THE UNIVERSITY OF MANITOBA

PERSISTENCE AND TRANSLOCATION OF ORGANOPHOSPHORUS INSECTICIDES ON STRUCTURAL SURFACES AND IN STORED GRAIN

BY

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ABSTRACT
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PERSISTENCE AND TRANSLOCATION OF ORGANOPHOSPHORUS INSECTICIDES ON STRUCTURAL SURFACES AND IN STORED GRAIN

Insecticides used to protect stored grain from insect infestation may be applied to the structural surfaces of granaries or to the grain itself. The degree of protection afforded by an insecticide depends on its rate of degradation or change after application. Various factors such as the type of formulation, type of substrate and conditions after treatment influence the behaviour and toxicity of insecticides. Laboratory and field studies were therefore conducted to investigate the effects of these factors on the persistence of malathion, bromophos, iodofenphos, and pirimiphos-methyl on structural surfaces and on stored grain using both chemical analysis with gas-liquid chromatography and bioassay.

Malathion, bromophos (EC and WP), and iodofenphos (EC) were applied as water-based solutions at 0.05 litre/m^2 to provide a deposit of 1.0g AI/m^2 on wood and concrete surfaces. Persistence was assessed in the laboratory at different times after treatment by bioassay and chemical assay of 30 g wheat, barley, and corn after the grains had been in contact for one week with the treated surfaces. The grains were bioassayed with susceptible *Cryptolestes ferrugineus* (Stephens) and *Tribolium castaneum* (Herbst) adults. Significantly higher ($P < 0.01$) mortalities of *C. ferrugineus* and *T. castaneum* were obtained on cereals in contact with treated wood surfaces than on cereals in contact with treated concrete surfaces. Malathion EC provided better control of the beetles on grains in contact with wood surfaces whilst bromophos formulations gave better control than malathion formulations or iodofenphos on grains in contact with concrete surfaces. Lower mortalities were obtained

on corn stored on treated structural surfaces than on wheat or barley. Reproduction of test beetles was significantly greater ($P < 0.01$) in grains previously stored on treated concrete surfaces than in grains stored on treated wood surfaces. Significantly more ($P < 0.01$) of each insecticide translocated into grain samples in contact with wood than with concrete surfaces. Smaller amounts of iodofenphos translocated into grain samples in contact with treated structural surfaces than malathion or bromophos. Lower amounts of insecticide residues were recovered from corn than from wheat or barley. Persistence of the insecticides on structural surfaces and their uptake into stored grains was found to decrease as the age of deposit increased.

The first field test was conducted with bromophos WP applied at 1.0g AI/m^2 to the concrete floor of a farm granary. Persistence and uptake of bromophos into wheat, enclosed by open-ends of plywood boxes on the treated floor, were determined by bioassay with *C. ferrugineus* and by chemical analysis of wheat samples. Complete mortality was obtained on the bottom 8.3-cm layers of grain in contact with the treated floor. Higher residues were also found in these layers. In the second field test, bromophos WP was applied at 1.0g AI/m^2 to the concrete floor and galvanized steel sides of a farm granary to determine the uptake of bromophos into wheat during seven months' storage of 1093 bushels of wheat in the treated granary. Bromophos residues of less than 1.0 ppm were detected in the peripheral layers of grain in contact with treated floor and walls.

Uptake of malathion and bromophos in wheat stored for one week on wood surfaces treated at 1.0g AI/m^2 was independent of wheat moisture content.

Studies of uptake of malathion by three layers of wheat in contact with wood surfaces treated at 1.0g AI/m^2 showed that the extent of progressive uptake of malathion past the bottom layer depended on the duration of storage.

The persistence of malathion, bromophos (EC and WP), and iodofenphos (EC) applied at 250 mg AI/m^2 to wood surfaces was enhanced by sweeping the surfaces one week after treatment. By contrast, treated surfaces that were abraded by the movement of wheat lost their effectiveness: after one day for iodofenphos, and after three weeks for malathion and bromophos.

Malathion, bromophos, iodofenphos, and pirimiphos-methyl in liquid formulations were applied to dry (12.0% mc) and tough (16.0% mc) wheat at initial doses equivalent to their tolerance levels and at 1.5 times these levels to examine the residual effects on susceptible and malathion-resistant strains of *T. castaneum* on 50 g wheat at certain intervals after treatment. Pirimiphos-methyl, at the dosages tested, was the most persistent and effective compound against both strains. Malathion at both dosages was ineffective against resistant *T. castaneum*. Pirimiphos-methyl at both rates prevented reproduction of both *T. castaneum* strains. Residue analysis of stored grain over a 24-week period revealed that pirimiphos-methyl was the most stable compound followed by bromophos, malathion, and iodofenphos. The bulk of insecticide residues in milled fractions of wheat were found in the bran and middlings, with very small amounts in the flour.

The residual effectiveness of bromophos and iodofenphos on structural surfaces and in stored grain coupled with their relatively short persistence and low mammalian toxicities demonstrate that these compounds are suitable alternatives to malathion for short-term protection of stored grain against insect infestations. Pirimiphos-methyl will be a very useful grain-protectant for long-term storage against susceptible and resistant strains of stored-grain insects.

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George Willie Ken Mensah

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CHAPTER I

INTRODUCTION

Insect pests have always demonstrated amazing plasticity in their abilities to overcome man's best efforts to control them. Thus, storage of grain and grain products always involves risk of infestation. It is therefore abundantly clear that continued research in insect pest control during storage of grain and grain products is essential to ensure abundant supplies of high quality food for the expanding populations of the world.

Protecting our cereal crops during storage on the farm and in warehouses is often more difficult than during the growing season. This is especially true where insect infestation starts in the field and continues throughout the duration of storage of both grain and grain products.

Among the numerous insect pests which cause losses and deterioration to stored food grains and cereal products are the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) and the red flour beetle, *Tribolium castaneum* (Herbst). These two species have been known in the Canadian grain industry as major biotic factors responsible for grain heating, spoilage, and grade losses (Sinha, 1971). These pest species can, if left unchecked, cause a substantial loss of food grains during storage.

Although thorough sanitation practices are the essential tools in maintaining quality and abundance of stored grain and grain products, prestorage treatment of granaries and food warehouses with contact insecticides is generally the most effective management method available to reduce insect populations to tolerable levels.

Malathion and pyrethrins are the major contact insecticides most widely used by the grain industry for the treatment of structural surfaces for the control of rusty grain beetle and red flour beetle infestations but information is also needed on other insecticides that may be more effective.

Scope and objectives of study

Treatments of structural surfaces with contact insecticides, in many instances, have been used effectively to confer long-term protection on insect-free commodities against infestation. Although persistent residues of contact insecticides on surfaces may be useful from the standpoint of insect pest control, tolerance levels established by international committees (FAO/WHO, 1967, 1968a,b, 1969a,b, 1973a,b, 1976a,b) and accepted by national regulatory agencies, e.g., Agriculture Canada (Anon., 1977), coupled with increasing consumer demands have necessitated determination of microquantities of residues of pesticides and their metabolites in stored products. Thus, the need for detailed checks on persistence of insecticide residues in stored products after treatment and, particularly, prior to consumption cannot be overstressed.

Various factors govern the persistence and biological effectiveness of stored product insecticides applied on granary surfaces and on stored grain. Under a wide range of environmental conditions in which the insecticide applications are made, the effects of grain moisture and temperature are well known, but other variable factors affecting persistence and effectiveness are not well understood. The objectives of the study were therefore to determine in the laboratory and during a limited field study:

(1) the persistence of malathion and bromophos both as emulsifiable concentrate (EC) and as wettable powder (WP) formulations, and iodofenphos as an EC applied to concrete and wood surfaces;

(2) the translocation of these insecticides into wheat, barley, and corn stored on treated concrete and wood surfaces;

(3) the effect of grain moisture content on uptake of malathion and bromophos residues from treated wood surfaces into wheat;

(4) the distribution of malathion residues in layers of grain kernels stored on treated wood surfaces;

(5) the effects of physical disruption on persistence of insecticide deposits on structural surfaces;

(6) the persistence of malathion, bromophos, iodofenphos, and pirimiphos-methyl residues in dry and tough stored wheat.

The above studies were done by both bioassay and chemical assay methods. The bioassay of cereal grains and structural surfaces was done with adults of the rusty grain beetle, *Cryptolestes ferrugineus* (Stephens) and the red flour beetle, *Tribolium castaneum* (Herbst) at different intervals after treatment. Chemical analysis using gas-liquid chromatography was carried out to supplement the bioassays, and to compare the residue levels with internationally approved tolerance limits.

The importance of study

Substantial quantities of food grains are often lost through damage caused by insect pests in the absence of efficient storage management systems. The increasing demand for food as a result of expanding human populations therefore underlines the need to conserve both the quality and quantity of food grains during storage.