CONTACT, RESIDUE, AND VAPOR TOXICITY OF NEW INSECTICIDES TO STORED-PRODUCT INSECTS. II.

Marketing Research Report No. 885

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PREFACE

The research described in this publication was done at the Stored-Product Insects Research and Development Laboratory at Savannah, Ga. This laboratory is a field station of the Stored-Product Insects Research Branch, Market Quality Research Division, Agricultural Research Service, U.S. Department of Agriculture. This research is part of a continuing program of basic evaluation of chemical compounds for their possible value as insecticides against stored-product insects. On the basis of information obtained from this program, new insecticidal chemicals can be selected for further evaluation in specific control programs under many other research projects of this Branch.

Marketing Research Report No. 546, published in 1962 under the same title as this one, reported results from the testing and evaluation of 22 chemical compounds in this program. This report presents the results of evaluation of 68 more compounds.

In this work the authors of this report were assisted by Margaret F. Secreast and W. E. Priddle, chemists at the Savannah laboratory, who conducted chemical analyses of malathion deposits for the tests of direct-contact and residue toxicity. Evelyn M. Osborne, Pesticide Chemicals Research Branch, Entomology Research Division, verified the nomenclature of the chemical compounds.

CONTENTS

This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

CAUTION: Pesticides can be injurious to humans, domestic animals, desirable plants, and fish or other wildlife—if they are not handled or applied properly. Use all pesticides selectively and carefully. Follow recommended practices for the disposal of surplus pesticides and pesticide containers.

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CONTACT, RESIDUE, AND VAPOR TOXICITY OF NEW INSECTICIDES TO STORED-PRODUCT INSECTS. II.

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SUMMARY

Sixty-eight candidate insecticides were evaluated for direct-contact, residue, and vapor toxicity to red flour beetle adults, *Tribolium castaneum* (Herbst), and black carpet beetle larvae, *Attagenus megatoma* (F.). Some of the most promising insecticides against both insect species were: Bay 34727, fenthion, Imidan, and Shell SD 4092 for direct-contact toxicity; Bay 29492, Bay 39193, and Shell SD 4092 for residue toxicity; and Bay 30911, Bay 34727, Bay 41831, Bay 42524, naled, Shell SD 6056, and Substanz #215 for vapor toxicity. In aging tests, the more persistently effective insecticide residues were Bay 29492, Ciodrin, fenthion, Imidan, Shell SD 4092, Shell SD 4457, Shell SD 5539, and Stauffer R–1571.

INTRODUCTION

In the search for more effective, safer, and less costly insecticides for protecting food, feed, seed, and other agricultural commodities against insect infestation, the Stored-Product Insects Research Branch of the Agricultural Research Service conducts a program of basic evaluation of insecticides to compare the effectiveness of new compounds against representative species of stored-product insects. This information is used in selection of new insecticide chemicals for further evaluation in the Branch's research on control of insects in specific commodities.

In these preliminary tests, red flour beetle adults, *Tribolium castaneum* (Herbst), and black carpet beetle larvae, *Attagenus megatoma* (F.), were used. These two species were selected because experience indicated that the flour beetle adults represent approximately the median of the range of susceptibility of stored-product insects to insecticides and the black carpet beetle larvae represent a high order of resistance. Both species are easy to handle under test conditions.

The 68 candidate insecticides evaluated in this report were the second group of materials evaluated in this program. Tests on the first group of 22 compounds were reported in MRR–546 in 1962.[1] The candidate insecticides tested since that time and their chemical names are given in table 1.

[1] SPEIRS, ROY D. CONTACT, RESIDUE, AND VAPOR TOXICITY OF NEW INSECTICIDES TO STORED-PRODUCT INSECTS. U.S. Dept. Agr. Market. Res. Rpt. 546. 31 pp. 1962.

TABLE 1.—*Designations of candidate insecticides and standards included in this report*

ENT No.[1]	Company or common name	Chemical name
25506	American Cyanamid 18706	Phosphorodithioic acid, *O,O*-dimethyl ester, *S*-ester with *N*-ethyl-2-mercaptoacetamide
24970	Bay 22408	Phosphorothioic acid, *O,O*-diethyl ester, *O*-ester with *N*-hydroxynapthalimide
25703	Bay 25316	Phosphorodithioic acid, *O,O*-dimethyl *S*-[(5-nitro-1*H*-indazol-1-yl) methyl] ester
25611	Bay 25660	Phosphorothioic acid, *O,O*-diethyl ester, *O*-ester with 3-(hydroxymethyl)-1,2,3-benzotriazin-4 (3*H*)-one
25596	Bay 26405	Phosphorodithioic acid, *S*-[2-[(*p*-chlorophenyl)thio] ethyl] *O,O*-dimethyl ester
25636	Bay 29492 (Bay 29492X)	Phosphorothioic acid, *O,O*-diethyl *O*-[4-(methylthio)-*m*-tolyl] ester
25635	Bay 30911	Phosphonothioic acid, methyl-,*O*-2,4-dichlorophenyl *O*-methyl ester
25677	Bay 33904	Phosphorodiamidic acid, *N,N'*-dimethyl-,4-(methylthio)-*m*-tolyl ester
25675	Bay 34727	Phosphorothioic acid, *O,O*-dimethyl ester, *O*-ester with *p*-hydroxybenzonitrile
25712	Bay 37289	Phosphonothioic acid, ethyl-, *O*-ethyl *O*-2,4,5-trichlorophenyl ester
25713	Bay 38156 (Stauffer N-2788)	Phosphonodithioic acid, ethyl-, *O*-ethyl *S*-*p*-tolyl ester
25714	Bay 38333	Phosphonothioic acid, methyl-, *O*-2, 4-dichlorophenyl *O*-ethyl ester
25701-X	Bay 38500	5(or 2)-Norbornene-2-methanol, 1,4,5,6,7,7-hexachloro-3-[(2-hydroxy-1-methylethoxy) methyl]- (chlorinated to contain 65% total chlorine)
25700-X	Bay 38920	6,9-Methano-3*H*-2,4-benzodioxepin, 6,7,8,9,10,10-hexachloro-1,5,5a,6,9, 9a-hexahydro-3-methyl- (chlorinated to contain 70% total chlorine)
25671	Bay 39007 (Baygon, Bay 9010)	Carbamic acid, methyl-, *o*-isopropoxyphenyl ester
25702	Bay 39193	Phosphonothioic acid, ethyl-, *O*-[2-(ethylthio)-6-methyl-4-pyrimidinyl] *O*-methyl ester
25670	Bay 39731	Carbamic acid, methyl-, *o*-cumenyl ester
25715	Bay 41831 (Sumithion, Folithion, American Cyanamid 47300, Fenitrothion)	Phosphorothioic acid, *O,O*-dimethyl *O*-4-nitro-*m* tolyl ester
25685	Bay 42524	Phosphorodithioic acid, *S*-*p*-chlorophenyl *O,O*-dimethyl ester
24482	Bidrin (Shell SD 3562)	Phosphoric acid, dimethyl ester, ester with 3-hydroxy-*N,N*-dimethyl-*cis*-crotonamide
20852	Butonate	Butyric acid, ester with *O,O*-dimethyl (2,2,2-trichloro-1-hydroxyethyl) phosphonate
24717	Ciodrin (Shell SD 4294)	Crotonic acid, 3-hydroxy-, *alpha*-methylbenzyl ester, dimethyl phosphate
19507	Diazinon	Phosphorothioic acid, *O,O*-diethyl *O*-(2-isopropyl-4-methyl-6-pyrimidinyl) ester
20738	Dichlorvos (DDVP; Vapona)	Phosphoric acid, 2,2-dichlorovinyl dimethyl ester
24650	Dimethoate (American Cyanamid 12880, Rogor, Cygon)	Phosphorodithioic acid, *O,O*-dimethyl ester, *S*-ester with 2-mercapto-*N*-methylacetamide
25704-X	Du Pont 691	Phosphorothioic acid, (chloromethyl)-,*O*-ethyl *O*-*p*-nitrophenyl ester (50% E. C.)
25540	Fenthion (Bay 29493, Baytex, Entex, Tiguvon, Lebaycid)	Phosphorothioic acid, *O,O*-dimethyl *O*-[4-(methylthio)-*m*-tolyl] ester
25558-X	Geigy 32465	4*H*-1,2,4-Triazole-3-thiol, 4-methyl-5-phenyl- (12.5% E. C.)

See footnote at end of table.

TABLE 1.—*Designations of candidate insecticides and standards included in this report*—Continued

ENT No.[1]	Company or common name	Chemical name
25584	Heptachlor epoxide (Velsicol 53–CS–17)	4,7-Methanoindan, 1,4,5,6,7,8,8-heptachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-
25705	Imidan (Stauffer R–1504, Prolate)	Phosphorodithioic acid, *O,O*-dimethyl ester, *S*-ester with *N*-(mercaptomethyl)-phthalimide
25545	Isobenzan (Telodrin, Shell SD 4402, Monsanto CP-14957)	4,7-Methanoisobenzofuran, 1,3,4,5,6,7,8,8-octachloro-1,3,3a,4,7,7a-hexahydro-
5	Lethane 60	Lauric acid, 2-thiocyanatoethyl ester
6	Lethane 384	Thiocyanic acid, 2-(2-butoxyethoxy)ethyl ester
	Lethane 384 special	Lethane 60 (40.6%) mixture with Lethane 384 (13.2%) as active ingredients
7796	Lindane	Cyclohexane, *gamma*-1,2,3,4,5,6-hexachloro-
17034	Malathion	Phosphorodithioic acid, S-[1,2-bis (ethoxycarbonyl) ethyl] *O,O*-dimethyl ester
7422	Maumee (no designation)	*m*-Toluidine, *alpha, alpha, alpha*-trifluoro-
13006	Maumee (no designation)	*m*-Acetotoluidide, *alpha, alpha, alpha*-trifluoro-
26181	Maumee (no designation)	Benzoic acid, *o*-mercapto-, methyl ester
26182	Maumee (no designation)	*o*-Toluidine, *alpha, alpha, alpha*-trifluoro-
26183	Maumee (no designation)	*m*-Toluidine, 6-chloro-*alpha, alpha, alpha*-trifluoro-
26184	Maumee (no designation)	Toluene, 4-chloro-*alpha, alpha, alpha*-trifluoro-3-nitro-
26185	Maumee (no designation)	*m*-Cresol, *alpha, alpha, alpha*-trifluoro-
26186	Maumee (no designation)	*p*-Toluidine, *alpha, alpha, alpha*-trifluoro-2-nitro-
26187	Maumee (no designation)	*m*-Acetotoluidide, *alpha, alpha, alpha*-trifluoro-4'-nitro-
26188	Maumee (no designation)	*m*-Toluidine, *alpha, alpha, alpha*-trifluoro-4-nitro-
26209	Maumee (no designation)	1,2,3-Benzotriazin-4(3*H*)-one, 3-butyl-
25599	Methyl Trithion	Phosphorodithioic acid, *S*-[[(*p*-chlorophenyl) thio] methyl] *O,O*-dimethyl ester
24988	Naled (Dibrom, RE–4355)	Phosphoric acid, 1,2-dibromo-2,2-dichloroethyl dimethyl ester
24964	Oxydemetonmethyl (Meta-Systox R, Bay 21097)	Phosphorothioic acid, *S*-[2-(ethylsulfinyl) ethyl] *O,O*-dimethyl ester (25% E. C.)
23284 (=24726)	Ronnel (Trolene, Dow ET–57, Korlan, Dow ET–14, Nankor, Viozene, fenchlorfos)	Phosphorothioic acid, *O,O*-dimethyl *O*-2,4,5-trichlorophenyl ester
25689	Shell SD 1996	Phosphoric acid, 2,3-dichloropropyl 2,2-dichlorovinyl ethyl ester
25692	Shell SD 2218	Phosphoric acid, 1-cyclohexen-1-yl diethyl ester
25623	Shell SD 2580	Acetoacetic acid, 2-phosphono-, triethyl ester
24654	Shell SD 4092	Crotonic acid, 3-hydroxy-, benzyl ester, dimethyl phosphate
24990	Shell SD 4457	Crotonic acid, 3-hydroxy-,2,4-dichlorobenzyl ester, dimethyl phosphate
25578	Shell SD 5539	Crotonic acid, 3-hydroxy-,*m*-nitrobenzyl ester, dimethyl phosphate
25631	Shell SD 6056	Phosphoric acid, 2,2-dichlorovinyl methyl phenyl ester
25532	Stauffer R–1448	Phosphorodithioic acid, *O,O*-diethyl ester, *S*-ester with *N*-(mercaptomethyl) phthalimide
25706	Stauffer R–1505	Phosphorothioic acid, *O,O*-diethyl ester, *S*-ester with *N*-(mercaptomethyl) phthalimide
25707	Stauffer R–1571	Phosphorothioic acid, *O,O*-dimethyl ester, *S*-ester with *N*-(mercaptomethyl) phthalimide
25661	Stauffer R–2968	Carbamic acid, 2-mercaptoethyl ester, S-ester with *O,O*-diethyl phosphorodithioate
25601	Substanz #215	Phosphonic acid, (2,2-dichloro-1-hydroxyvinyl)-, dimethyl ester, acetate

See footnote at end of table.

TABLE 1.—*Designations of candidate insecticides and standards included in this report*—Continued

ENT No.[1]	Company or common name	Chemical name
4225	TDE (DDD, Rhothane)	Ethane, 1,1-dichloro-2,2-bis(*p*-chlorophenyl)-
25674	Thiometan (Bay 23655)	Phosphorothioic acid, *S*-[2-(ethylsulfinyl)-1-methylethyl] *O,O*-dimethyl ester
25604	Velsicol 53–CS–27	4,7-Methanoindan, 1(or 2),4,5,6,7,8,8-heptachloro-3a,4,7,7a-tetrahydro-
25603	Velsicol 57–CS–47	4,7-Methanoindan, 1,2,4,5,6,7,8,8-octachloro-2,3-epoxy-3a,4,7,7a-tetrahydro-
25620	Velsicol 58–CS–39	Succinic acid, mercapto-,4-allyl 1-(2-mercaptopropyl) ester, *S,S*-diester with *O,O*-dimethyl phosphorodithioate
25622	Velsicol 58–CS–51	Phosphorodithioic acid, *O,O*-dimethyl ester, *S,S*-diester with 1,1'-thiodi-2-propanethiol
25621	Velsicol 58–CS–56	Succinic acid, 2,2-dimercapto-, diethyl ester, *S,S*-diester with *O,O*-dimethyl phosphorodithioate

[1] Code number assigned by the Entomology Research Division, Agricultural Research Service, to compounds distributed for screening.

PROCEDURE

Direct-Contact Toxicity

The direct-contact toxicity of the candidate insecticides was determined by using solutions of technical-grade material in a 50-50 mixture (w/w) of Deobase and tetrachloroethylene. (Several of the materials were not technical grade, and this is indicated with the chemical name in table 1. Formulations were based on active ingredients. These solutions were applied to the insects as settling sprays inside cylindrical stainless steel towers in the same manner as that described by Kantack and Laudani.[2] The formulations used in the tests had concentrations of 1.7, 6.8, and 20.4 mg. of insecticide per milliliter of the solution, which gave theoretical rates of application of 0.9, 3.5, and 10.4 mg./sq. ft., respectively. These rates differ from the rates of 0.75, 3.0, and 9.0 mg./sq. ft. shown in MRR–546 because they are based on more recent chemical and dye analyses of the deposits. A higher solution concentration of 40.8 mg. of insecticide per milliliter was used with a few of the less toxic materials to obtain a theoretical rate of application of 20.8 mg./sq. ft.

In order to get some of the insecticides into solution in the desired concentrations, it was necessary to replace some of the solvent mixture with acetone or ethanol as shown here:

Insecticides	Supplementary solvent (*Pct./volume*)
Acetone:	
Stauffer R–1448 (0.9 mg./sq. ft. rate)	0.3
Bay 39007 and Bay 39731 (0.9 mg./sq. ft. rate)	.8
Imidan (0.9 mg./sq. ft. rate)	1.0
Stauffer R–1448 (3.5 mg./sq. ft. rate)	1.3
Imidan (3.5 mg./sq. ft. rate) and Stauffer R–1448 (10.4 mg./sq. ft. rate)	4.0
Bay 34727, Bay 38500, Bay 39007, Du Pont 691, and Stauffer R–2968 (all rates) and Bay 39731 (10.4 mg./sq. ft. rate)	10.0
Imidan (10.4 mg./sq. ft. rate)	12.0
Bay 25316, fenthion, Shell SD 1996, Shell SD 2218, Shell SD 3562, Shell SD 5539, and Stauffer R–1505 (all rates)	20.0
Stauffer R–1571 (all rates)	40.0
Bay 22408 (all rates)	50.0
Ethanol:	
American Cyanamid 18706 and dimethoate (all rates)	50.0

[2] KANTACK, BEN H., and LAUDANI, HAMILTON. COMPARATIVE LABORATORY TESTS WITH EMULSION AND WETTABLE-POWDER RESIDUES AGAINST THE INDIAN-MEAL MOTH. Jour. Econ. Ent. 50(4): 513–514. 1957.

Malathion was used as a standard for comparison. Solvent-treated insects were used as checks in all tests.

Stainless steel towers, 6 feet high and 2 feet in diameter, were used in the direct-contact toxicity evaluation tests. The test insecticides were introduced directly through a nozzle placed in an opening at the center of the tower top. After a one-half-hour exposure, an exhaust baffle at the top was opened, a vent door next to the floor was opened, and the insects were removed through the bottom vent door.

The red flour beetle adults used in the test were 7 to 14 days old. These insects were reared on a medium consisting of 47.5 percent of white flour, 47.5 percent of cornmeal, and 5 percent of brewer's yeast. The black carpet beetle larvae were 3 to 5 months old and were reared on ground Purina laboratory chow.

The room in which the towers were located was maintained at a temperature of 75° to 80° F. during all tests. The test insects were placed in open 20- by 100-mm. petri dishes (10 insects per dish). The bottoms of the petri dishes were covered with kraft paper to give the insects footing. Four dishes of each species were placed on the kraft paper-covered floor in each of four towers. The bottom vent door and the top exhaust baffle were closed, and 2 ml. of the experimental insecticide solution being tested was introduced. The nozzle used was a Spraying Systems Co. air atomizing nozzle No. 1/4 J-2850-70, using 10 p.s.i. air pressure. The aerosols were allowed to settle for 30 minutes. Previous tests had shown that most of the particles settling on the floor were from 5 to 10 microns in size. The most recent chemical and dye analyses showed that about 80 percent of the insecticide settled out in 30 minutes.

After exposure, the insects were removed from the towers and transferred to clean petri dishes. The bottoms of the dishes to contain flour beetles were covered with kraft paper. The insects were held for postexposure observations in a room maintained at a temperature of 80° ± 2° F. and a relative humidity of 60 ± 5 percent. Insects that could not move about were counted at various intervals. Of these insects, some were considered inactive and those that showed little or no response when probed lightly were considered either dead or moribund.

The towers were aired, using forced air movement, for 10 minutes after each exposure. Clean kraft paper was placed on the floor of the towers at each change to a different insecticide. The towers were periodically disassembled and washed with water and acetone.

Residue Toxicity

The residue toxicity of the candidate insecticides was determined by applying solutions of the insecticides to surfaces and then confining the insects on the treated surfaces by use of open-end glass cylinders.

The insecticides were formulated in acetone. One milliliter of the formulation was applied by use of a Gardner automatic blade applicator to 3- by 12-inch sheets of 15-pound kraft paper laminated to 0.00035-inch-thick aluminum foil. The paper side of the sheets was used to represent an absorbent surface and the aluminum side a nonabsorbent surface. This application gave deposit rates of 5, 25, and 50 mg./sq. ft. on aluminum surfaces and 8, 40, and 80 mg./sq. ft. on paper surfaces. In earlier reports these rates were stated as 10, 50, and 100 mg./sq. ft. on both surfaces, but more recent chemical and dye analyses of the deposits show the new rates to be more nearly accurate. Lower or higher rates of 1.25, 2.5, 100, and 200 mg./sq. ft. on aluminum surfaces and 4, 160, 320, 640, and 960 mg./sq. ft. on paper surfaces were used with some of the insecticides to obtain a wider range of mortality data. Malathion was used as a standard for comparison. Acetone-treated sheets were used as checks.

Four sheets of each surface at each rate of application were treated. The treated papers were stapled to Celotex boards and stored at a constant temperature of 80° ± 2° F. and a relative humidity of 60 ± 5 percent. Two sheets of each surface (one for each species of test insect) were set up with insects 24 hours after treatment, and the other two sheets were set up with insects 28 days after treatment. The treated sheets were removed from the boards and placed on tables with the treated surface up. Four open-end glass cylinders were placed on each treated surface. Ten insects were placed inside each cylinder. One sheet for each species of test insect was used for each treatment. A 4-hour exposure period was used for the flour beetles 1 day after

the insecticide had been applied. A 24-hour exposure period was used for the flour beetles in the 28-day aging test and for the black carpet beetle larvae both in the exposures 1 day after the insecticide had been applied and in the 28-day aging tests. After exposure, the insects were transferred to clean petri dishes. The bottoms of those that were to contain flour beetles were covered with kraft paper. The inactive, dead, and moribund insects were counted at various intervals. Exposure and post-exposure tests were conducted in a room maintained at a temperature of 80° ± 2° F. and a relative humidity of 60 ± 5 percent.

Vapor Toxicity

The vapor action of the experimental compounds was determined by use of the jar test technique described by Laudani.[3] The tests were conducted in a room maintained at a temperature of 80° ± 2° F. and a relative humidity of 60 ± 5 percent. The candidate insecticides were formulated in acetone to have 4 mg. of active ingredient per milliliter of solution. Four milliliters were introduced into each 1-quart mason test jar. The jar was rolled on its side to spread the chemical on the inside surface. This gave a rate of application of 200 mg./sq. ft. Malathion and lindane were used as standards for comparison, and acetone-treated jars were used as checks. To allow the solvent to volatilize completely, the jars were stored open for 24 hours before making the exposures. Clean, 50-mm.-diameter crystallizing dishes were used to hold the insects during exposure. Ten insects were placed in each crystallizing dish; the bottoms of the dishes that were to contain flour beetles were covered with paper. A canopy, made by cutting the sides from a waxed-paper cup, covered each dish to prevent crystals of the insecticide from falling into the dish containing the insects. Dishes thus prepared were placed on jar lids, and the treated jars were inverted over the dishes on the lids. Four replicate jars were tested for each insecticide. The number of inactive, dead, and moribund insects was determined at various intervals of exposure.

RESULTS

The results of initial tests with red flour beetle adults and black carpet beetle larvae are presented in tables 2 through 7. Data were corrected for natural mortalities (most less than 5 percent) by using Abbott's formula.[4] Bay 41831 was not tested as a direct-contact or residue toxicant and is, therefore, not shown in tables 2 through 6. Dichlorvos was not tested as a residual or vapor toxicant and is not shown in tables 3 through 7. Oxydemetonmethyl, thiometan, and Velsicol 58-CS-51 and 58-CS-56 were eliminated from the direct-contact and residue tests because they showed little or no toxicity in exploratory tests; however, they were tested for vapor toxicity (table 7). Similarly, Maumee ENT-26209 was eliminated from the complete direct-contact test (table 2), and Bay 39007, Bay 39731, Lethane 60, and Lethane 384 Special were eliminated from the residue tests (tables 3 through 6). The following candidate insecticides were eliminated from all complete toxicity tests because they showed little or no toxicity in exploratory tests: Bay 33904, Geigy 32465, and Maumee compounds ENT-7422, ENT-13006, ENT-26181, ENT-26182, ENT-26183, ENT-26184, ENT-26185, ENT-26186, ENT-26187, and ENT-26188.

Direct-Contact Toxicity

The most effective insecticides in contact action against red flour beetle adults were Bay 25316, Bay 34727, Ciodrin, dichlorvos, fenthion, Imidan, naled, and Shell SD 4092 (table 2).

The most effective insecticides in direct-contact toxicity to black carpet beetle larvae were Bay 29492, Bay 34727, Bay 39193, Ciodrin, fen-

[3] LAUDANI, HAMILTON. EVALUATION OF STROBANE AND PERTHANE AS PROTECTANTS FOR WOOLENS AGAINST FABRIC INSECT DAMAGE AND AS TOXICANTS IN CONTROLLING BLACK CARPET BEETLES. Soap and Chem. Spec. 31(8): 149, 151, 153, 177, 179, 181. 1955.

[4] ABBOTT, W. S. A METHOD OF COMPUTING THE EFFECTIVENESS OF AN INSECTICIDE. Jour. Econ. Ent. 18(2): 265–267. 1925.

thion, Imidan, Methyl Trithion, Shell SD 4092, and Shell 5539 (table 2).

Residue Toxicity

The exposure tests of red flour beetle adults on treated paper surfaces revealed that residues of Bay 29492, Bay 34727, Bay 39193, Bay 42524, fenthion, heptachlor epoxide, and isobenzan were the most effective (table 3). In similar tests on aluminum surfaces, residues of Bay 25316, Bay 29492, Bay 39193, Bidrin, Ciodrin, dimethoate, Du Pont 691, fenthion, Imidan, isobenzan, Methyl Trithion, Shell SD 1996, Shell SD 4092, Shell SD 4457, Shell SD 5539, Stauffer R-1505, and Stauffer R-1571 were the most effective (table 4). Tests with flour beetles on surfaces 28 days after application of the insecticide showed that Bay 25316, Bay 26405, Bay 29492, Bay 34727, Bay 39193, Bay 42524, Ciodrin, fenthion, Imidan, and Shell SD 4092 were the most effective insecticides as persistent residues on paper surfaces (table 5); and Bay 25316, Bay 25660, Bay 29492, Ciodrin, Imidan, Shell SD 4092, Shell SD 4457, Shell SD 5539, Stauffer R-1505, and Stauffer R-1571 were the most effective as persistent residues on aluminum surfaces (table 6). (*Text continues on p. 32.*)

TABLE 2.—*Percentage of red flour beetle adults and black carpet beetle larvae inactive or dead and moribund after a ½-hour exposure to a candidate insecticide in aerosol form* [1]

Insecticide	Intended deposit	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		336 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
American Cyanamid 18706	10.4	76	0	78	62	100	0	100	12
	3.5	1	0	1	1	84	0	86	11
	0.9	0	0	0	0	22	0	16	7
Bay 22408	10.4	100	89	100	100	46	0	78	28
	3.5	99	63	99	99	76	0	74	23
	0.9	1	0	1	1	78	0	65	7
Bay 25316	10.4	100	100	100	100	92	15	92	32
	3.5	100	100	100	100	92	11	90	15
	0.9	100	100	100	100	94	8	90	8
Bay 25660	10.4	100	100	100	100	100	56	99	67
	3.5	85	78	83	83	100	21	90	25
	0.9	0	0	1	1	50	4	22	9
Bay 26405	10.4	100	99	100	99	91	37	79	53
	3.5	44	27	34	33	28	22	27	25
	0.9	0	0	0	0	4	2	21	16
Bay 29492	10.4	100	100	100	100	100	96	100	100
	3.5	100	100	100	100	100	93	100	94
	0.9	100	84	87	86	96	49	75	53

See footnotes at end of table.

TABLE 2.—*Percentage of red flour beetle adults and black carpet beetle larvae inactive or dead and moribund after a ½-hour exposure to a candidate insecticide in aerosol form* [1]—Continued

Insecticide	Intended deposit	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		336 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 30911	10.4	100	100	100	100	98	28	76	33
	3.5	89	59	90	74	24	3	25	15
	0.9	0	0	0	0	0	0	0	0
Bay 34727	10.4	100	100	100	100	100	51	100	51
	3.5	100	100	100	100	100	37	100	37
	0.9	100	100	100	100	100	22	100	22
Bay 37289	10.4	100	99	100	100	91	0	98	61
	3.5	73	34	46	43	14	0	30	16
	0.9	0	0	0	0	0	0	3	2
Bay 38156	10.4	100	97	100	99	100	2	100	68
	3.5	68	34	43	43	82	0	57	24
	0.9	0	0	0	0	12	0	11	8
Bay 38333	20.8					57	0	28	11
	10.4	100	99	100	99	6	0	11	8
	3.5	66	18	27	26	0	0	0	0
	0.9	0	0	0	0	0	0	0	0
Bay 38500	20.8	94	19	100	94	16	0	63	7
	10.4	50	9	100	48	9	0	36	7
	3.5	16	1	72	26	0	0	2	1
	0.9	0	0	4	0	0	0	0	0
Bay 38920	10.4	74	1	100	66	40	0	96	32
	3.5	3	0	83	6	0	0	26	0
	0.9	0	0	0	0	0	0	0	0
Bay 39007	20.8	39	28	40	38	3	0	4	1
	10.4	7	5	13	13	4	0	5	4
	0.9	1	1	1	1	0	0	0	0
Bay 39193	10.4	100	100	100	100	100	20	100	56
	3.5	100	100	100	100	100	21	100	54
	0.9	84	67	79	76	96	20	94	38
Bay 39731	20.8	20	12	22	22	6	0	9	6
	10.4	12	8	13	13	5	0	6	4
	0.9	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 2.—*Percentage of red flour beetle adults and black carpet beetle larvae inactive or dead and moribund after a ½-hour exposure to a candidate insecticide in aerosol form* [1]—Continued

Insecticide	Intended deposit	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		336 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 42524	10.4	100	100	100	100	100	44	100	56
	3.5	100	100	100	100	100	45	100	51
	0.9	56	26	42	35	80	13	73	21
Bidrin	10.4	94	79	92	91	97	13	91	13
	3.5	21	6	11	11	51	8	26	14
	0.9	0	0	0	0	6	4	6	6
Butonate	20.8					50	3	45	4
	10.4	84	79	88	84	19	0	12	4
	3.5	7	4	8	6	0	0	0	0
	0.9	0	0	0	0				
Ciodrin	10.4	100	100	100	100	100	98	100	99
	3.5	100	100	100	100	100	85	100	85
	0.9	98	91	98	96	100	40	99	40
Diazinon	10.4	100	100	100	100	100	76	100	75
	3.5	100	100	100	100	97	56	94	56
	0.9	76	60	66	64	10	1	11	6
Dichlorvos	10.4	100	100	100	100	100	14	100	14
	3.5	100	100	100	100	62	2	32	7
	0.9	100	99	100	100	1	0	2	1
Dimethoate	10.4	100	6	100	76	100	0	100	10
	3.5	100	2	100	76	98	0	96	6
	0.9	66	0	57	43	30	0	19	2
Du Pont 691	10.4	100	100	100	100	100	23	100	45
	3.5	66	55	64	60	97	5	91	40
	0.9	4	2	4	4	0	0	6	4
Fenthion	10.4	100	100	100	100	100	12	100	53
	3.5	100	93	100	100	100	5	100	45
	0.9	100	90	100	100	95	0	100	45
Heptachlor epoxide	10.4	100	100	100	100	99	46	100	100
	3.5	100	89	100	89	72	4	78	46
	0.9	59	34	23	20	1	0	0	0

See footnotes at end of table.

TABLE 2.—*Percentage of red flour beetle adults and black carpet beetle larvae inactive or dead and moribund after a ½-hour exposure to a candidate insecticide in aerosol form* [1]—Continued

Insecticide	Intended deposit	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		336 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Imidan	10.4	100	100	100	100	100	27	100	90
	3.5	100	100	100	100	100	28	100	74
	0.9	100	100	100	100	100	23	100	43
Isobenzan	10.4	100	100	100	100	100	22	100	22
	3.5	100	100	100	100	100	2	100	18
	0.9	92	68	100	88	25	0	56	8
Lethane 60	10.4	0	0	0	0	0	0	0	0
	3.5	0	0	0	0	0	0	0	0
	0.9	0	0	0	0	23	4	27	21
Lethane 384	10.4	0	0	0	0	0	0	0	0
	3.5	0	0	0	0	0	0	0	0
	0.9	0	0	0	0	0	0	0	0
Lethane 384 Special	10.4	0	0	0	0	0	0	0	0
	3.5	0	0	0	0	0	0	0	0
	0.9	0	0	0	0	10	0	22	18
Malathion [2]	0.9	91	74	88	86	92	15	86	26
Methyl Trithion	10.4	100	100	100	100	100	85	100	85
	3.5	99	73	94	92	100	60	100	60
	0.9	0	0	0	0	87	28	62	29
Naled	10.4	100	26	100	100	100	0	99	10
	3.5	100	34	100	100	86	0	68	11
	0.9	100	10	100	97	7	0	6	4
Ronnel	10.4	100	26	100	95	0	0	100	11
	3.5	34	6	26	24	0	0	34	6
	0.9	0	0	0	0	0	0	0	0
Shell SD 1996	10.4	100	100	100	100	68	14	59	19
	3.5	90	84	90	90	6	2	6	4
	0.9	0	0	0	0	0	0	0	0
Shell SD 2218	20.8	56	38	56	56	98	10	92	22
	10.4	0	0	0	0	22	0	14	4
	0.9	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 2.—*Percentage of red flour beetle adults and black carpet beetle larvae inactive or dead and moribund after a ½-hour exposure to a candidate insecticide in aerosol form* [1]—Continued

Insecticide	Intended deposit	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		336 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Shell SD 2580	10.4	97	89	95	90	76	32	63	45
	3.5	14	3	6	6	46	20	38	28
	0.9	0	0	0	0	0	0	0	0
Shell SD 4092	10.4	100	100	100	100	100	72	100	95
	3.5	100	100	100	100	100	75	100	84
	0.9	99	92	99	99	100	44	100	44
Shell SD 4457	10.4	100	100	100	100	100	98	100	98
	3.5	100	94	97	94	100	60	99	60
	0.9	1	0	0	0	62	8	30	8
Shell SD 5539	10.4	100	100	100	100	100	53	100	75
	3.5	100	97	100	100	100	46	100	46
	0.9	82	52	76	72	100	10	100	10
Shell SD 6056	10.4	100	100	100	100	90	8	40	21
	3.5	100	90	98	97	21	5	15	10
	0.9	53	28	49	46	2	0	1	1
Stauffer R-1448	10.4	100	100	100	100	100	13	98	45
	3.5	94	90	93	93	100	22	92	37
	0.9	11	4	10	8	60	11	33	18
Stauffer R-1505	10.4	100	99	100	100	96	28	96	51
	3.5	75	64	74	74	82	18	69	30
	0.9	2	0	2	2	37	5	23	17
Stauffer R-1571	10.4	100	100	100	100	100	54	100	72
	3.5	100	100	100	100	80	25	78	33
	0.9	83	55	84	83	6	0	6	5
Stauffer R-2968	20.8	96	90	94	94	94	16	89	34
	10.4	78	64	75	75	89	16	78	24
	3.5	14	4	8	8	36	2	20	7
Substanz #215	10.4	100	100	100	100	9	1	5	3
	3.5	10	4	9	9	0	0	0	0
	0.9	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 2.—*Percentage of red flour beetle adults and black carpet beetle larvae inactive or dead and moribund after a ½-hour exposure to a candidate insecticide in aerosol form* [1]—Continued

Insecticide	Intended deposit	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		336 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
TDE	10.4	15	6	17	17	49	0	33	2
	3.5	0	0	0	0	61	0	31	2
	0.9	0	0	0	0	76	0	5	0
Velsicol 53-CS-27	10.4	0	0	0	0	20	0	11	10
	3.5	0	0	0	0	8	0	4	1
	0.9	0	0	0	0	0	0	0	0
Velsicol 57-CS-47	10.4	69	46	60	49	0	0	0	0
	3.5	16	3	9	9	0	0	0	0
	0.9	0	0	0	0	0	0	0	0
Velsicol 58-CS-39	10.4	100	100	100	100	70	21	66	24
	3.5	43	19	32	30	27	9	22	15
	0.9	0	0	0	0	0	0	0	0

[1] I = inactive; D + M = dead and moribund.
[2] Malathion data are the averages from 28 tests.

TABLE 3.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface* [1]

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
American Cyanamid 18706	80	0	0	0	0	45	0	52	0
	40	0	0	0	0	72	0	62	0
	8	0	0	0	0	0	0	0	0
Bay 22408	80	25	12	25	25	2	0	5	0
	40	0	0	0	0	5	0	7	2
	8	17	2	2	2	0	0	0	0

See footnotes at end of table.

TABLE 3.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 25316	160	14	5	12	12	0	0	0	0
	80	90	80	85	85	----	----	----	----
	40	68	60	65	63	0	0	0	0
Bay 25660	960	65	52	58	55	88	37	70	67
	640	38	30	32	30	72	24	45	34
	80	0	0	0	0	20	8	10	10
Bay 26405	320	38	30	30	30	----	----	----	----
	80	0	0	0	0	22	10	10	10
	40	0	0	0	0	8	5	8	8
	8	0	0	0	0	22	8	15	10
Bay 29492	80	100	100	100	100	100	100	100	100
	40	100	100	100	100	100	100	100	100
	8	100	100	100	100	100	100	100	100
Bay 30911	80	75	75	77	77	62	40	50	40
	40	2	0	0	0	2	0	0	0
	8	0	0	0	0	28	2	12	8
Bay 34727	80	100	100	100	100	100	52	100	68
	40	100	100	100	100	100	48	100	77
	8	100	99	100	100	100	42	100	57
	4	98	92	92	92	100	42	100	47
Bay 37289	40	100	100	100	100	100	20	100	28
	8	18	2	5	5	0	0	2	2
	4	0	0	0	0	0	0	0	0
Bay 38156	40	100	100	100	100	100	25	100	34
	8	2	2	2	2	15	0	8	5
	4	0	0	0	0	0	0	0	0
Bay 38333	160	----	----	----	----	100	0	82	25
	40	100	80	90	82	2	0	2	2
	8	0	0	0	0	----	----	----	----
	4	0	0	0	0	----	----	----	----
Bay 38500	320	----	----	----	----	8	0	8	0
	40	72	16	100	65	0	0	0	0
	8	25	0	95	36	----	----	----	----
	4	0	0	45	5	----	----	----	----

See footnotes at end of table.

TABLE 3.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 38920	40	100	82	100	100	52	0	72	0
	8	34	0	95	33	2	0	0	0
	4	0	0	40	8	0	0	0	0
Bay 39193	40	100	100	100	100	100	35	100	55
	8	100	92	100	100	100	38	100	40
	4	100	85	100	94	95	15	92	27
Bay 42524	40	100	100	100	100	95	29	100	69
	8	95	90	90	90	100	32	95	45
	4	45	32	38	32	60	10	55	15
Bidrin	320	0	0	2	0	18	2	10	2
	160	0	0	0	0	22	8	20	12
	80	0	0	0	0	12	5	15	15
Butonate	160	75	72	72	72	22	0	18	5
	80	60	46	52	50	15	2	10	2
	40	5	2	5	5	8	2	8	2
Ciodrin	80	82	77	81	81	100	85	100	100
	40	42	34	35	35	100	77	100	100
	8	98	95	98	98	100	80	100	97
Diazinon	40	100	100	100	100	100	27	100	43
	8	88	83	85	86	65	0	22	5
	4	45	30	38	33	2	2	2	2
Dimethoate	80	100	2	100	80	98	0	95	0
	40	65	0	60	55	65	0	58	2
	8	0	0	0	0	0	0	0	0
Du Pont 691	40	55	5	15	15	100	15	100	35
	8	8	0	2	2	95	8	75	27
	4	0	0	0	0	45	2	35	5
Fenthion	80	100	97	100	100	100	0	100	52
	40	100	97	100	100	100	0	100	50
	8	100	85	100	100	100	0	100	45
Heptachlor epoxide	80	100	100	100	100	92	22	100	52
	40	100	100	100	100	90	38	90	53
	8	100	100	100	100	82	10	58	30

See footnotes at end of table.

TABLE 3.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Imidan	160	2	2	2	2	48	2	32	2
	80	5	2	12	12	53	8	40	8
	40	10	2	15	15	62	2	52	18
	20	8	2	5	5	88	40	88	40
	8	0	0	0	0	18	2	18	4
Isobenzan	40	92	27	100	100	100	28	100	42
	8	100	25	100	100	75	0	70	5
	4	98	24	100	90	8	0	14	2
Lethane 384	80	5	2	5	5	0	0	0	0
	40	5	0	7	7	6	0	5	0
	8	5	0	2	2	16	0	16	5
Malathion [2]	80	100	78	100	98	100	54	100	73
	40	100	87	100	99	100	41	100	68
	8	96	87	96	95	97	36	97	53
	4	83	73	80	79	78	14	73	20
Maumee ENT 26209	.160	0	0	0	0	0	0	0	0
Methyl Trithion	160	100	85	95	95				
	80	70	38	58	55	100	100	100	100
	40	62	25	40	35	100	98	100	98
	8	72	40	65	60	100	100	100	100
Naled	80	100	28	100	98	100	10	100	20
	40	100	25	100	90	100	0	100	5
	8	90	2	90	85	15	0	12	2
Ronnel	80	100	10	100	100	100	0	100	5
	40	100	5	98	92	95	0	100	12
	8	0	0	0	0	22	0	18	2
Shell SD 1996	40	100	100	100	100	100	38	100	48
	8	75	50	72	65	15	2	8	5
	4	0	0	0	0	5	0	5	0
Shell SD 2218	320	92	83	92	92	100	42	100	43
	160	61	35	61	61	100	20	100	28
	80	12	10	10	10	100	12	95	23
	40	0	0	0	0	20	2	12	5

See footnotes at end of table.

TABLE 3.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Shell SD 2580	80	100	100	100	100	100	92	100	100
	40	100	100	100	100	100	98	100	100
	8	0	0	0	0	0	0	2	2
Shell SD 4092	80	100	100	100	100	100	85	100	100
	40	100	97	100	100	100	92	100	100
	8	90	80	89	87	100	88	100	98
Shell SD 4457	160	0	0	0	0				
	80	0	0	0	0	45	12	32	14
	40	0	0	0	0	2	0	2	2
	8	0	0	0	0	0	0	0	0
Shell SD 5539	320	100	100	100	100	100	44	100	62
	160	64	47	78	72	98	35	98	58
	80	15	10	58	55	58	18	55	33
Shell SD 6056	80	100	100	100	100	100	20	100	31
	40	100	100	100	100	95	10	74	31
	8	38	32	35	32	0	0	0	0
Stauffer R–1448	320	0	0	2	2	0	0	0	0
	160	0	0	0	0	0	0	0	0
	80	0	0	0	0	5	0	2	0
Stauffer R–1505	320	2	0	2	2	3	0	5	0
	160	7	3	5	5	23	8	25	12
	80	5	5	5	5	39	2	45	18
Stauffer R–1571	320	90	70	90	90	67	10	68	23
	160	89	64	84	84	61	4	55	12
	80	38	25	38	38	37	2	28	8
Stauffer R–2968	320	0	0	0	0	22	8	22	15
	160	0	0	0	0	20	8	20	17
	80	0	0	0	0	18	0	20	13
Substanz #215	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	2	2

See footnotes at end of table.

TABLE 3.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to paper surfaces 1 day after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
TDE	80	2	2	2	2	27	0	0	0
	40	0	0	0	0	18	0	0	0
	8	0	0	0	0	11	0	0	0
Velsicol 53-CS-27	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	5	0	0	0
Velsicol 57-CS-47	80	100	70	100	86	20	2	32	2
	40	100	60	100	70	2	2	5	2
	8	5	2	2	2	0	0	5	0
Velsicol 58-CS-39	160	37	13	19	19	35	12	28	22
	80	0	0	0	0	22	8	22	13
	40	0	0	0	0	12	0	10	5

[1] I = inactive; D + M = dead and moribund.
[2] Malathion data for the 80, 40, 8, and 4 mg./sq. ft. rates are the averages from 12, 22, 23, and 11 tests, respectively.

TABLE 4.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface* [1]

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
American Cyanamid 18706	50	15	0	18	18	72	0	90	0
	25	35	0	45	38	72	0	100	0
	5	0	0	0	0	80	0	92	8

See footnotes at end of table.

TABLE 4.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 22408	50	52	40	50	50	12	0	15	2
	25	95	50	92	92	18	0	27	5
	5	15	7	17	17	0	0	2	2
Bay 25316	200	----	----	----	----	5	0	12	10
	50	----	----	----	----	20	5	30	13
	25	100	100	100	100	25	8	32	20
	5	100	100	100	100	----	----	----	----
	2.5	100	100	100	100	----	----	----	----
Bay 25660	50	100	100	100	100	100	100	100	100
	25	100	100	100	100	100	100	100	100
	5	98	84	88	84	100	95	100	100
Bay 26405	50	100	100	100	100	100	92	100	100
	25	100	100	100	100	95	80	100	100
	5	92	88	92	92	80	50	88	65
Bay 29492	50	100	100	100	100	100	100	100	100
	25	100	100	100	100	100	100	100	100
	5	100	100	100	100	100	100	100	100
Bay 30911	50	100	100	100	100	50	38	50	38
	25	25	25	25	25	0	0	0	0
	5	0	0	2	2	50	30	50	30
Bay 34727	50	100	100	100	100	100	42	100	62
	25	100	100	100	100	100	50	100	60
	5	62	28	36	36	25	5	18	5
	2.5	0	0	0	0	0	0	0	0
Bay 37289	25	100	100	100	100	100	18	100	28
	5	85	50	65	65	70	5	52	10
	1.25	0	0	0	0	0	0	0	0
Bay 38156	25	100	100	100	100	100	32	100	50
	5	32	10	18	18	5	0	2	0
	1.25	0	0	0	0	0	0	0	0
Bay 38333	25	28	10	20	18	0	0	0	0
	5	0	0	0	0	0	0	0	0
	1.25	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 4.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 38500	200					0	0	0	0
	25	93	21	100	63	8	0	5	2
	5	98	41	100	80				
	2.5	45	5	98	45				
Bay 38920	25	100	90	100	100	100	2	92	20
	5	60	8	98	56	2	0	2	0
	2.5	0	0	2	2	0	0	0	0
Bay 39193	25	100	100	100	100	100	12	100	30
	5	100	100	100	100	100	30	100	64
	2.5	100	100	100	100	100	30	100	42
Bay 42524	25	100	100	100	100	100	25	100	44
	5	79	74	74	74	48	12	45	20
	2.5	2	2	2	2	5	5	5	5
Bidrin	25	100	100	100	100	100	44	100	92
	5	100	92	100	100	100	57	100	72
	2.5	70	50	72	70	100	47	95	51
Butonate	25	100	100	100	100	60	8	62	15
	5	0	0	0	0	0	0	0	0
	2.5	0	0	0	0	0	0	0	0
Ciodrin	50	100	100	100	100	100	80	100	95
	25	100	100	100	100	100	70	100	100
	5	100	100	100	100	100	82	100	98
Diazinon	25	100	100	100	100	90	10	72	27
	5	0	0	0	0	0	0	0	0
	2.5	0	0	0	0	0	0	0	0
Dimethoate	50	100	2	100	90	100	0	100	2
	25	100	0	100	95	100	0	100	8
	5	100	2	100	98	100	0	100	8
Du Pont 691	25	100	100	100	100	100	15	100	32
	5	100	93	100	100	100	18	100	35
	2.5	88	70	82	80	100	12	100	38

See footnotes at end of table.

TABLE 4.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq.ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fenthion	50	100	100	100	100	100	0	100	55
	25	100	95	100	100	100	0	100	50
	5	100	92	100	100	100	0	100	47
Heptachlor epoxide	50	100	100	100	100	95	32	100	66
	25	100	100	100	100	90	33	97	53
	5	50	43	49	43	80	12	70	25
Imidan	25	100	100	100	100	98	30	100	38
	5	100	100	100	100	98	32	100	38
	2.5	100	100	100	100	88	25	100	32
Isobenzan	25	100	7	100	100	100	15	100	43
	5	100	14	100	100	100	8	100	13
	2.5	100	32	100	98	64	0	61	13
Lethane 384	50	5	5	8	8	0	0	0	0
	25	27	20	30	30	5	0	5	5
	5	2	2	2	2	5	0	7	5
Malathion [2]	50	100	80	100	98	100	56	100	74
	25	100	89	100	100	100	42	100	68
	5	100	90	100	99	99	42	98	70
	2.5	98	97	98	98	100	33	100	56
	1.25	52	25	40	40	100	8	100	40
Maumee ENT 26209	50	49	42	65	54	88	18	88	69
	25	5	5	22	10	13	5	13	10
	5	0	0	3	3	0	0	0	0
Methyl Trithion	50	100	100	100	100	100	85	100	100
	25	100	100	100	100	100	95	100	100
	5	100	98	100	100	100	93	100	93
Naled	50	100	35	100	95	100	5	100	20
	25	100	45	100	95	100	2	100	10
	5	0	0	0	0	12	0	18	12
Ronnel	50	65	5	50	50	100	0	100	8
	25	50	0	48	45	45	0	50	5
	5	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 4.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Shell SD 1996	25	100	100	100	100	100	40	100	52
	5	100	100	100	100	100	45	100	80
	2.5	30	25	28	28	100	52	100	66
Shell SD 2218	200	100	100	100	100	100	49	100	74
	100	100	98	100	98	100	38	100	58
	50	2	0	2	2	60	0	48	5
Shell SD 2580	50	100	100	100	100	100	95	100	100
	25	100	100	100	100	100	100	100	100
	5	0	0	0	0	0	0	0	0
Shell SD 4092	50	100	100	100	100	100	88	100	100
	25	100	100	100	100	100	88	100	100
	5	100	100	100	100	100	87	100	100
Shell SD 4457	50	100	100	100	100	100	52	100	90
	25	100	100	100	100	100	37	100	100
	5	100	100	100	100	100	45	100	90
Shell SD 5539	25	100	93	100	100	100	28	100	69
	5	80	37	98	95	100	16	100	62
	2.5	72	20	90	87	100	31	100	71
Shell SD 6056	50	100	100	100	100	100	25	100	82
	25	100	100	100	100	100	15	75	48
	5	0	0	0	0	0	0	0	0
Stauffer R-1448	25	95	93	95	95	20	5	32	10
	5	39	30	49	49	10	0	12	5
	2.5	22	12	25	25	2	0	5	0
Stauffer R-1505	25	100	100	100	100	75	15	82	18
	5	98	84	95	95	62	10	75	16
	2.5	90	65	92	92	45	8	45	16
Stauffer R-1571	25	100	100	100	100	100	17	100	48
	5	98	94	98	98	95	15	95	53
	2.5	98	62	100	100	95	8	95	55
Stauffer R-2968	25	100	100	100	100	88	20	90	45
	5	28	18	22	22	40	8	45	20
	2.5	10	8	8	8	35	5	30	24

See footnotes at end of table.

TABLE 4.—*Percentage of inactive or dead and moribund insects among red flour beetle adults exposed for 4 hours and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 1 day after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Substanz #215	50	0	0	0	0	2	0	2	2
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
TDE	50	60	32	72	72	32	0	5	5
	25	32	27	42	42	22	0	2	2
	5	2	0	7	2	10	2	2	2
Velsicol 53–CS–27	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	8	2	8	5
	5	0	0	0	0	0	0	0	0
Velsicol 57–CS–47	50	65	20	57	20	10	0	8	2
	25	50	12	49	14	2	2	2	2
	5	2	0	0	0	0	0	0	0
Velsicol 58–CS–39	50	100	100	100	100	95	48	100	76
	25	100	100	100	100	100	52	100	58
	5	68	65	68	67	60	28	60	33
	2.5	40	32	37	37	20	14	20	14

[1] I = inactive; D + M = dead and moribund.

[2] Malathion data for the 50, 25, 5, and 2.5 mg./sq. ft. rates are the averages from 12, 22, 23, and 10 tests, respectively.

TABLE 5.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface* [1]

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
American Cyanamid 18706	80	0	0	0	0	15	2	18	5
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 5.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 22408	80	97	97	97	97	11	0	14	10
	40	59	54	59	59	0	0	9	10
	8	5	2	7	7	11	0	27	20
Bay 25316	160	100	100	100	100	5	0	5	2
	80	100	100	100	100	0	0	0	0
	40	100	100	100	100				
Bay 25660	960	100	97	98	98	78	28	78	30
	640	100	98	100	100	65	30	65	35
	80	25	20	25	20	0	0	0	0
Bay 26405	320	100	100	100	100				
	80	100	100	100	100	20	15	18	15
	40	100	95	100	100	25	18	25	25
	8	0	0	0	0	0	0	0	0
Bay 29492	80	100	100	100	100	100	70	100	100
	40	100	100	100	100	95	62	98	98
	8	100	100	100	100	28	20	25	25
Bay 30911	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	2	0	0	0
	8	2	2	2	2	0	0	0	0
Bay 34727	80	100	100	100	100	100	8	100	42
	40	100	100	100	100	98	15	95	28
	8	100	100	100	100	32	12	28	15
Bay 37289	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	2	0	2	2
Bay 38156	80	62	42	55	55	5	0	5	0
	40	0	0	0	0	5	3	5	3
	8	0	0	0	0	0	0	0	0
Bay 38333	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 5.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 38500	320					0	0	0	0
	80	28	10	65	28	2	0	0	0
	40	22	2	65	18				
	8	0	0	8	2				
Bay 38920	80	42	8	92	37	0	0	0	0
	40	10	0	23	8	0	0	0	0
	8	0	0	2	2	0	0	0	0
Bay 39193	80	100	100	100	100	100	18	100	30
	40	100	100	100	100	100	17	100	22
	8	5	5	5	5	0	0	0	0
Bay 42524	80	100	100	100	100	100	28	100	50
	40	100	100	100	100	5	0	0	0
	8	100	100	100	100	20	2	18	5
Bidrin	320	48	27	55	53	10	0	8	0
	160	22	10	28	28	22	2	22	17
	80	15	8	22	20	10	2	10	5
Butonate	160	0	0	0	0	0	0	0	0
	80	0	0	0	0	5	5	5	5
	40	0	0	0	0	0	0	0	0
Ciodrin	80	100	96	100	100	100	2	100	100
	40	100	92	100	100	100	10	100	100
	8	0	0	0	0	25	5	18	7
Diazinon	80	100	100	100	100	27	8	23	8
	40	80	71	74	74	8	0	3	0
	8	0	0	0	0	0	0	0	0
Dimethoate	80	5	0	8	8	20	0	22	10
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
Du Pont 691	80	88	80	88	85	60	18	58	25
	40	72	62	65	65	25	0	28	2
	8	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 5.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fenthion	80	100	100	100	100	100	7	100	60
	40	100	100	100	100	97	2	95	52
	8	20	12	22	22	0	0	0	0
Heptachlor epoxide	80	88	75	75	75	18	0	25	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
Imidan	160	100	95	100	100	15	0	10	5
	80	100	98	100	100	10	0	10	2
	40	100	100	100	100	35	7	38	20
Isobenzan	80	98	80	100	90	62	0	65	5
	40	92	18	100	72	0	0	0	0
	8	5	0	22	5	0	0	0	0
Lethane 384	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
Malathion [2]	80	87	75	87	86	77	20	75	38
	40	69	58	69	68	48	11	46	20
	8	43	38	43	42	9	1	7	2
Maumee ENT 26209	160	0	0	0	0	0	0	0	0
Methyl Trithion	160	100	100	100	100				
	80	100	100	100	100	100	90	100	90
	40	5	5	8	8	0	0	0	0
	8	0	0	0	0	0	0	0	0
Naled	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
Ronnel	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
Shell SD 1996	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 5.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Shell SD 2218	320	0	0	0	0	0	0	0	0
	160	0	0	0	0	0	0	0	0
	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
Shell SD 2580	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
Shell SD 4092	80	100	100	100	100	100	28	100	100
	40	100	96	100	100	100	18	100	100
	8	0	0	0	0	8	2	5	5
Shell SD 4457	160	72	62	70	70	----	----	----	----
	80	85	70	88	88	42	12	35	12
	40	72	55	70	70	8	0	5	0
	8	0	0	2	2	0	0	0	0
Shell SD 5539	320	65	25	70	70	82	18	82	32
	160	65	30	85	72	22	8	22	8
	80	55	12	70	66	0	0	0	0
Shell SD 6056	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
Stauffer R-1448	320	0	0	2	2	0	0	0	0
	160	0	0	0	0	0	0	2	0
	80	0	0	0	0	2	0	2	0
Stauffer R-1505	320	100	90	100	98	12	0	12	4
	160	92	86	92	90	30	8	28	10
	80	48	35	48	48	15	2	15	4
Stauffer R-1571	320	100	98	100	100	32	0	28	0
	160	100	98	100	98	20	0	12	5
	80	100	98	100	98	8	0	2	2
Stauffer R-2968	320	76	72	76	76	2	0	2	0
	160	35	27	32	32	10	0	10	8
	80	48	42	45	45	2	0	2	0

See footnotes at end of table.

TABLE 5.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to paper surfaces 28 days after a candidate insecticide had been applied to the paper surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Substanz #215	80	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	0	0
	8	0	0	0	0	0	0	0	0
TDE	80	5	5	5	5	0	0	0	0
	40	0	0	0	0	5	0	0	0
	8	0	0	0	0	0	0	0	0
Velsicol 53-CS-27	80	2	2	2	2	0	0	0	0
	40	2	2	2	2	0	0	0	0
	8	0	0	2	2	0	0	0	0
Velsicol 57-CS-47	80	82	17	85	50	0	0	0	0
	40	52	25	58	33	0	0	0	0
	8	2	2	2	2	0	0	0	0
Velsicol 58-CS-39	160	100	100	100	100	12	0	10	5
	80	95	86	94	94	5	0	5	0
	40	80	67	80	80	0	0	0	0

[1] I = inactive; D + M = dead and moribund.
[2] Malathion data are the averages from 23 tests.

TABLE 6.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface* [1]

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
American Cyanamid 18706	50	20	0	28	28	52	0	65	2
	25	2	0	2	2	50	0	42	8
	5	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 6.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg. sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 22408	50	100	100	100	100	41	2	71	32
	25	100	95	100	100	15	2	29	22
	5	50	45	49	49	13	0	20	15
Bay 25316	200					0	0	8	0
	50	100	100	100	100	2	0	2	2
	25	100	100	100	100				
	5	100	100	100	100				
Bay 25660	50	100	100	100	100	100	98	100	98
	25	100	100	100	100	100	90	100	98
	5	100	93	100	93	70	42	72	45
Bay 26405	50	100	100	100	100	100	72	100	100
	25	100	100	100	100	75	50	98	98
	5	0	0	0	0	0	0	0	0
Bay 29492	50	100	100	100	100	90	75	90	90
	25	100	100	100	100	5	2	5	5
	5	100	100	100	100	0	0	0	0
Bay 30911	50	0	0	0	0	5	2	8	8
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	7	5	5	5
Bay 34727	50	5	2	5	5	0	0	0	0
	25	2	0	2	2	2	2	2	2
	5	0	0	0	0	0	0	0	0
Bay 37289	50	22	5	22	20	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Bay 38156	50	18	8	12	12	8	2	8	8
	25	0	0	2	2	0	0	0	0
	5	0	0	0	0	0	0	0	0
Bay 38333	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 6.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Bay 38500	200					0	0	0	0
	50	100	60	100	100	0	0	0	0
	25	100	83	100	95				
	5	100	52	100	82				
Bay 38920	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Bay 39193	50	100	100	100	100	100	0	100	32
	25	0	0	0	0	2	0	2	0
	5	0	0	0	0	0	0	0	0
Bay 42524	50	75	75	75	75	75	15	75	36
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Bidrin	50	75	75	75	75	100	12	100	57
	25	68	65	68	68	38	5	42	33
	5	0	0	0	0	0	0	0	0
Butonate	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Ciodrin	50	100	100	100	100	100	5	100	94
	25	100	100	100	100	100	0	100	98
	5	100	100	100	100	100	15	100	100
Diazinon	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Dimethoate	50	100	0	100	98	100	0	100	15
	25	100	2	100	82	98	2	98	10
	5	52	5	52	50	20	0	22	0
Du Pont 691	50	85	85	85	85	100	28	100	38
	25	75	75	75	75	35	12	35	15
	5	3	3	3	3	0	0	0	0

See footnotes at end of table.

TABLE 6.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Fenthion	50	100	100	100	100	100	10	100	75
	25	100	100	100	100	100	5	100	70
	5	5	2	3	3	0	0	3	2
Heptachlor epoxide	50	25	14	20	20	35	2	45	20
	25	2	2	2	2	0	0	0	0
	5	0	0	0	0	0	0	0	0
Imidan	50	100	100	100	100	67	18	72	32
	25	100	100	100	100	92	28	98	37
	5	100	100	100	100	85	14	98	27
Isobenzan	50	100	100	100	100	75	0	70	8
	25	100	100	100	100	68	0	40	2
	5	52	10	90	35	0	0	0	0
Lethane 384	50	0	0	0	0	2	0	2	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Malathion [2]	50	81	71	81	80	70	22	71	45
	25	48	40	49	48	39	9	39	20
	5	13	10	13	13	12	3	12	6
Maumee ENT 26209	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	5	0	0	0
	5	0	0	0	0	0	0	0	0
Methyl Trithion	50	100	100	100	100	100	95	100	100
	25	60	55	55	55	78	68	75	75
	5	0	0	0	0	0	0	0	0
Naled	50	5	0	2	2	0	0	0	0
	25	60	5	65	65	13	0	10	0
	5	0	0	2	2	0	0	0	0
Ronnel	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0

See footnotes at end of table.

TABLE 6.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Shell SD 1996	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Shell SD 2218	200	0	0	0	0	0	0	0	0
	100	0	0	0	0	0	0	0	0
	50	0	0	0	0	0	0	0	0
Shell SD 2580	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Shell SD 4092	50	100	100	100	100	100	10	100	98
	25	100	100	100	100	100	22	100	100
	5	100	100	100	100	100	8	100	100
Shell SD 4457	50	100	100	100	100	----	----	100	88
	25	100	100	100	100	100	68	100	85
	5	100	100	100	100	100	60	100	72
Shell SD 5539	50	100	80	100	100	100	17	100	54
	25	100	97	100	100	100	15	100	52
	5	95	65	95	95	100	8	100	45
Shell SD 6056	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
Stauffer R-1448	50	92	92	92	92	0	0	2	2
	25	82	68	78	78	23	7	30	12
	5	82	68	80	80	13	0	20	7
Stauffer R-1505	50	100	100	100	100	85	25	92	40
	25	98	93	95	95	75	10	78	25
	5	98	96	98	98	52	8	60	20
Stauffer R-1571	50	100	100	100	100	100	25	100	62
	25	100	100	100	100	100	18	100	45
	5	88	77	88	88	78	15	80	27

See footnotes at end of table.

TABLE 6.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed for 24 hours to aluminum surfaces 28 days after a candidate insecticide had been applied to the aluminum surface* [1]—Continued

Insecticide	Rate of application	Effect of insecticide on—							
		Red flour beetle adults				Black carpet beetle larvae			
		24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
		I	D+M	I	D+M	I	D+M	I	D+M
	Mg./sq. ft.	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Stauffer R-2968	25	100	100	100	100	70	10	75	14
	5	0	0	0	0	0	0	0	0
Substanz #215	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	0	0	0	0
	5	0	0	0	0	0	0	0	0
TDE	50	61	30	66	66	28	0	0	0
	25	18	8	18	18	8	0	2	2
	5	0	0	0	0	2	0	0	0
Velsicol 53-CS-27	50	0	0	0	0	0	0	0	0
	25	0	0	0	0	2	2	2	2
	5	2	2	2	2	0	0	0	0
Velsicol 57-CS-47	50	85	23	78	47	0	0	0	0
	25	70	20	70	38	0	0	0	0
	5	0	0	0	0	0	0	0	0
Velsicol 58-CS-39	50	100	100	100	100	90	15	92	56
	25	100	100	100	100	18	5	22	18
	5	0	0	0	0	0	0	0	0

[1] I = inactive; D + M = dead and moribund.
[2] Malathion data are the averages from 23 tests.

Exposure of black carpet beetle larvae to residues of the various candidate insecticides on paper surfaces showed that residues of Bay 29492, Bay 34727, Bay 39193, Bay 42524, Ciodrin, fenthion, Methyl Trithion, and Shell SD 4092 produced the highest toxicity values (table 3). On aluminum surfaces, Bay 25660, Bay 29492, Bidrin, Ciodrin, Methyl Trithion, Shell SD 1996, Shell SD 4092, Shell SD 4457, and Shell SD 5539 produced the highest toxicity values (table 4). Aging tests of residues, conducted 28 days after application of the insecticides, showed that as persistent residues Bay 29492, Bay 34727, Bay 39193, Ciodrin, fenthion, and Shell SD 4092 were the most effective on paper surfaces (table 5); and Bay 25660, Bay 26405, Ciodrin, fenthion, Imidan, Methyl Trithion, Shell SD 4092, Shell SD 4457, Shell SD 5539, and Stauffer R-1571 were the most effective on aluminum surfaces (table 6).

Vapor Toxicity

A number of the candidate insecticides showed high vapor toxicity against red flour beetle adults and black carpet beetle larvae. Those

showing high vapor toxicity against the red flour beetle adults were Bay 30911, Bay 34727, Bay 38333, Bay 41831, Bay 42524, diazinon, isobenzan, Shell SD 6056, Substanz #215, Velsicol 58-CS-51, and Velsicol 58-CS-56 (table 7). The insecticides showing high vapor toxicity against the black carpet beetle larvae were Bay 30911, Bay 34727, Bay 41831, Bay 42524, diazinon, isobenzan, naled, Shell SD 2218, Shell SD 2580, Shell SD 5539, Shell SD 6056, and Substanz #215 (table 7).

TABLE 7.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed to vapors of a candidate insecticide applied at 200 mg./sq. ft. in 1-quart mason jars* [1]

Insecticide	Effect of insecticide on—							
	Red flour beetle adults after exposure for—				Black carpet beetle larvae after exposure for—			
	24 hours		120 hours		24 hours		360 hours	
	I	D+M	I	D+M	I	D+M	I	D+M
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
American Cyanamid 18706	0	0	0	0	0	0	8	2
Bay 22408	77	45	100	100	17	0	100	42
Bay 25316	0	0	0	0	2	0	0	0
Bay 25660	0	0	0	0	0	0	0	0
Bay 26405	0	0	0	0	0	0	2	2
Bay 29492	15	8	100	100	45	18	100	97
Bay 30911	100	100	100	100	100	27	100	100
Bay 34727	100	100	100	100	100	92	100	100
Bay 37289	75	45	100	100	2	0	100	48
Bay 38156	100	80	100	100	92	2	100	64
Bay 38333	100	100	100	100	2	0	100	50
Bay 38500	0	0	100	70	0	0	25	2
Bay 38920	95	30	100	100	40	2	100	87
Bay 39007	0	0	0	0	0	0	0	0
Bay 39193	100	98	100	100	52	5	100	87
Bay 39731	0	0	0	0	2	0	2	2
Bay 41831	100	100	100	100	100	5	100	57
Bay 42524	100	100	100	100	100	52	100	57
Bidrin	0	0	2	2	5	0	100	40
Butonate	75	69	100	100	12	5	98	55
Ciodrin	0	0	0	0	0	0	90	84
Diazinon	100	100	100	100	88	85	100	100
Dimethoate	0	0	10	0	0	0	95	5
Du Pont 691	0	0	37	33	0	0	100	30
Fenthion	100	82	100	100	92	0	100	22
Heptachlor epoxide	98	25	100	100	0	0	100	93
Imidan	0	0	0	0	0	0	0	0
Isobenzan	100	100	100	100	85	0	100	97
Lethane 60	0	0	0	0	10	0	3	5
Lethane 384	0	0	22	10	15	0	28	23

See footnotes at end of table.

TABLE 7.—*Percentage of inactive or dead and moribund insects among red flour beetle adults and black carpet beetle larvae exposed to vapors of a candidate insecticide applied at 200 mg./sq. ft. in 1-quart mason jars* [1]—Continued

Insecticide	Effect of insecticide on—							
	Red flour beetle adults				Black carpet beetle larvae			
	24 hours after exposure		120 hours after exposure		24 hours after exposure		168 hours after exposure	
	I	D+M	I	D+M	I	D+M	I	D+M
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Lethane 384 special	58	22	94	84	20	0	47	28
Lindane [2]	99	83	100	99	84	15	100	86
Malathion [2]	36	21	100	98	47	14	100	79
Maumee ENT 26209	0	0	0	0	0	0	0	0
Methyl Trithion	0	0	40	30	2	2	100	90
Naled	100	95	100	100	100	0	100	65
Oxydemetonmethyl	12	0	100	100	18	2	93	42
Ronnel	72	5	100	100	80	0	100	12
Shell SD 1996	98	98	100	100	78	25	100	28
Shell SD 2218	82	75	100	100	100	48	100	84
Shell SD 2580	38	28	100	100	100	92	100	100
Shell SD 4092	0	0	0	0	2	0	98	77
Shell SD 4457	0	0	0	0	0	0	0	0
Shell SD 5539	72	72	100	100	98	23	100	73
Shell SD 6056	100	100	100	100	100	14	100	100
Stauffer R-1448	0	0	0	0	0	0	0	0
Stauffer R-1505	0	0	0	0	0	0	0	0
Stauffer R-1571	0	0	0	0	0	0	0	0
Stauffer R-2968	0	0	8	3	0	0	58	33
Substanz #215	100	100	100	100	100	45	100	100
TDE	0	0	0	0	0	0	18	7
Thiometan	0	0	100	95	22	2	100	42
Velsicol 53-CS-27	0	0	10	4	0	0	22	0
Velsicol 57-CS-47	72	18	100	100	0	0	100	88
Velsicol 58-CS-39	100	80	100	100	10	8	100	98
Velsicol 58-CS-51	100	100	100	100	10	0	100	100
Velsicol 58-CS-56	100	100	100	100	2	2	75	60

[1] I = inactive; D + M = dead and moribund.

[2] Lindane and malathion data are the averages from 24 tests.

DISCUSSION

A few of the insecticides demonstrated relatively high toxicity to one species but low toxicity to the other, for example, dichlorvos and Methyl Trithion. The higher mortalities for flour beetles on the 28-day-aged residues than on the 1-day-aged residues do not necessarily

indicate an increase in toxicity of the residues because the exposure period for the 28-day tests was longer; for example, Bay 26405 on paper surfaces.

In some instances the lower rates of surface application seemed more effective than higher rates; for example, Bay 22408 on aluminum surfaces against flour beetle adults and Imidan on paper surfaces against black carpet beetle larvae. The authors observed that different crystal patterns formed on the surfaces when different concentrations of some of the solid insecticides were used. Perhaps this made the insecticide more available for pickup by the insects at the lower rates.

Compounds with lower residue toxicity on aluminum surfaces but with higher toxicity on paper surfaces often displayed early knockdown of the insects in the vapor tests; for example, Bay 34727, Bay 42524, and diazinon. This is probably attributable to relatively high insecticide volatility. The insecticide vapor may be released more slowly from the absorbent paper surface. Some other, apparently less volatile compounds may be absorbed into the paper and, therefore, be less available to the insects than are the residues on aluminum surfaces; for example, Imidan and Shell SD 4457. Hoskins [5] reviewed the properties of pesticide deposits on various surfaces.

Most of the insects inactivated early by the insecticides did not recover. However, with some of the materials, insects did recover; for example, Shell SD 6056 and TDE against black carpet beetle larvae. Also, a few of the insecticides showed a delayed action or a more gradual action, as evidenced by increase in the numbers of insects inactive at the later readings; for example, Bay 38500, Bay 38920, and ronnel in direct-contact toxicity to black carpet beetle larvae.

[5] HOSKINS, W. M. SOME IMPORTANT PROPERTIES OF PESTICIDE DEPOSITS ON VARIOUS SURFACES. *In* Francis A. Gunther [ed.], Residue Reviews, v. 1, pp. 66–91. Academic Press, New York. 1962.

CONCLUSIONS

The results of these evaluation tests will enable researchers studying control of stored-product insects on specific commodities to select those insecticides that show the most promise in a particular type of action. The candidate insecticides considered highly promising on the basis of their toxicity to the two species of insects tested are Bay 29492, Bay 34727, Bay 39193, Ciodrin, fenthion, Imidan, Shell SD 4092, Shell SD 4457, Shell SD 5539, and Stauffer R-1571. For situations where use of insecticide vapors may be the best method (in enclosed spaces such as chests, crates, and tight buildings, or as grain protectants), further tests with Bay 30911, Bay 41831, Bay 42524, Shell SD 6056, and Substanz #215 should be considered. Other factors, in addition to toxicity to the insects, may be important in selecting materials for further testing. These factors include mammalian toxicity, fate of residues, and the commercial potential of the chemical. The most recent information of this kind can be obtained from the manufacturer.

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