LABORATORY AND FIELD EVALUATION OF SEVERAL ORGANOCHLORINE AND ORGANOPHOSPHORUS COMPOUNDS FOR CONTROL OF IMPORTED FIRE ANTS

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This paper contains the results of chemical-screening research only. Mention of potentially effective pesticides does not constitute a recommendation for use, nor does it imply that the pesticides are registered under the Federal Insecticide, Fungicide, and Rodenticide Act as amended. The use of trade names in this publication does not constitute a guarantee, warranty, or endorsement of the products by the U.S. Department of Agriculture.

LABORATORY AND FIELD EVALUATION OF SEVERAL ORGANOCHLORINE AND ORGANOPHOSPHORUS COMPOUNDS FOR CONTROL OF IMPORTED FIRE ANTS

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ABSTRACT

Eleven organochlorine and twelve organophosphorus pesticides and one antibiotic were selected from laboratory screening tests for field evaluation in baits for control of the red imported fire ant, *Solenopsis invicta* Buren. BAY 38920 (6,7,8,9,10,10-hexachloro-1,5,5a,6,9,9a-hexahydro-3-methyl-6,9-methano-2,4-benzodioxepin, chlorinated to contain 70 percent total chlorine) was the only compound that gave 90 percent or greater reduction in the number of active nests in a corncob grits and soybean oil formulation, as well as in two slurry baits: white flour and peanut butter. Erratic results precluded further studies with this compound. 1-Fluorochlordene (4,5,6,7,8,8-hexachloro-1-fluoro-3a,4,7,7a-tetrahydro-4,7-methanoindene) and coumaphos [*O*-(3-chloro-4-methyl-2-oxo-2*H*-1-benzopyran-7-yl) *O,O*-diethyl phosphorothioate] were the only other two compounds that gave greater than 90 percent kill in any test, but performance also was erratic. 1-Fluorochlordene gave 92 percent reduction in the white flour bait, but it was not tested in the peanut butter bait and gave only 7 percent kill in the corncob grits bait. Coumaphos gave 99 percent reduction in the peanut butter bait, 85 percent in the white flour bait, and 23 percent in the corncob grits bait. The only other compounds that eliminated 75 percent or more of the active nests in any test were: aldrin (1,2,3,4,10,10-hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene), BAY 38500 (1,4,5,6,7,7-hexachloro-3-[(2-hydroxy-1-methylethoxy)methyl]bicyclo[2.2.1]hept-2(or 5)-ene-2-methanol, chlorinated to contain 65 percent total chlorine), Hooker HRS–1362 [*N*-1,1a,3,3a,4,5,5,5a,5b,6-decachlorooctahydro-2-hydroxy-1,3,4-metheno-1*H*-cyclobuta[*cd*]pentalen-2-yl)acetamide], and fervenulin (6,8-dimethylpyrimido[5,4-*e*]-1,2,4-triazine-5,7(6*H*,8*H*)-dione). **KEYWORDS: baits, chemical control (imported fire ants), chemical control (insects), Formicidae, imported fire ants, insecticides, *Solenopsis invicta, Solenopsis richteri.***

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INTRODUCTION

The red and black imported fire ants, *Solenopsis invicta* Buren and *Solenopsis richteri* Forel, have been the target of large-scale control programs since 1957 when the U.S. Congress, acting on requests from farm and wildlife groups in the infested States, authorized the U.S. Department of Agriculture to initiate a cooperative control program with the affected States. In late 1957, treatment of infested areas with granular heptachlor (1,4,5,6, 7,8,8 - heptachloro - 3a,4,7,7a - tetrahydro - 4,7-methanoindene; AI3–15152)[4] was begun, with dieldrin (1,2,3,4,10,10-hexachloro-6,7-epoxy-1,4, 4a,5,6,7,8,8a-octahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene; AI3–16225) being used instead of heptachlor in areas where whitefringed beetles, *Graphognathus* spp., were also present.

At the onset of the control program, USDA established a Methods Development Laboratory at Gulfport, Miss., to evaluate and improve methods of control. Laboratory and field evaluation of candidate insecticides, as residual contact treatments or as bait toxicants, was initiated, with special emphasis given to the development of a toxic bait (*2, 5, 10*).[5] These studies revealed that mirex (dodecachlorooctahydro - 1,3,4 - metheno - 1*H* - cyclobuta[*cd*] pentalene; AI3–25719) was effective against the ants in an oil bait (*11*), and by 1962 an effective granular formulation of mirex bait had been developed for use in the control program (*7–9*). Studies were continued by the Methods Development Laboratory, and in 1968 studies were also initiated at the Insects Affecting Man Research Laboratory of the Agricultural Research Service (ARS), Gainesville, Fla., to find other chemicals that might be effective in a toxic bait. The program has evaluated more than 3,200 chemicals.

Even though more than 3,200 chemicals have been evaluated in the laboratory studies, relatively few have shown sufficient promise to warrant field tests. Several toxicants that had shown promise in the laboratory and given good kill in slurry baits in the field failed to perform satisfactorily in the corncob grits bait, even after repeated testing. The results of these tests demonstrated that only toxicants exhibiting delayed toxicity over a wide range of dilutions would be satisfactory in the corncob grits bait. Since the corncob grits bait is the only formulation that has proven practical for use over large areas, only those compounds that exhibited delayed toxicity at 10 or more sequential dilutions were tested in the field after these initial tests. Only 19 chemicals that exhibit this degree of toxicity have been evaluated. This paper reports the results of laboratory and field tests with 12 of these 19 compounds and shows the comparative effectiveness in different bait formulations of these and several other compounds that had shown promise in laboratory screening. The other seven compounds either were not available in sufficient quantities for field testing or the results of field tests have been previously reported (*3, 12*).

METHODS AND MATERIALS

Laboratory Tests

In the initial tests to evaluate bait toxicants, the ants were confined in plastic flower pots (20 per pot) and exposed continuously for 8 days to the toxicant, which was dissolved in peanut oil. Mortality readings were taken at 1, 2, 4, 8, and 24 hours after initial exposure and at 24-hour intervals thereafter for the remainder of the 8-day test.

The test procedure evolved to that described by Stringer et al. (*12*). Further minor modifications were made (*4, 10, 13*), and the following procedure is now utilized in the laboratory.

Disposable 30-ml plastic medicine cups (40-mm i.d. at the top, tapering to 32-mm i.d. at the bottom, 38 mm high) are used as test chambers. A 6-mm hole is drilled through the bottom of each cup, and a layer of plaster of paris and portland cement (9 : 1 ratio) is poured over the interior bottom of the cup. The plaster mixture covers the hole and acts as a wick to draw up water when the cup is placed on a bed of wet peat moss. Water is necessary to maintain high humidity in the cups and thereby prevent dessication of the ants. The cement adds sufficient hardness to the plaster to prevent the ants from tunneling through the plaster and escaping during the test.

Field-collected ants are brought into the laboratory and held in soil in large plastic tubs or

[4] AI3 numbers are assigned by Agricultural Research Service to chemicals used in entomological investigations.

[5] Italic numbers in parentheses refer to items in "Literature Cited" at the end of this publication.

buckets. Twenty worker ants are placed in each test pot about 24 hours before the start of the test. This pretreatment holding period allows the ants to recover from the handling and become oriented to the container.

Candidate chemicals, depending on solubility, are dissolved directly in the food material, for example peanut or soybean oil or 10 percent sucrose solution. The toxic solution is offered to the ants on cotton plugs saturated with the material and placed in the test chamber in small vial caps. Materials that are insoluble in the food materials are mixed directly into peanut butter or are dissolved in acetone, and this solution is then mixed with peanut butter and the acetone is then evaporated. The peanut butter is offered to the ants in vial caps. Preliminary tests with all chemicals are conducted at concentrations of 1.0, 0.1, and 0.01 percent. Chemicals that give complete kill at the lowest concentration are diluted and further tested until the minimum concentration giving 90 percent or greater kill is determined.

The ants are allowed to feed as they desire on the toxic bait for 24 hours. After this exposure, the toxicant is removed and the ants remain without food for an additional 24 hours. At the end of this time, new vial caps containing cotton plugs saturated with neat soybean or peanut oil are placed in the chamber for the remainder of the test period. Mortality counts are made at 1, 2, 3, 6, 8, 10, 13, and 14 days after initial exposure of the ants to the toxicant. Each test consists of two replications. Room temperature is maintained at 27° ± 2° C.

All candidate bait toxicants are classified by effectiveness according to the following system modified from that given by Lofgren et al. (*10*). Delayed toxicity is defined as mortality of less than 15 percent after 24 hours and more than 89 percent at the end of the test.

Class I.—Compounds that give insufficient kill at the preliminary concentrations (less than 90 percent kill at the end of the test period).

Class	*Effectiveness*
Ia	Maximum kill 0–29 percent.
Ib	Maximum kill 30–59 percent.
Ic	Maximum kill 60–89 percent.

Class II.—Compounds that kill too quickly at the higher concentrations but give insufficient kill at the lower concentrations, that is 15 percent or more kill after 24 hours and 90 to 100 percent at the end of the test period at the higher concentrations, but less than 90 percent kill with the lower concentrations at the end of the test period.

Class	*Effectiveness*
IIa	Fast kill at 1.0 percent.
IIb	Fast kill at 1.0 and 0.1 percent.
IIc	Fast kill at 1.0, 0.1, and 0.1 percent and failed to give delayed kill at any lower concentration.

Class III.—Compounds in which there is no greater than a ninefold difference between the minimum and maximum concentrations that exhibit delayed toxicity.

Class	*Effectiveness*
IIIa	Delayed toxicity exhibited between 0.1 to 1.0 percent.
IIIb	Delayed toxicity exhibited between 0.01 to 0.1 percent.
IIIc	Delayed toxicity exhibited between 0.001 to 0.01 percent.

Class IV.—Compounds in which there is at least a 10-fold but not greater than 99-fold difference between the minimum and maximum concentrations that exhibit delayed toxicity.

Class V.—Compounds in which there is at least a hundredfold difference between the minimum and maximum concentrations that exhibit delayed toxicity.

Field Tests

Toxicants

Table 1 lists the 24 chemicals selected on the basis of laboratory tests and availability for field tests against natural infestations of red imported fire ants. All compounds except one were class III or greater in laboratory tests. Baits containing Kepone (decachlorooctahydro-1,3,4 - metheno - 2*H* - cyclobuta[*cd*]pentalen-2 - one; AI3–16391) or mirex were applied as a standard for comparison in all tests.

Formulations and rates of application

Five bait formulations were used to evaluate the effectiveness of the toxicants, but not all toxicants were tested in every formulation. The formulations used and the rates of application were as follows:

(*1*) *White flour bait.*—These baits were formulated as an oil slurry composed of 50 or 56 percent white flour; 47, 43, or 42 percent soybean or peanut oil and toxicant; and 3, 1, or 2 percent monoglycerides. The following toxi-

TABLE 1.—*Chemicals selected for field tests against natural infestations of red imported fire ants*

Item No.	AI3 No. (AI3–)	Chemical	Common name or other designation[1]
1	27933	*O*-(2-Bromophenyl) *O,O*-dimethyl phosphorothioate	Hebrew Univ. RS–13.
2	27932	*O*-(3-Bromophenyl) *O,O*-dimethyl phosphorothioate	Hebrew Univ. RS–12.
3	27931	*O*-(4-Bromophenyl) *O,O*-dimethyl phosphorothioate	Hebrew Univ. RS–11.
4	9735	Chlorinated camphene containing 67%–69% chlorine	Toxaphene.
5	27916	*O*-(7-Chloro-4-benzofurazan-yl) *O*-ethyl ethylphosphonothioate.	Shell SD–23687.
6	24968	2-Chloro-1-(2,5-dichlorophenyl)ethenyl diethyl phosphate	General Chemical GC–3583.
7	17957	*O*-(3-Chloro-4-methyl-2-oxo-2*H*-1-benzopyran-7-yl) *O,O*-diethyl phosphorothioate.	Coumaphos.
8	26184	1-Chloro-2-nitro-4-(trifluoromethyl)benzene	....
9	25586	*S*-[[(4-Chlorophenyl)thio]methyl] *O,O*-dimethyl phosphorodithioate.	Methyl Trithion.*
10	27040	*N*-(1,1a,3,3a,4,5,5,5a,5b,6-Decachlorooctahydro-2-hydroxy-1,3,4-metheno-1*H*-cyclobuta[*cd*]pentalen-2-yl) acetamide.	Hooker HRS–1362.
11	27937	*O*-(2,4-Dibromophenyl) *O,O*-dimethyl phosphorothioate	Hebrew Univ. RS–17.
12	17470	*O*-(2,4-Dichlorophenyl) *O,O*-diethyl phosphorothioate	Dichlofenthion.
13	25647	*O*-(2,4-Dichlorophenyl) *O*-methyl (1-methylethyl) phosphoramidothioate.	Zytron.*
14	50812	6,8-Dimethylpyrimido [5,-4-*e*]-1,2,4-triazine-5,7(6*H*,8*H*)-dione.	Fervenulin.
15	25616	*O*-Ethyl *O*-[4-(ethylsulfinyl) phenyl] methylphosphonothioate.	BAY 30749.
16	27935	*O*-(2-Fluorophenyl) *O,O*-dimethyl phosphorothioate	Hebrew Univ. RS–15.
17	23447	1,2,3,4,7,7,-Hexachloro-5-(dichloromethyl) bicyclo[2.2.1]hept-2-ene.	Hercules 426.
18	25562	4,5,6,7,8,8-Hexachloro-1-fluoro-3a,4,7,7a-tetrahydro-4,7-methanoindene.	1-Fluorochlordene.
19	15949	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-1,4-*endo-exo*-5,8-dimethanonaphthalene.	Aldrin.
20	22376	1,2,3,4,10,10-Hexachloro-1,4,4a,5,8,8a-hexahydro-5,8-epoxy-1,4-methanonaphthalene.	Shell 52–RL–45.
21	25700–X	6,7,8,9,10,10-Hexachloro-1,5,5a,6,9,9a-hexahydro-3-methyl-6,9-methano-2,4-benzodioxepin, chlorinated to contain 70% total chlorine.	BAY 38920.
22	25701–X	1,4,5,6,7,7-Hexachloro-3-[(2-hydroxy-1-methylethoxy) methyl]bicyclo[2.2.1]hept-2(or 5)-ene-2-methanol, chlorinated to contain 65% total chlorine.	BAY 38500.
23	22377	3,4,5,6,9,9-Hexachloro-1a,2,2a,3,6,6a,7,7a-octahydro-2,7-epoxy-3,6-methanooxireno[*b*]naphthalene.	Shell 52–RL–71.
24	7422	3-(Trifluoromethyl) benzenamine	....

[1] An asterisk indicates that the name is a trademark.

cants were tested at the indicated concentrations in the white flour bait: toxaphene, 0.5 percent; aldrin, 0.01 and 0.025 percent; 1-fluorochlordene, 0.0025 and 0.005 percent; BAY 38920, 0.02 and 0.05 percent; Methyl Trithion, 0.05 and 0.1 percent; dichlofenthion, 0.25 and 0.5 percent; and coumaphos, 0.01, 0.02, 0.05, and 0.1 percent. All white flour baits were applied at 6.0 lb/acre.

(*2*) *Peanut butter bait*.—These baits were also formulated as oil slurries with the toxicant mixed into the peanut butter at the appropriate concentration. The toxicants tested in peanut butter baits and the concentrations were: Hercules 426, 0.02 and 0.05 percent; BAY 38500, 0.01 and 0.025 percent; BAY 38920, 0.01 and 0.025 percent; GC–3583, 0.2 and 0.4 percent; Methyl Trithion, 0.1 and 0.25 percent; coumaphos, 0.02 and 0.05 percent; BAY 30749, 0.005 and 0.0125 percent; and AI3–26184 and AI3–7422, 2.0 percent. All peanut butter baits were applied at 6.0 lb/acre.

(*3*) *Corncob grits bait.*—These baits, composed of 85 percent corncob grits and 15 percent soybean oil and toxicant, were made by dissolving the toxicant at the appropriate concentration into the oil and pouring or spraying the solution onto the corncob grits as the grits were tumbled in a mixer. Toxicants and the concentrations tested in corncob grits baits were: HRS–1362, 0.075, 0.15, and 0.3 percent; Shell 52–RL–45, 0.0015 and 0.00375 percent; Shell 52–RL–71, 0.00375 percent; BAY 38920, 0.0075, 0.015, and 0.03 percent; 1-fluorochlorodene, 0.01 and 0.02 percent; Shell SD–23687, 0.1 and 0.5 percent; Zytron, 0.075 and 0.15 percent; coumaphos, 0.00375, 0.0075, and 0.015 percent; and fervenulin, 0.1 and 0.25 percent. The corncob grits baits were applied at the rate of 10 lb/acre for all toxicants except the coumaphos baits, which were applied at 20 lb/acre, the 0.15 percent Zytron bait, which was applied at 5.0 lb/acre, and the Shell SD–23687 and fervenulin baits, which were applied at 1.0 lb/acre.

(*4*) *Latex-coated corncob grits bait.*—These baits, composed of 80 percent corncob grits and 20 percent soybean oil and toxicant, were formulated in the same manner as the regular corncob grits baits and then sprayed with a 40 percent aqueous solution of Morton AA–421 acrylic latex (*1*) at the rate of 100 ml/kg of bait. The toxicants tested in the latex-coated baits were Hooker HRS–1362 and Hebrew University compounds RS–11, RS–13, RS–15, and RS–17. HRS–1362 was tested at 0.15 and 0.3 percent, and the other four were tested at a concentration of 0.1 percent. The HRS–1362 baits were applied at a rate of 2.5 lb/acre, and the other four baits were applied at a rate of 1.25 lb/acre.

(*5*) *Sugar beet pulp bait.*—These baits, composed of 77.5 percent sugar beet pulp and 22.5 percent soybean oil and toxicant, were formulated by dissolving the toxicant at the appropriate concentration in the oil and pouring the solution onto the sugar beet pulp as it was stirred in a food mixer. Hebrew University compounds RS–11 and RS–12 and fervenulin were tested at a concentration of 0.45 percent. All applications were at 1.25 lb/acre.

Application

Application of the baits was made with several pieces of equipment, as follows:

(*1*) *Pumps.*—Compressed-air grease pumps or progressing cavity-type pumps (*6*) were jeep-mounted to apply the oil slurry baits. The slurry was forced from the tank through metal or plastic lines and a boom to orifices (5 or 10 ft apart) from which the bait was expelled to fall in narrow bands on the soil surface.

(*2*) *Cyclone hand-seeder.*—These small seeders, which were carried on a shoulder strap by a man, were powered by a hand crank for application of the corncob grits baits. They provided broadcast application with fair uniformity of distribution.

(*3*) *Cyclone power-seeder.*—These units were tractor- or jeep-mounted and driven by a small electric motor. The power-seeders were used for all the granular baits and provided a broadcast application with good uniformity of distribution.

(*4*) *Buffalo Turbine blower.*—This unit was jeep-mounted and powered by the power-takeoff unit. The blower was used for the corncob grits baits and provided a broadcast application with fair uniformity of distribution.

(*5*) *Gandy row-crop applicators.*—These were fertilizer or seed applicators modified to drop the bait onto vertically spinning propellers. This unit provided a broadcast application with excellent uniformity of distribution. It was used for the corncob grits baits.

Plots and evaluation procedures

All tests were conducted in permanent pasture in southern Mississippi or northern Florida. Plot size ranged from 0.5 to 12 acres. In those tests in which large areas were treated, subplots of 0.75 to 2.5 acres were established within the treated area for pretreatment and posttreatment counts of active mounds. In the smaller tests, the entire plot was counted or a circular subplot was counted within the larger plot. The effectiveness of each treatment was determined by the procedures outlined by Banks et al. (*1*), which consisted of opening, with a spade, each mound on the plots and examining for the presence of live worker ants or de-alated females. A mound was considered active if 20 or more worker ants were found, or with less than 20 if a de-alated female was present. The percentage of reduction at each evaluation was calculated by comparing the number of active mounds present with the pretreatment count.

(*Continued on page 9.*)

TABLE 2.—*Effectiveness of candidate bait toxicants against worker ants in the laboratory*

[Average of 2 or more replications at each dosage level]

Item No.[1]	Chemical	Concentration (%)	Percent knockdown and kill after indicated days								Mortality class[2]
			1	2	3	6	8	10	13	14	
1	Hebrew Univ. RS-13	0.01	1	2	2	12	15	17	26	31	IV
		.1	2	4	11	40	60	75	93	97	...
		1.0	2	45	68	89	92	93	96	98	...
2	Hebrew Univ. RS-12	.01	2	3	5	14	24	35	53	56	IV
		.1	1	3	29	85	99	100	...	...	...
		1.0	14	89	100	...	...	...	...	...	...
3	Hebrew Univ. RS-11	.01	1	2	5	10	17	24	28	34	IV
		.1	2	7	19	54	77	90	97	98	...
		1.0	3	38	69	88	92	95	97	98	...
4	Toxaphene[3]	.005	5	5	5	10	10	...	...	...	IIIb
		.1	0	10	53	80	90	...	...	...	...
		1.0	40	63	85	95	95	...	...	...	...
4	Toxaphene	.01	0	1	2	6	10	11	12	15	Ib
		.1	1	1	1	4	6	7	7	7	...
		1.0	1	6	18	35	45	45	49	50	...
5	Shell SD-23687	.0001	1	4	8	32	43	49	55	59	IIc
		.001	6	23	39	65	72	79	86	88	...
		.01	31	68	82	95	98	99	99	99	...
		.1	97	100	...	...	...	...	...	...	...
		1.0	100	...	...	...	...	...	...	...	...
6	General Chemical GC-3583[3]	.01	0	0	0	0	3	...	...	...	IIIb
		.1	5	23	70	100	...	...	...	...	...
		1.0	18	30	43	83	88	...	...	...	...
6	General Chemical GC-3583	.01	1	5	6	6	6	11	14	15	IIIb
		.1	2	4	9	52	74	80	91	92	...
		1.0	26	51	51	53	55	58	63	63	...
7	Coumaphos	.01	2	12	55	87	97	97	97	97	IIIc
		.1	87	90	97	100	...	...	...	...	...
		1.0	95	97	97	100	...	...	...	...	...
8	AI3-26184	.01	3	3	3	10	10	...	...	...	IIIa
		.25	0	28	50	60	75	...	...	...	...
		.5	3	8	15	35	78	...	...	...	...
		1.0	3	30	50	100	...	...	...	...	...
9	Methyl Trithion[3]	.01	0	0	0	5	8	...	...	...	IIIb
		.05	3	18	33	88	100	...	...	...	...
		.1	3	25	38	80	100	...	...	...	...
		.25	43	93	100	...	...	...	...	...	...

9	Methyl Trithion	.01	0	0	2	2	5	7	12	12	IIIb
		.1	5	15	35	75	90	97	97	97	...
		1.0	37	97	100	...	...	...	...	...	...
10	Hooker HRS-1362	.01	0	0	0	0	0	0	0	0	IV
		.1	0	0	13	65	98	100	...	...	...
		1.0	3	13	20	58	83	95	100	...	...
11	Hebrew Univ. RS-17	.01	0	1	3	4	7	12	20	22	IV
		.1	2	6	47	93	97	99	100	...	...
		1.0	2	78	86	91	93	100	...	...	...
12	Dichlofenthion	.01	2	2	2	2	2	2	2	5	IIIb
		.1	2	2	2	45	77	90	92	92	...
		1.0	57	95	100	...	...	...	...	...	...
13	Zytron	.001	5	5	5	5	5	5	5	10	IIIc
		.01	0	14	41	68	83	88	91	93	...
		.1	95	100	...	...	...	...	...	...	...
		1.0	100	...	...	...	...	...	...	...	...
14	Fervenulin	.01	0	0	0	5	12	20	27	32	IIIa
		.1	2	8	28	61	66	71	74	76	...
		.5	2	17	40	86	90	92	97	97	...
		1.0	2	5	20	61	70	73	78	80	...
15	BAY 30749[3]	.01	10	50	57	83	90	...	...	...	IIIc
		.1	60	63	70	95	100	...	...	...	...
		1.0	100	...	...	...	...	...	...	...	...
15	BAY 30749	.01	10	50	57	83	90	...	...	...	IIIc
		.1	60	63	70	95	100	...	...	...	...
		1.0	100	...	...	...	...	...	...	...	...
16	Hebrew Univ. RS-15	.01	1	2	12	60	81	90	95	95	IV
		.1	4	88	96	100	...	...	...	...	...
		1.0	100	...	...	...	...	...	...	...	...
17	Hercules 426[3]	.01	10	13	13	20	25	...	...	...	IIIb
		.1	10	35	73	100	...	...	...	...	...
		1.0	78	100	...	...	...	...	...	...	...
17	Hercules 426	.01	0	0	0	0	0	2	5	5	Ib
		.1	2	2	2	10	10	10	15	17	...
		1.0	5	32	35	37	37	37	37	37	...
18	1-Fluorochlordene	.0025	1	30	39	51	59	64	78	78	IIIc
		.005	8	30	38	49	51	71	81	82	...
		.01	5	33	53	81	91	94	96	99	...
		.025	51	75	90	100	...	...	...	...	...
19	Aldrin[3]	.005	3	3	5	13	13	...	...	...	IIIc
		.01	3	8	45	100	...	...	...	...	...
		.1	93	100	...	...	...	...	...	...	...
		1.0	100	...	...	...	...	...	...	...	...
19	Aldrin	.01	5	25	27	47	47	47	47	47	IIa
		.1	30	67	70	72	75	75	75	75	...
		1.0	57	100	...	...	...	...	...	...	...

See footnotes at end of table.

TABLE 2.—*Effectiveness of candidate bait toxicants against worker ants in the laboratory*—Continued

[Average of 2 or more replications at each dosage level]

Item No.[1]	Chemical	Concentration (%)	Percent knockdown and kill after indicated days: 1	2	3	6	8	10	13	14	Mortality class[2]
20	Shell 52–RL–45	.001	1	1	3	3	8	19	53	56	IV
		.0025	0	3	4	31	66	84	96	98	...
		.005	1	4	15	46	71	83	98	98	...
		.01	1	25	44	84	91	100	...	...	...
		.025	9	39	70	98	100	...	...	...	...
		.05	13	44	61	81	88	100	...	...	...
21	BAY 38920	.005	0	0	0	41	48	50	54	[4]55	IIIb
		.01	0	0	5	49	50	54	69	[4]74	...
		.025	0	20	45	51	54	69	93	[4]94	...
		.05	0	20	40	80	95	99	100	...	...
22	BAY 38500[3]	.01	3	3	82	100	...	...	...	...	IIIc
		.1	43	100	...	...	...	...	...	...	...
		1.0	100	...	...	...	...	...	...	...	...
23	Shell 52–RL–71	.001	4	4	5	9	24	34	60	65	IV
		.0025	0	1	1	24	39	66	93	98	...
		.005	4	5	11	28	64	81	96	99	...
		.01	1	4	15	64	86	94	99	100	...
		.025	5	28	46	83	93	94	96	96	...
		.05	10	41	78	96	99	99	100	...	...
		.1	21	41	66	85	93	99	100	...	...
24	AI3–7422[3]	.01	10	10	15	15	28	...	...	...	IIIa
		.1	15	15	15	25	35	...	...	...	...
		.5	0	0	0	3	18	...	...	...	...
		1.0	8	15	50	100	...	...	...	...	...
...	Kepone (standard)	.005	0	0	0	0	0	1	19	27	IV
		.01	1	1	1	3	3	20	59	64	...
		.025	0	0	0	4	66	91	96	99	...
		.1	0	25	55	88	98	99	99	99	...
		.25	1	41	64	83	91	95	96	98	...
		1.0	24	69	85	99	99	100	...	...	...
...	Mirex (standard)	.01	1	1	1	16	66	80	89	95	V
		.1	0	1	37	85	94	98	99	99	...
		1.0	2	68	95	100	...	...	...	...	...
...	Soybean oil (check)		1	1	1	2	3	4	6	6	...

[1] Item No. corresponds to item Nos. given in table 1.
[2] For explanation of mortality class, see page 3.
[3] Ants exposed continuously to bait for 8 days.
[4] Data for 15th day instead of 14th.

RESULTS AND DISCUSSION

Laboratory Tests

The results of laboratory tests with the 24 chemicals are shown in table 2. Eight of the chemicals were rated as class IV, with Shell 52–RL–45 and Shell 52–RL–71 being the most effective. Both these chemicals gave delayed kill at dosages ranging from 0.0025 to 0.05 percent, a twentyfold range.

Fifteen of the toxicants were class III in initial tests. Eight of these chemicals, however, were tested by the early procedure of continuous exposure to the toxicant for 8 days. When six of these eight were retested by the limited feeding test, three were reclassified as class I, one as class II, and only two remained in class III. One of the chemicals (Shell SD–23687) utilized in the field tests was class II, although in some laboratory tests it gave delayed kill comparable to class III and IV and in one class V. None of the chemicals approached the effectiveness of mirex, which in these tests gave delayed kill at dosages ranging from 0.01 to 1.0 percent, and which has been shown in other testing *(12)* to be effective at dosages ranging from 0.0025 to 1.0 percent, a 400-fold range.

Field Tests

Three of the candidate toxicants (BAY 38920, coumaphos, and 1-fluorochlordene) effectively controlled natural populations of red imported fire ants, but the results obtained with these materials were erratic (table 3). BAY 38920 (AI3–25700–X) reduced the number of active mounds 93 and 99 percent at dosages of 0.54 and 1.36 g/acre, respectively, in white flour baits. In peanut butter baits, dosages of 0.27 and 0.68 g/acre reduced the number of active mounds 71 and 84 percent respectively. When BAY 38920 was applied in corncob grits baits, 0.34 g/acre caused 99 percent reduction in the number of active mounds, 0.68 g/acre caused reductions of 17, 98, and 100 percent in three tests, and 1.36 g/acre caused reductions of 33, 86, 100 percent in three tests. The reason for the extremely low kill obtained in one test at dosages of 0.68 and 1.36 g/acre is unknown. In subsequent tests with BAY 38920, results were erratic at all dosages. Further testing of the compound was not done because of these problems, and development of the compound was ultimately discontinued by the manufacturer.

The only organophosphorus compound effective in field tests was coumaphos (AI3–17957). Dosages of 0.54 and 1.36 g/acre in 6.0 lb peanut butter bait per acre reduced the number of active nests 99 and 96 percent, respectively. In white flour baits, coumaphos was less effective, causing a maximum reduction in the number of active nests of 85 percent at 0.54 g toxicant/acre in 6.0 lb bait/acre. Dosages above or below this level gave poor control. Coumaphos was ineffective in the corncob grits bait, causing a maximum reduction of 23 percent at 0.34 g toxicant/acre in 20 lb bait/acre. Dosages of 0.68 or 1.34 g/acre were less effective.

1-Fluorochlordene (AI3–25562) was the only other compound that gave effective control. A dosage of 0.14 g/acre in 6.0 lb white flour bait per acre reduced the number of active nests by 92 percent. At 0.07 g/acre only 70 percent reduction occurred. In the corncob grits bait, 1-fluorochlordene was totally ineffective, producing only 7 percent reduction at 0.45 g/acre and 0 percent reduction at 0.90 g/acre.

Aldrin (AI3–15949), BAY 38500 (AI3–25701–X), Hooker HRS–1362 (AI3–27040), and fervenulin (AI3–50812) were the only other compounds that eliminated more than 75 percent of the active nests in any test. Kill was erratic from plot to plot, and in subsequent tests these compounds gave poor control.

The Kepone and mirex bait standards consistently gave good control, producing 90 to 100 percent inactivation of nests in all but three tests. Kepone gave a maximum reduction of 88 percent in tests with peanut butter bait; mirex caused a 72 percent reduction at 1.25 lb/acre in the test with sugar beet pulp baits.

An effective bait toxicant has been characterized *(12)* as (1) not repellent to the ants when combined with a bait, (2) readily transferred from one ant to another with ensuing death of both donor and recipient, and (3) having at least a tenfold to a hundredfold and preferably greater difference between the minimum and maximum dosages exhibiting delayed toxicity. The first two characteristics are probably necessary. Repellency, depending upon the degree, can reduce or negate the effectiveness of otherwise effective chemicals. Many of the organophosphates are repellent to the ants, and

(Continued on page 12.)

TABLE 3.—*Effectiveness of promising bait toxicants against natural infestations of red imported fire ants in permanent pasture*

[Average of 3 replications]

Item No.[1]	Chemical	Rate of application: Bait (lb/acre)	Rate of application: Toxicant (g/acre)	Pretreatment count of active mounds	Percent reduction in number of active mounds after indicated weeks[2]: 2	4	8	13	16	26	36
				Corncob grits baits (applied with Gandy applicator)							
10	Hooker HRS-1362	10.0	3.4	114	...	19	64	...	...	...	...
		10.0	6.8	117	...	54	87	...	...	...	...
		10.0	13.6	117	...	53	85	...	...	...	...
18	1-Fluorochlordene	10.0	.45	69	4	7	...	...	...	...	...
		10.0	.90	93	0	0	...	...	...	...	...
20	Shell 52-RL-45	10.0	.068	129	7	2	23	...	40	...	...
		10.0	.17	141	5	5	16	...	46	...	...
21	BAY 38920	10.0	.34	108	88	99	95	...	93	...	...
		10.0	.68	99	0	17	...	...	...	...	...
		10.0	.68	105	60	98	97	...	91	...	...
		10.0	.68	96	89	100	96	...	87	...	...
		10.0	1.36	117	31	0	...	...	...	...	...
		10.0	1.36	111	21	61	80	...	72	...	...
		10.0	1.36	75	95	100	96	...	87	...	...
23	Shell 52-RL-71	10.0	.17	129	7	2	23	...	40	...	...
				Corncob grits baits (applied with Cyclone power-seeder)							
5	Shell SD-23687	1.0	0.45	94	...	27	60	...	26	...	...
		1.0	2.26	84	...	7	63	...	22	...	...
13	Zytron	5.0	3.4	186	0	0	8	...	0	...	...
		10.0	3.4	174	0	0	0	...	0	...	...
14	Fervenulin	1.0	.45	90	...	27	77	...	62	...	...
		1.0	1.12	90	...	38	29	...	76	...	...
...	Mirex (standard)	10.0	3.4	109	74	95	96	...	89	...	...
		10.0	6.8	100	99	99	98	...	97	...	...
				Corncob grits baits (applied with Cyclone hand-seeder)							
7	Coumaphos	20.0	0.34	58	19	23	21	...	...	...	...
		20.0	.68	56	0	16	3	...	...	...	...
		20.0	1.36	88	8	9	9	...	...	...	...
				Latex-coated baits (applied with Cyclone power-seeder)							
1	Hebrew Univ. RS-13	1.25	0.57	57	...	15	4	21	...	0	15

3	Hebrew Univ. RS-11	1.25	.57	60	...	5	0	7	...	0	4
10	Hooker HRS-1362	2.5	1.7	62	...	23	57	66	...	75	...
		2.5	3.4	62	...	30	53	62	...	77	...
11	Hebrew Univ. RS-17	1.25	.57	55	...	1	0	7	...	0	0
16	Hebrew Univ. RS-15	1.25	.57	61	...	1	0	4	...	0	0
...	Mirex (standard)	1.25	1.7	55	...	30	57	70	...	65	81
		2.5	3.4	63	...	38	56	86	...	92	...
	Peanut butter baits (applied with grease or cavity pump)										
6	General Chemical GC-3583	6.0	5.4	60	57	44	47	...	18	...	...
		6.0	10.9	54	29	11	7	...	21	...	...
7	Coumaphos	6.0	.54	72	93	99	90	...	65	...	...
		6.0	1.36	66	86	93	96	...	56	...	...
8	AI3-26184	6.0	54.4	66	12	0	0	...	0	...	...
9	Methyl Trithion	6.0	2.72	66	72	73	51	...	37	...	...
		6.0	6.81	51	69	52	51	...	4	...	...
15	BAY 30749	6.0	.136	63	27	31	16	...	...	...	...
		6.0	.34	45	57	48	0	...	...	...	...
17	Hercules 426	6.0	.54	60	70	55	39	...	11	...	...
		6.0	1.36	27	57	27	19	...	0	...	...
21	BAY 38920	6.0	.27	78	71	68	...	...	...	...	...
		6.0	.68	72	84	77	...	...	...	...	...
22	BAY 38500	6.0	.27	63	70	57	...	...	...	...	...
		6.0	.68	63	82	78	...	...	...	...	...
24	AI3-7422	6.0	54.4	57	0	30	0	...	...	...	...
...	Kepone (standard)	6.0	3.4	73	63	81	88	...	45	...	...
	Sugar beet pulp baits (applied with Cyclone power-seeder)										
2	Hebrew Univ. RS-12	1.25	2.55	130	...	12	15	...	22	16	...
3	Hebrew Univ. RS-11	1.25	2.55	126	...	0	0	...	14	7	...
14	Fervenulin	1.25	2.55	125	...	5	10	...	14	0	...
...	Mirex (standard)	1.25	1.7	124	...	39	62	...	72	70	...
	White flour baits (applied with grease or cavity pump)										
4	Toxaphene	6.0	13.61	84	23	31	...	...	...	...	...
7	Coumaphos	6.0	.27	84	41	59	45	...	...	...	...
		6.0	.54	60	57	85	55	...	...	...	...
		6.0	1.36	63	52	24	19	...	...	...	...
		6.0	2.72	96	69	68	31	...	...	...	...
9	Methyl Trithion	6.0	1.36	120	34	47	...	...	...	...	...
		6.0	2.72	111	34	48	...	...	...	...	...
12	Dichlofenthion	6.0	6.81	99	10	22	...	...	...	...	...
		6.0	13.62	69	46	35	...	...	...	...	...

See footnotes at end of table.

TABLE 3.—*Effectiveness of promising bait toxicants against natural infestations of red imported fire ants in permanent pasture* —Continued

[Average of 3 replications]

Item No.[1]	Chemical	Rate of application		Pretreatment count of active mounds	Percent reduction in number of active mounds after indicated weeks[2]						
		Bait (lb/acre)	Toxicant (g/acre)		2	4	8	13	16	26	36
	White flour baits (applied with grease or cavity pump)—Continued										
18	1-Fluorochlordene	6.0	.07	78	1	59	52	...	...	...	...
		6.0	.14	63	62	92	77	...	...	...	...
19	Aldrin	6.0	.27	69	70	82	68	...	...	...	...
		6.0	.68	108	66	79	51	...	...	...	...
21	BAY 38920	6.0	.54	42	86	93	93	...	49	...	...
		6.0	1.36	42	99	99	96	...	62	...	...
...	Kepone (standard)	6.0	6.81	48	88	99	97	...	...	...	...

[1] Item No. corresponds to item Nos. given in table 1.
[2] Data corrected by Abbott's formula for reductions on untreated checks.

the reduced kill with increased concentrations of such chemicals as Hercules 426, GC–3583, Methyl Trithion, and coumaphos may be attributed to repellency. Failure of the foraging ants, or the primary feeders on a bait, to pass ingested toxicant on to other colony members or a lack of toxicity in the transferred material would also significantly reduce control.

The third requirement of a broad range of delayed toxicity is more flexible. While delayed action over a wide range of dosages is desirable, and possibly a necessity in some formulations with limited oil content (such as the corncob grits bait), some chemicals with a narrow range of delayed action may give good control of the ants when properly formulated. Other than the Kepone and mirex standards, the three chemicals most effective in our field tests gave delayed kill at only one dosage level in the laboratory tests. The two chemicals (Shell 52–RL–45 and 52–RL–71) that gave delayed kill over the greatest range of dosages (0.0025 to 0.05 percent) in our laboratory tests were ineffective in the field. Normally, compounds with the greatest range of dosages giving delayed action would be expected to provide the highest level of control in the field. Most compounds with a restricted range of effective dosages would be quickly rendered ineffective through dilution as trophallaxis occurred.

The level of hunger of the ants in the field may also strongly affect the performance of chemicals with a limited range of effective dosages. Hungry ants would consume more of the oil containing the toxicant, and dispersal through the colony would be much faster than would be the case with ants that had access to an abundance of alternate foods in the field. This variation in hunger can explain the variability sometimes seen with a given dosage of a chemical from one test to another. The difference also emphasizes the need for replicating a test at several sites to assess fully the potential of a chemical for controlling the fire ants over a large area.

The results of these tests indicate that probably few chemicals in toxic baits, and particularly in the corncob grits formulation, can be expected to give adequate control of imported fire ants. Certain of the toxicants were much more effective in one type of formulation than another, indicating that formulation is important in the performance of a toxicant against the ants. Considerable effort should be devoted to research on formulations and on the factors influencing bait acceptance and harvest in the field.

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