

ARTICLES

EFFECTIVENESS OF INSECTICIDAL RESIDUES ON U. S. ARMY TENTING AGAINST *ANOPHELES* SPP.^{1, 2}ROBERT M. ALTMAN³ AND JAMES B. GAHAN⁴

The tests reported here are a continuation of the cooperative program sponsored jointly by the Armed Forces Pest Control Board and the Entomology Research Division, Agricultural Research Service, United States Department of Agriculture, to encourage entomologists of the Department of Defense to evaluate insecticides in the areas of the world where U. S. military personnel are deployed.

In the initial phases of most military conflicts and in many field exercises, the troops usually utilize canvas tents for shelter. When appropriate, the inner surface of these tents has been sprayed with DDT or malathion, but complaints have been frequent about the ineffectiveness and injurious effects of these applications.

At the request of the Surgeon General, Department of the Army, the Gainesville, Florida laboratory of the Entomology Research Division undertook tests to determine the effects of insecticidal residues on canvas tenting.

For the laboratory tests, 929.03-square-centimeter (1 square-foot) sections of standard tenting were attached to plywood panels and sprayed with insecticides at the rate of 2 grams per square meter. The panels were then air-dried and stored indoors at a temperature of 80° F. and a relative humidity of 45 percent until time

for the assays. The assays were made by exposing adult female *Anopheles quadrimaculatus* Say from the susceptible strain colonized in the laboratory to the treated surfaces the first and fourth weeks after treatments and at 4-8 week intervals thereafter throughout a test period of 6 months. On each occasion 20 females, restrained under petri dish tops, were exposed to the treated surface for one hour. After the exposure, the mosquitoes were transferred to clean containers and held for 24-hour mortality counts. The results are shown in Table 1.

Dursban, Diazinon, and Bay 39007 wettable powders and emulsifiable concentrates were all effective for 24 weeks. Mobam wettable powder was also effective for 24 weeks, but the emulsifiable concentrate failed between the first and the fourth week. Malathion, chlordane, and DDT were ineffective the first week.

In 1967, field tests of the insecticidal residues were made in the Panama Canal Zone.

The malathion 57 percent emulsifiable concentrate and the DDT 75 percent wettable powder were procured under military specifications. The other insecticides were obtained from the various chemical companies by the Gainesville, Florida laboratory.

The weather at Fort Sherman during the tests was as follows:

Days with rain	40
Total rainfall	19.46 inches
Maximum temperature, range	77 to 94° F.
Minimum temperature, range	70 to 78° F.
Mean temperature, range	75 to 86° F.

¹ Mention of a proprietary product does not necessarily imply endorsement of any products mentioned by the U. S. Army or by the U. S. Department of Agriculture.

² The field tests were supported by U. S. Army, Medical Research and Development Command Grant No. 8977.

³ Armed Forces Pest Control Board, Walter Reed Army Medical Center, Washington, D. C. 20012.

⁴ Entomology Research Division, Agr. Res. Serv., U.S.D.A., Gainesville, Florida 32601.

TABLE 1.—Toxicity of insecticidal residues applied to tenting at a rate of 2 gram/m² against adult *A. quadrimaculatus*. (Test conducted at the U.S.D.A. laboratory, Gainesville, Florida.)

Insecticide	Type formulation	Percentage kill in 24 hr. after indicated weeks of aging					
		1	4	8	12	20	24
Malathion	WP	78	...	...	...	...	...
	EC	88	...	...	...	...	...
Chlordane	WP	58	...	...	...	...	...
	EC	40	...	...	...	...	...
Mobam® (benzo[<i>b</i>]thien-4-yl methylcarbamate)	WP	100	100	100	98	95	100
	EC	100	28	13	...	95	100
Dursban® (<i>O,O</i> -diethyl <i>O</i> -3,5,6-trichloro-2-pyridyl phosphorothioate)	WP	100	100	100	98	100	100
	EC	100	100	100	88	100	100
Diazinon	WP	100	100	100	100	100	100
	EC	100	100	100	100	100	100
Bay 39007 (<i>o</i> -isopropoxy-phenyl methylcarbamate)	WP	100	100	100	100	100	100
	EC	100	100	100	100	100	100
DDT	WP	23	13	...	...	...	...
	EC	78	20	3	...	...	...

On July 28 the temperature inside one tent rose from 83° at 7 a.m. to 92° at 10 a.m. and the relative humidity decreased from 98 percent at 7 a.m. to 66 percent at 11 a.m.

The first series of tests was made from June 29 to August 11 with the general purpose tents occupied by the troops at Fort Sherman, C.Z. The insecticides were applied to 30-in. panels on the roofs of the tents with a two-gallon compressed air sprayer at the rate of 1 gram/m² except for DDT which was applied at a rate of 2 gram/m². Treated areas were separated by a 30-in. untreated panel. Each treatment was replicated once, and exposures to the duplicate panels were made on alternate weeks. Satisfactory treatments were obtained with DDT wettable powder and with the emulsifiable concentrates, but the other wettable powders had a tendency to settle out and clog the nozzles, which caused uneven treatments. Also, all the wettable powders were aesthetically unsatisfactory because the residues were unsightly. There were no complaints

about odor, and none of the chemicals caused the tents to leak. Each week, 20 female *Anopheles albimanus* Wiedemann, also from the susceptible strain reared at the laboratory, were exposed to the treated surfaces between 7 and 8 a.m. by confining them under WHO plastic cones. After the exposure, they were transferred to clean containers, given sugar water, and held for 24 hours at 80° F. Also, two groups of 20 mosquitoes placed on the roofs of untreated tents for the same period were used as controls. The maximum control mortality was 5 percent. The results are shown in Table 2.

The second series of field tests was also conducted at Fort Sherman from July 13 to August 11, again with general purpose tents occupied by troops. The rate of application and method of treatment were the same except that an entire side of the roof was treated with one insecticide. Each treatment was replicated once, and the exposures to the duplicates were made in alternate weeks. The results of the tests are shown in Table 3.

TABLE 2.—Toxicity of insecticidal residues applied to tenting at a rate of 1 gram/m² in tests against *A. albimanus* adults. (Tests conducted at Ft. Sherman, C.Z.)

Insecticide	Type formulation	Percentage kill in 24 hr. after indicated weeks ^a					
		1	2	3	4	5	6
Malathion	EC	5	5	10	15	0	...
Dursban® (<i>O,O</i> -diethyl <i>O</i> -3,5,6-trichloro-2-pyridyl phosphorothioate)	WP	100	100	100	100	100	65
	EC	100	100	100	100	100	35
Diazinon	WP	100	100	5	0	...	...
	EC	95	100	...	0	10	...
Bay 39007 (<i>o</i> -isopropoxyphenyl methylcarbamate)	WP	100	100	100	30	0	...
	EC	5	10	25	15	10	...
DDT ^b	WP	15	5	50	35	0	...

^a Tents were taken down after 6th week.

^b DDT applied at rate of 2 gram/m².

The third series of tests was made from October 31 to December 12 on a general purpose tent at Corozal, C.Z. The method and rate of treatment were the same as in the first tests, and the replicates and exposures were as before. The rainfall at Corozal during the tests was very heavy, and the temperatures were about the same as those at Fort Sherman. The results are shown in Table 4.

Also, one additional test was made to determine whether the mosquitoes would avoid surfaces treated with Dursban. One-half a tent roof was sprayed with Dursban emulsifiable concentrate at the rate of 1 gram/m². Then 11 days later, at 5:30

a.m., 100 engorged *A. albimanus* were released inside the tent, and one hour later, 30 mosquitoes were collected from the untreated and 31 were collected from the treated portions of the tent and held for 24-hour mortality counts. The results were as follows:

	Dead	% Mortality
Untreated Surface	2 of 30	6.7
Treated Surface	29 of 31	94

In Panama, both formulations of Dursban were superior to the other test chemicals, and the emulsifiable concentrate ap-

TABLE 3.—Toxicity of insecticidal residues applied as emulsifiable concentrates to tenting at the rate of 1 gram/m² in tests against *A. albimanus* adults. (Tests conducted at Ft. Sherman, C.Z.)

Insecticide	Percentage kill in 24 hr. after indicated weeks ^a			
	1	2	3	4
Malathion	90	100	15	0
Dursban® (<i>O,O</i> -diethyl <i>O</i> -3,5,6-trichloro-2-pyridyl phosphorothioate)	100	100	30	100
Diazinon	100	100	0	5
Bay 39007 (<i>o</i> -isopropoxyphenyl methylcarbamate)	5	...	5	5

^a Tents were taken down after 4th week.

TABLE 4.—Toxicity of insecticidal residues applied as emulsifiable concentrates to tenting at the rate of 1 gram/m² in tests against *A. albimanus* adults.
(Tests conducted at Corozal, C.Z.)

Insecticide	Percentage kill in 24 hr. after indicated weeks						
	1	2	3	4	5	6	7
Malathion	95 100	95 90	0 0	10 0	0 5	0 5	....
Dursban® (O,O-diethyl O-3,5,6-trichloro-2- pyridyl phosphorothioate)	100 100	100 100	100 100	50 55	100 100	95 5	5 0
Diazinon	20 15	0 0	0 5	....	......	....	....
Bay 39007 (o-isopropoxy- phenyl methylcarbamate)	30 0	0 0	0 0	....	......	....	....

peared to be a promising spray for the treatment of Army tenting. The compound produced 100 percent kill for 5 consecutive weeks in one series, for 3 of 4 weeks in another, and for 4 of 5 weeks in the third series. The most durable treatments with Bay 39007 and Diazinon caused 90 to 100 percent mortality for only 2 to 3 weeks, and two of the four applications of each were ineffective the first week.

Dursban, Bay 39007, and Diazinon were much less effective in Panama than in the laboratory tests at Gainesville. However, *A. albimanus* and *A. quadrimaculatus* have similar susceptibility to residual sprays (LaBrecque *et al.* 1961). Therefore, the lower doses of insecticides used in the Panama tests were probably responsible for the difference in results. Also, the hot humid weather in Panama could have been more deleterious to the residues than the moderate temperature and humidity maintained in the laboratory during the Gainesville tests.

Malathion was somewhat better in Panama than in Gainesville but was not a highly effective material in either place.

The failure of the DDT residues on the tenting was surprising because both strains of *Anopheles* used in the tests were susceptible to the insecticide and DDT wettable powder applied on wood surfaces protected from rain and direct sunlight has continued to kill 100 percent of *A.*

albimanus and *A. quadrimaculatus* from the same colonies for over 6 months after a 30- to 60-minute exposure.

SUMMARY. In laboratory tests in Florida, Dursban, Diazinon, and Bay 39007 wettable powders and emulsifiable concentrates applied to canvas tenting at the rate of 2 gram/m² were effective against adult *Anopheles quadrimaculatus* for 24 weeks after a one-hour exposure to the treated surface. Mobam wettable powder was also effective for 24 weeks, but the emulsifiable concentrate failed between the first and fourth weeks. Malathion, chlordane, and DDT were ineffective the first week. In field tests in Panama where U. S. Army general purpose tents were sprayed at the rate of 1 gram/m², Dursban was superior to Diazinon, Bay 39007, and malathion against *Anopheles albimanus*, but DDT was again ineffective. Dursban emulsifiable concentrate is a promising treatment for army tenting.

ACKNOWLEDGMENT. The assistance of SP5, William C. Langston, Environmental Health Division, Office of the Chief Surgeon, HQUSARSO, Ft. Clayton, C.Z. in conducting these tests is gratefully acknowledged.

Literature Cited

- LABRECQUE, G. C., GAHAN, J. B., and WILSON, H. G. 1961. Relative susceptibility of four species of mosquitoes to insecticides residues. Florida Entomologist 44(4):185-188.