LONGEVITY OF INSECTICIDES IN SOIL AS TESTED AGAINST THE EYE GNAT *HIPPELATES COLLUSOR*[1]

MIR S. MULLA

University of California Citrus Experiment Station, Riverside

INTRODUCTION. *Hippelates* eye gnats breed principally in cultivated agricultural land composed of loose and friable soil. They breed to a lesser degree in non-cultivated irrigated land. The normal agricultural practices such as tillage, irrigation, availability of decaying organic matter and disking under cover crops for conditioning of the soil provide ideal conditions for gnat breeding. The adult eye gnats disperse from the breeding grounds and fly to residential and recreational areas, annoying man and domestic animals.

At the present time, a practical approach toward controlling eye gnats in their breeding grounds consists of incorporating residual larvicides into the soil where the gnats are breeding. Selection of a suitable eye gnat larvicide is dictated by factors such as initial effectiveness, residual activity, disappearance of the material from the soil surface before disking in, and side effects of the larvicide on crop plants.

Gathering data on the performance of a larvicide in the field is a tedious task and often a very expensive one. Valuable information on the effectiveness and longevity of larvicides, however, can be readily obtained in the laboratory. Promising materials can thus be singled out for field experimentation against eye gnats.

The effectiveness of organochlorine and organophosphorus insecticides as soil treatments against the eye gnat *H. collusor* was determined in the laboratory (Mulla, 1960a, 1961a). Similarly the loss of activity of the most active organochlorine insecticides in soil against the eye gnat was studied (Mulla, 1960b). Loss of some of these insecticides from soil surface prior to disking under in the field was determined (Mulla, 1960c). As a result of all these studies, DDT, endrin and Shell Development Compound SD-4402 were the only organochlorine insecticides singled out for field trials. Field investigations on these and other materials demonstrated that DDT yielded better and longer control of eye gnats than the other organochlorine insecticides evaluated (Mulla *et al.*, 1960, Mulla, 1961b).

Studies on the initial effectiveness of 27 organophosphorus and carbamate insecticides as soil treatments against *H. collusor* (Mulla, 1961a) showed many of these insecticides to have a high degree of biological activity. However, information on residual activity is also necessary to determine which materials are most promising for use in field trials. Preliminary studies on the longevity of 12 insecticides (9 organophosphorus, 2 carbamate and 1 organochlorine) in soil are reported. Detailed studies on the residual activity of some of these and other insecticides are under way.

METHODS AND MATERIALS. Three 1-gallon quantities (11.5 pounds) of Coachella fine sand (containing 0.15 percent organic matter) were treated with each material listed in Table 2. The amount of soil treated with each material listed in Table 3 was one-half gallon. After treatment the soil was thoroughly mixed and transferred to either one or one-half gallon jars. Prior to storage, water was added to the soil in the jars to obtain an initial moisture content of 13 percent, dry weight basis. The jars were covered with muslin cloth and stored in a greenhouse at 88° ± 2° F.

At 2-month intervals, additional water was added to the soil treated with materials listed in Table 2 to maintain the moisture content at 13 percent. The soil treated

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with the materials listed in Table 1 was maintained at lower moisture content and no additional water was added until after 6 months of storage.

To determine the long term activity, quantities of the treated soil to be tested were air-dried and processed in the same manner used to determine the longevity of organochlorine compounds (Mulla, 1960b). Organic matter (56 grams of alfalfa meal, 28 grams of brewer's yeast, and 28 grams of whole-wheat flour per gallon quantity) was added to the soil and mixed thoroughly. The 1-gallon lots were divided into 10 portions and the 1/2-gallon lots were divided into 5 portions, thus yielding 10 replicates and 5 replicates, respectively. Control treatments were also run during each test. Each portion of the processed soil was placed in a narrow-mouthed pint fruit jar. To the pint jars, 140 ml. of water were added, and each jar was seeded with 200 eggs of the eye gnat *H. collusor*. Gnat emergence was recorded and the percent reduction was determined by comparing the insecticidal treatments with the control treatment.

The percent loss for each material and dosage was determined by reading off the amount of toxicant corresponding to a certain reduction in eye gnat emergence, using the dosage mortality line of the material against the eye gnat (Mulla, 1961a). From the amount of the toxicant present in the soil at the time of testing and the initial amount applied to the soil, it was possible to calculate the percent loss at the testing intervals.

Due to the nature of dosage-response line it was apparent that in cases where the reduction in eye gnat emergence was over 98 percent, the percent loss of a material could not have been adequately determined, although the percent loss could have been appreciable. Reductions in eye gnat emergence over 98 percent are not indicated on the dosage mortality line. Similarly, it was not possible to ascertain the exact losses of materials that produced lower than 5 percent reductions in eye gnat emergence. Reductions of this magnitude could be due to experimental variations. In such cases the apparent losses of materials for practical purposes were considered to be 100 percent.

Results and Discussion. According to previous studies (Mulla, 1961a), Co-Ral, Bayer 25141 (*O,O*-diethyl *O-p*-methyl sulfinylphenyl phosphorothioate), and Bayer 29493 (*O,O*-dimethyl *O*-3-methyl-thiophenyl phosphorothioate) were found to be highly effective against the gnat (Table 1). Therefore, these materials were tested

TABLE 1.—Effectiveness of twelve insecticides as soil treatments against the eye gnat *Hippelates collusor* as determined by their LD_{90} levels in soil

Material	Pounds/ acre LD_{90}	Material	Pounds/ acre LD_{90}
Co-Ral	0.052	Parathion	4.8
Bayer 25141	0.096	Dimethoate	5.0
Bayer 29493	0.131	AC 5727	10.2
G-30494	0.400	Sevin	20.5
Ethion	1.260	Thiodan	33.0
Guthion	1.300		
Delnav	1.640		

at lower dosages but still several times their initial LD_{90} levels. Geigy Chemical Company compound G-30494, Ethion, Guthion, and Delnav were also highly effective, but with lower activity than the above compounds. Guthion was tested at a relatively low dosage, but the remaining three materials were tested at low to moderate dosages. Parathion and Dimethoate, with moderate activity, were tested at moderate dosages. Hercules Powder Company Compound AC-5727 (*m*-isopropylphenyl N-methylcarbamate), Sevin and Thiodan were studied at relatively higher dosages since the activity of these compounds against the gnat is very low.

Bayer 25141 at 1 pound per acre and Ethion at 6 pounds per acre gave almost complete reduction of eye gnats after 7 months of storage (Table 2). After 13 months, Bayer 25141 caused no reduction in eye gnat emergence and was considered to have lost its activity completely. Ethion at 6 pounds per acre after 15 months caused

TABLE 2.—Longevity of insecticides in soil as tested against the eye gnat *Hippelates collusor*[1]

Insecticide and formulation	Dosage, lbs. tox./acre	Avg. gnat emergence per jar (Gnats/J) and % control after (months)								% loss after (months)			
		(3)		(4)		(7)		(13–15)					
		Gnats/J	% Red.	Gnats/J	% Red.	Gnats/J	% Red.	Gnats/J	% Red.	(3)	(4)	(7)	13–15
Bayer 25141 EC 2	1.0	–	–	2	98	1	99	117	0	–	–	–	100
Ethion EC 4	6.0	0	100	–	–	0	100	10	91	–	–	–	79
AC-5727 EC 1.1	11.0	86	17	–	–	–	–	–	–	81	–	–	–
	22.0	93	10	–	–	–	–	109	4	93	–	–	100
Dimethoate EC 4	6.0	–	–	104	5	–	–	–	–	–	97	–	–
Parathion EC 2	5.0	103	1	–	–	–	–	–	–	100	–	–	–
Bayer 29493 EC 2	1.5	–	–	93	15	–	–	–	–	–	98	–	–
Co-Ral EC 1.5	0.5	44	57	–	–	–	–	–	–	93	–	–	–
Guthion EC 1.5	1.5	110	0	–	–	–	–	–	–	100	–	–	–
Control		104	–	109	–	100	–	113	–	–	–	–	–

[1] One-gallon quantities of soil were treated. Initially 700 ml. of water were added per jar. After 6 months 350 ml. of water were added to each of the remaining soil quantities.

good reduction in eye gnat emergence, but 79 percent of the material had been lost. Hercules Powder Company Compound AC-5727, dimethoate, parathion, Bayer 29493, and Guthion lost most or all of their activity after 3 to 4 months of storage. Co-Ral, when applied at 0.5 pound per acre, resulted in a moderate reduction of eye gnats after 3 months of storage but lost 93 percent of its activity.

Geigy Chemical Company Compound G-30494 and Delnav were evaluated at three dosage levels each (Table 3). When tested after 3 months of storage the former compound lost over 90 percent of its activity at all dosage levels and the latter material lost more than half of its activity. Sevin and Thiodan also lost a good portion of their activity after 3 months of storage. Complete loss of activity was ascertained for all five materials, 6 months after start of the storage period.

From these studies it is obvious that Compound AC-5727, Dimethoate, parathion, Bayer 29493, Guthion, Compound G-30494, Sevin, Thiodan, and Delnav would not be suitable for obtaining economical and practical eye gnat control. The information obtained on the longevity of these materials in soil might aid in predicting the suppressing effect on eye gnat populations of these insecticides when they are used as soil treatments for the control of other agricultural pests. Only Bayer 25141, Ethion, and Co-Ral, among all of the materials tested, merit further laboratory and field investigations. These materials have considerable biological activity and are more residual in soil than the other materials.

TABLE 3.—Longevity of insecticides in soil as determined by bio-assaying against the eye gnat *Hippelates collusor* [1]

Insecticide and formulation	Dosage, lbs. tox./acre	Avg. no. gnats/jar and % reduction after (months) (3) Gnats/J	(3) % Red.	(6) Gnats/J	(6) % Red.	% loss after (months) (3)	% loss after (months) (6)
G-30494 EC 2	2	94	12	89	0	93	100
	4	64	40	87	0	95	100
	8	44	59	100	0	97	100
Sevin 50% WP	20	72	32	97	0	58	100
Thiodan EC 2	32	61	43	98	0	38	100
Delnav EC 3	2	78	27	89	0	60	100
	4	61	43	84	0	76	100
	8	45	58	89	0	86	100
Control	—	106	—	87	—	—	—

[1] One-half gallon of soil was used per treatment. Prior to storage 350 ml. of water were added to each jar. Subsequently 200 ml. of water were added to each jar every 2 months.

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