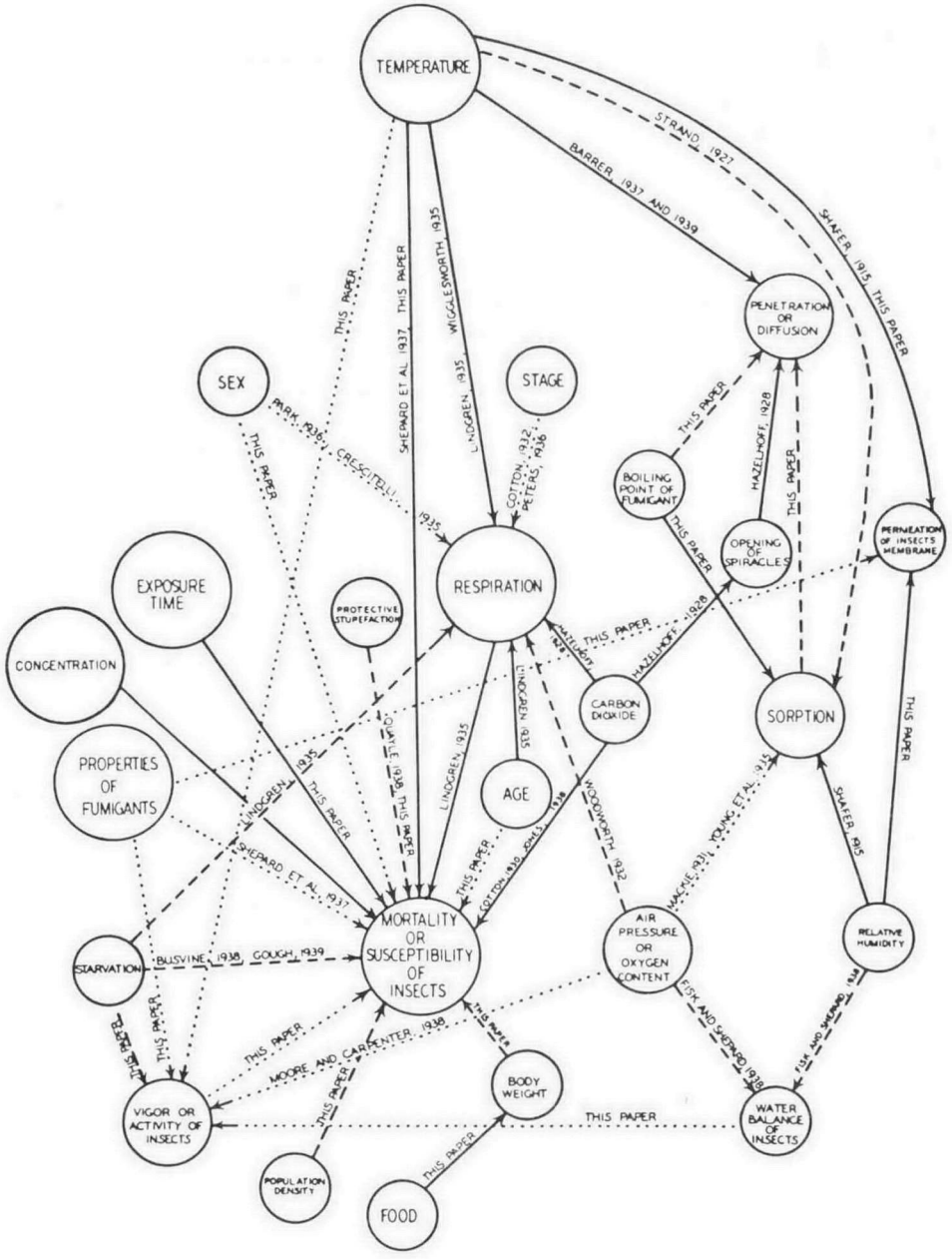

FIGURE 1. Relationship of various factors to the susceptibility of insects to fumigants [4].

with resistance to pesticides. Recently we have been studying the mode of action of the fumigant phosphine to try to understand how it exerts its toxic effects and why insects respond as they do. We have tried to identify the site of action and have studied the relationship of carbon dioxide to the toxic effect. Close examination of the respiratory chain revealed that cytochrome oxidase

was actively inhibited by phosphine and carbon dioxide appeared to enhance toxicity by interfering with phosphorylation. If we know how a pesticide exerts its effect we can take steps to provide optimum environmental conditions for maximum effectiveness. This is particularly true of pesticides used on stored products where the environment is largely man made and can often be closely controlled. With improved knowledge of pesticides and their action we will have a comprehension of the resistance mechanisms that will allow more effective counter action to reduce the problem. Pesticide resistance in stored product pests will continue to develop as long as we practice pest control by present methods. By close communication and coordination of our activities with all others concerned with food storage and preservation and by improving our standards for research and development considerable progress can be made to reduce problems of pest infestation and control.

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