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Organic Phosphates Good Bait Poisons for DDT-Resistant Flies; Herbicide Absorption

INSECTICIDE BAITS

Dry Sugar Baits for the Control of Houseflies

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Extensive tests were conducted in 1953 by the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine to evaluate the effectiveness of dry sugar baits for the control of houseflies resistant to DDT and other chlorinated hydrocarbon insecticides. In laboratory tests sugar baits containing only 0.1% of malathion, Diazinon, or Bayer L 13/59 gave 99% kills of flies in 16 hours. Higher concentrations gave faster kills. Baits stored for 1 month showed no loss of toxicity. In practical tests in open dairy barns and poultry houses applications of 100 grams of the bait per 2500 to 5000 square feet of floor area usually gave reductions of 90% or higher within 4 hours. Five applications per week of baits containing 0.5 and 1.0% of the toxicants maintained highly effective control of flies under adverse conditions. As flies feed on individual grains of sugar, the bait can be scattered so sparsely that animals would be unlikely to eat much of it. The bait is inexpensive, easily prepared, and easily applied from a jar with holes in the lid.

WIDESPREAD RESISTANCE to the chlorinated hydrocarbon insecticides has intensified research on the development of new insecticides and other means of controlling houseflies, *Musca domestica* L. At the Orlando, Fla., laboratory of the Bureau of Entomology and Plant Quarantine the greatest emphasis has been placed on attractant baits. Studies during 1952 and 1953 indicated that baits consisting of an attractant and toxicant in water provided effective control of houseflies when exposed in metal pans or applied lightly on hard-surfaced floors of barns with a garden sprinkling can (*1*, *2*). However, the exposure of large quantities of poison bait in pans might be too hazardous for practical use, and spoiled baits create a disposal problem. The sprinkling-can method of applying baits caused unsightly staining of hard-surfaced barn floors, and the treatments were not highly effective on absorbent surfaces, such as earthen floors.

In the course of studies with liquid baits it was observed that flies were attracted to and fed on the dry residue on barn floors for several hours after the bait had been applied. This observation suggested that a dry bait might be effective against flies and at the same time overcome the objections to liquids. In subsequent laboratory tests it was found that dry granulated sugar was eaten more readily than aqueous sugar solutions, and combined with certain phosphorus insecticides was effective in killing houseflies. Although baits are still effective after storage for 28 days, daily application of small amounts of sugar minimizes danger to small animals and eliminates residual hazards. The most promising combinations of sugar and toxicants were tested extensively for the control of resistant flies in dairy barns and poultry houses in the vicinity of Orlando. This paper presents the results of the laboratory and field investigations.

Laboratory Studies

Tests were conducted to compare the effectiveness of dry granulated-sugar baits containing Diazinon [*O,O*-diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) thiophosphate], malathion, or Bayer L 13/59 (a dialkyl phosphonate). The toxicants were mixed with the sugar at concentrations of 5, 2, 1, 0.5, and 0.1% and ground in a mortar. Technical

Table I. Toxicity of Dry Sugar Baits Containing Bayer L 13/59, Diazinon, or Malathion in Cage Tests Against Houseflies

Toxicant and % Concn.	Per Cent Mortality				
	15 min.	30 min.	1 hour	16 hours	24 hours
L 13/59					
5	19	67	92	100	100
2	22	55	76	100	100
1	16	59	92	100	100
0.5	6	22	57	100	100
0.1	0	1	25	99	100
Diazinon					
5	13	57	92	100	100
2	12	40	77	100	100
1	15	45	69	100	100
0.5	18	44	67	100	100
0.1	16	41	73	99	100
Malathion					
5	11	51	79	100	100
2	16	56	81	100	100
1	10	42	80	100	100
0.5	8	46	83	100	100
0.1	2	18	52	99	100

L 13/59 and commercial 25% wettable powders of Diazinon and malathion were used. One-half-gram samples of the various baits were placed in uncovered 2-inch Petri dishes and exposed inside small cylindrical screen-wire cages containing 20 female flies of the highly DDT-resistant Orlando No. 1 strain. Every generation of this strain for the past 8 years has been heavily sprayed with DDT, and the adults are now almost completely immune to this insecticide. Mortalities were recorded at various intervals after exposure during a 24-hour period. Averages of four tests with each bait on different days against different lots of flies are given in Table I.

The flies were attracted to and fed readily on the baits. All three toxicants were highly effective, even the 0.1% concentration showing 99% kill in 16 hours. The lower concentrations of each insecticide appeared to be slower in action than the higher concentrations, but the differences were neither great nor consistent. Some of the variations in results may reflect the promptness with which the flies started to feed, rather than differences in the effectiveness of the baits.

Sugar baits containing 1% of the toxicants were held at room temperature in 100-ml. beakers covered with pieces of paper for observation of possible physical changes and for determining the effect of storage on their toxicity. Results of tests after 14 and 28 days of storage in comparison with freshly made mixtures are given in Table II.

The stored baits containing malathion and L 13/59 were as effective as freshly prepared baits in both the 14- and 28-day tests. The Diazinon bait was somewhat slower in action after 28 days, but still caused complete kill of flies within an exposure period of 16 hours, indicating little if any loss of toxicity during storage. Relative humidity was exceptionally high during the storage period and the L 13/59–sugar mixture absorbed so much moisture that it could not be applied with a salt shaker. There was slight adherence of the sugar crystals in the samples containing Diazinon and malathion, but the material separated readily when shaken and was satisfactory for use.

Field Studies

Dairy Barns Field tests were run in a number of unscreened dairy barns heavily infested with flies that were highly resistant to all the chlorinated hydrocarbon insecticides. Sugar containing 1% of insecticide was used in early tests, but concentrations of 0.25 and 0.5% were tried late in the season. As in the laboratory tests, commercial 25% wettable powders of Diazinon and malathion and technical L 13/59 were used, and mixing was done with a mortar and pestle. One hundred grams of sugar bait was sifted lightly on the cement floors of dairy barns where flies congregated in the greatest numbers during the daytime. A pint fruit jar with small holes punched in the lid was used for the applications.

The abundance of flies was determined by counting those that alighted on a piece of hardware cloth laid over two Petri dishes containing equal parts of malt and water and exposed in locations where the density of flies was greatest. Counts were made on 3 days before the tests were started and on 5 days each week (Monday through Friday) thereafter. Treatments were also applied daily Monday through Friday. The degree of control was based on the difference between the counts of flies before treatment and the daily counts thereafter. Results of the tests are summarized in Table III.

Some flies died within 10 to 20 minutes after the application of sugar containing 1% of the three insecticides, and within 4 hours reductions of at least 97% were indicated. Concentrations of 0.5% of the insecticides were somewhat slower in action, but in most of the tests 90% or higher reductions occurred within 4 hours.

With two exceptions, every application of bait containing 0.5 or 1% of malathion and 1% of Diazinon or L 13/59 showed more than 90% reduction after 24 hours. The average reducs tions for each series of application ranged from 93 to 98%, which represents excellent control of flies under

Table II. Toxicity to Houseflies of Dry Sugar Baits Containing 1% of L 13/59, Diazinon, or Malathion at Various Intervals After Preparation

Date Tested	Age of Bait, Days	Per Cent Mortality			
		15 min.	30 min.	1 hour	16 hours
		L 13/59			
Aug. 6	0	50	80	100	100
20	14	13	58	95	100
	0	23	53	90	100
Sept. 3	28	0	53	85	100
	0	0	28	65	100
		Diazinon			
Aug. 6	0	10	53	80	100
20	14	43	90	98	100
	0	28	93	98	100
Sept. 3	28	0	0	35	100
	0	10	30	83	100
		Malathion			
Aug. 6	0	10	33	75	100
20	14	25	88	100	100
	0	8	40	98	100
Sept. 3	28	0	20	75	100
	0	5	53	65	100

Table III. Effectiveness of Dry Sugar Baits Against Natural Infestations of Houseflies in 11 Dairy Barns

(100 grams of bait per application except as indicated)

Toxicant and % Concn.	Pretreatment Count of Flies	No. of Applications	% Initial Reduction[a]	% Daily Reduction	
				Range	Average
Malathion					
1.0	245	13	..	81–98	93
0.5	410	8	99	94–99	98
0.5	190	7	99	85–98	95
0.25	164	8	27	58–92	78
Diazinon					
1.0	184	15	97	94–99	98
0.5	122	10	67	69–97	87
0.5	160	13	98	65–95	83
0.5	211	6	97	53–99	83
L 13/59					
1.0	212	15	97	93–100	98
0.5	249	4	79	48–75	65
		6[b]	..	61–95	78
0.5	176	5	90	96–99	97

[a] 4 hours after initial application.
[b] Rate of application 150 grams.

conditions generally favorable for fly breeding. Baits containing 0.5% of Diazinon or L 13/59 were definitely less effective than those containing 1% of these toxicants, as indicated by the lower average control for comparable series of applications. Nevertheless, repeated applications over a period of 2 weeks eventually produced good control in most of the test sites. This was also true in one series of applications of bait containing 0.25% of malathion.

Poultry Houses Additional tests were conducted to determine the effectiveness of sugar baits in two small poultry houses, where conventional insecticide treatments had failed to provide satisfactory control of houseflies. One of these buildings was open on all sides, and the chickens were confined above the floor in coops with hardware-cloth bottoms, which allowed the manure to drop to the ground. The other building was of approximately the same size, but was simply a large pen with boarded or screened sides, and the chickens moved about freely inside. In both houses the manure was allowed to accumulate to a depth of several inches for a month or more before removal. At the time the tests were started, breeding was exceptionally heavy and the adult flies were more numerous than in most of the dairy barns in which tests were under way.

Sugar baits containing 1% of Diazinon, L 13/59, or malathion were prepared and applied in the same manner as in the dairy barns. With Diazinon and L 13/59, 100 grams of bait per application was used throughout the tests, but with malathion it was necessary to increase the dosage to 400 grams when the usual application failed to reduce the large fly population. The material was sifted under and about the bases of the coops and any other locations where large numbers of flies congregated. Treatments were made daily Monday through Friday. Counts of flies were made before and after treatment and reductions calculated in the same manner as in the dairy tests. Results of the tests are given in Table IV.

Sugar baits containing 1% of Diazinon or L 13/59 gave effective control of houseflies in two poultry houses. Daily reductions varied somewhat during the first 2 weeks, and there was considerable restoration of fly populations over week ends, when treatments were not made. However, uniformly high control was maintained during the third week of treatment and, as breeding pressure had been greatly reduced, fly populations remained at a low level for a week or more after treatments were discontinued.

Four applications of a 1% malathion bait failed to cause any reduction in the poultry house previously treated with Diazinon bait. Thousands of dead flies were observed, but the normal application of 100 grams of bait apparently was not sufficient to cause a reduction in the face of the heavy emergence of new adults. When the rate of application was increased to 400 grams, reductions of 79% were indicated in less than 4 hours and 83% in 24 hours. Subsequent treatments were highly effective, reductions ranging from 87 to 99%. The results of this test indicate that the quantity of bait needed to establish and maintain good control will vary with the density of the infestation and the breeding potential. Although not demonstrated during the short duration of this test, previous tests suggest that, once fly breeding has been reduced to a low level by repeated treatments, normal rates of application will maintain satisfactory control.

Discussion

The results of these tests indicate that dry sugar baits offer a promising means of controlling houseflies in locations where the more conventional methods are no longer effective. In most of the dairy barns sugar baits gave a higher degree of control than liquid-bait formulations in earlier tests. However, as with the liquid baits, frequent applications were necessary to maintain satisfactory control. Omission of treatments over week ends usually resulted in a noticeable increase in the fly density, at least until fly breeding had been reduced to a negligible level by repeated treatments over a period of 2 to 3 weeks.

Regardless of the insecticide employed, this type of bait appears to be comparatively safe and effective. Since flies feed on the individual grains of sugar, it can be scattered thinly, so that an animal would have little chance of eating more than a small fraction of it. The bait is very economical. Only 1 gram of insecticide is required for each application of the sugar bait in a typical dairy barn with 6000 square feet of ceiling and wall surface, whereas residual treatments of 100 mg. per square foot would require 600 grams of insecticide and would have to be repeated several times during the fly-breeding season. Also, the sugar-insectide baits are suitable for mixing with water and applying with a sprinkling can, which may be preferable under certain conditions. In either method the cost of equipment and time for application are negligible and these are important factors to people concerned with fly control.

Table IV. Effectiveness of Dry Sugar Baits Against Natural Infestations of Houseflies in Two Poultry Houses

(100 grams of bait per application except as indicated)

Location	Toxicant (1%)	Pretreatment Count of Flies	No. of Applications	% Initial Reduction[a]	% Daily Reduction	
					Range	Average
Darnold	L 13/59	142	15	90	61–99	90
Saxton	Diazinon	159	15	97	49–98	83
	Malathion	240	4	0	0–0	0
		439	5[b]	79	83–99	91

[a] Four hours after initial application.
[b] Rate of application 400 grams.

Summary

Laboratory and field tests were conducted to evaluate the effectiveness of dry baits consisting of granulated sugar with malathion, Diazinon [*O,O*-diethyl *O*-(2-isopropyl-6-methyl-4-pyrimidinyl) thiophosphate], or Bayer L 13/59 against houseflies, *Musca domestica* L. In laboratory tests the lowest test concentration of 0.1% of toxicant with sugar gave 99% kill of flies in 16 hours. Higher concentrations provided considerably faster kills. Baits containing malathion and L 13/59 showed no loss of toxicity after 1 month's storage, and the Diazinon bait was also still highly effective, although slightly slower in action.

Practical tests were run in dairy barns and poultry houses heavily infested with resistant houseflies. The baits were sifted on the floors and other locations where flies congregated, usually at the rate of 100 grams per application. Some flies died within 10 to 20 minutes after the initial applications in dairy barns, and in most of the tests reductions of at least 90% were indicated after 4 hours. Repeated applications (five per week) of baits containing 0.5 and 1% of the toxicants over a period of 2 to 3 weeks gave highly effective control in most of the dairy barns. Effective control was also obtained in poultry houses with repeated applications of baits containing 1% of the toxicants.

As flies feed on individual grains of sugar, the bait can be scattered sparsely, so that an animal would have little chance of eating more than a small fraction of it. The dry sugar bait is inexpensive and easily prepared, and the cost of equipment and time for application are negligible.

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HERBICIDE ACTION

Absorption and Translocation of Carbon-14 Applied As O-Isopropyl *N*-Phenyl Carbamate in *Avena* and *Zea*

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Advancement in the knowledge of chemical weed control may well depend on an extension of fundamental research on growth processes in plants on one hand and study of the mode of action of herbicides on the other. Studies on the herbicidal value of O-isopropyl *N*-phenyl carbamate were therefore undertaken to gain further information on some of the problems concerning its use as a grass killer. Information regarding its actual entry into the tissue of corn and oat plants and the transport of this herbicide from the point of entry to the other parts of plants was obtained. The results show that O-isopropyl *N*-phenyl carbamate was absorbed through the cut surface of leaves, cut surfaces of roots, and intact roots (in descending order of absorption rate). Intact leaf surfaces did not absorb it in appreciable amounts. The absorption through roots was greater in corn plants than in oat plants, which indicated the specific difference in the rate absorption. Soil application or application of this chemical immediately after cutting the grass should give better control.

ABSORPTION AND TRANSLOCATION of *O*-isopropyl *N*-phenyl carbamate (IPC) in plants have had little study. Mitchell and Marth (*3*) and Ennis (*1*) noted that soil application is necessary to obtain an effective kill, suggesting that *O*-isopropyl *N*-phenyl carbamate is normally absorbed by roots, not by the leaves. Preliminary work with radioactive tracers in this laboratory suggests that the material is translocated, but not in appreciable quantities.

The purpose of this investigation was to study the extent of absorption and translocation after application of carbon-14–labeled *O*-isopropyl *N*-phenyl carbamate (2.82×10^5 counts per minute per mg., labeled on the secondary carbon of the isopropyl group) to intact and cut leaves and roots of oat (*Avena sativa*) and corn (*Zea mays*) plants, and to analyze the plant parts for radioactivity.

Experimental Methods

Plant Culture Oat plants (*Avena sativa*, var. gray winter) and corn plants (*Zea mays*, var. yellow flint) were grown under greenhouse conditions in flats filled either with Chehalis sandy loam which had previously been treated with 10-9-4 fertilizer, or with coarse Dantor (exploded silica) and kept watered with nutrient solution until they were ready for treatment. (One liter of nutrient solution contains 2.3