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EVALUATION OF PYRETHRIN AND TWO SYNTHETIC PYRETHROIDS ALONE AND IN MIXTURES WITH MALATHION AS ULV GROUND AEROSOLS AGAINST RICELAND MOSQUITOES

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ABSTRACT. Permethrin, pyrethrin, resmethrin and malathion were tested as ULV ground aerosols against caged, field collected *Anopheles quadrimaculatus* and *Culex quinquefasciatus*. Pyrethrin-malathion, resmethrin-malathion (91%) mixtures were also tested. The synthetic pyrethroids alone were more effective at 1 hr posttreatment than any mixture or malathion alone.

In recent years ultralow volume (ULV) cold aerosol generators have become important for control of adult mosquito populations. For adequate control, mosquito re-infestation following treatment often requires nightly applications of insecticides. Many commonly used insecticides such as malathion require several hours to kill adult mosquitoes. Although excellent control may be obtained for those mosquitoes present at the time of spraying, subsequent influx of mosquitoes from outside the treatment zone may completely replace those killed. There is thus a need for compounds that possess quick knockdown, such as synthetic pyrethroids. These are expensive, however, and generally show short residual. Mixing pyrethroids with malathion may produce an economical compound with quick knockdown and effective residual. There are no prior data on potentiation available. This study was conducted at the University of Arkansas Rice Research and Experiment Center at Stuttgart, in 1977–78, to evaluate pyrethrin pyrethroid/malathion mixtures.

Effective control of the riceland mosquitoes *Psorophora columbiae* (Dyar and Knab) and *Anopheles quadrimaculatus* Say by ULV ground aerosols of resmethrin and pyrethrin was reported by Coombes and Meisch (1976). Thompson and Meisch (1977) found ULV ground aerosols of permethrin very effective against *Culex quinquefasciatus* Say.

MATERIALS AND METHODS

Two synthetic pyrethroids and pyrethrin were mixed with malathion, and evaluated in 1977–78 as ULV ground aerosols against caged, field collected mosquitoes.

In tests conducted in 1977, pyrethrin-malathion (5%/91%, PY/MA) mixtures along with standard formulations of pyrethrin (5%) permethrin (25%), and malathion (91% were evaluated against adult *An. quadrimaculatus*. The

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adult mosquitoes were collected from resting sites by hand-held, battery operated aspirators. The mosquitoes were anesthetized with CO_2 in the laboratory and placed in 20.3 × 6.99 cm 16 mesh screen wire cages with screened, canning jar lid ends. Approximately 20 adults were placed in each cage. The untreated controls were handled in the same way. The treatment cages were attached to steel stakes 1.52 m off the ground at 15.24, 30.48, 60.96 nd 91.44 m perpendicular to and downwind from the spray route. All test compounds were applied with a truck mounted Leco® (ULV) HD cold aerosol generator. The tests were replicated a minimum of 3 times, and most were replicated 8 times. The controls were placed in an area unassociated with the test for 10 min and removed to the laboratory. Wind velocity did not exceed 16 km/h and temperature was ca. 26.6°C. After treatment, the mosquitoes remained in the treatment cages and were offered cotton pads soaked in 10% sugar solution which were placed on the cages.

PY/MA mixtures, 1:6 and 1:7 ratios were applied at 88.8 and 118.3 ml/min at 3.5 psi. Pyrethrin was tested at 88.8 ml/min at 3 psi, and permethrin at 14.8 and 29.6 ml/min at 3 psi. Malathion was applied at 88.8 and 127.2 ml/min at 6 psi. Ground speed for all tests except the PY/MA mixture was 16 km/h. In order to achieve the correct rate for PY/MA, a speed of 12 km/h was used.

In 1978, resmethrin (40%), malathion (91%), and resmethrin-malathion (40%/91%, RE/MA) mixtures were evaluated against *An. quadrimaculatus* and *Cx. quinquefasciatus*. *Anopheles quadrimaculatus* were collected and handled in the same manner as described above with 20 adults per cage and each species in a separate

Table 1. Efficacy of various insecticides and insecticide combinations applied by ULV cold aerosol against *Anopheles quadrimaculatus* and *Culex quinquefasciatus* contained in cages, at the Rice Research and Experiment Center, Stuttgart, Arkansas, 1977 and 1978.[1]

Insecticide and dosage (ml/min)	% mortality 1 hour posttreatment			
	Swath width (m)			
	15.24	30.48	60.96	91.44
Permethrin 29.6	100 a	100 a	100 a	100 a
Permethrin 14.8	100 a	100 a	100 a	97 a
Pyrethrin 88.8	99 ab	100 a	97 a	97 a
Resmethrin 269.2, [a] 16 km/h	100 a	97 ab	68 abc	72 abc
Resmethrin 269.2, [a] 16 km/h[2]	100 a	96 abc	83 ab	48 bcde
Malathion 127.2, 5 psi	66 abc	89 abc	69ab	45 cde
PY/MA (1:6) 118.3	98 ab	81 abc	86 ab	92 ab
Malathion 88.8, 5 psi	95 ab	79 abc	90 ab	52 bcd
RE/MA (1:183) 127.2	89 ab	73 abcd	81 ab	83 ab
RE/MA (1:95) 59.2	78 ab	64 bcd	65 bc	39 ced
Malathion 127.2, 6 psi	82 ab	50 cde	38 dc	28 ced
RE/MA (1:95) 59.2	49 bcde	45 cdef	23 d	22 de
RE/MA (1:95) 127.2[2]	34 cdef	36 defg	16 d	5 e
PY/MA (1:7) 88.8	84 ab	30 efg	31 d	34 cde
PY/MA (1:7) 118.3	5 f	16 efg	14 d	3 e
Malathion 127.2, 5 psi[2]	8 ef	14 efg	2 d	0 e
Malathion 88.8, 6 psi	64 abcd	7 fg	21 d	37 cde
PY/MA (1:6), 88.8	18 ef	2 g	13 d	22 de
Malathion 127.2, 7 psi	26 def	1 g	1 d	4 e

[1] Means followed by the same common letter are not significantly different at P = 0.05.
[2] These compounds were administered against *Cx. quinquefasciatus*.

cage; however, *Cx. quinquefasciatus* were collected from resting sites in Memphis, TN, in cooperation with the Shelby County Health Department. These *Culex* were suspected to have resistance to malathion (Moseley et al. 1977).

Resmethrin was applied according to label specifications for mosquito control at 0.0032 kg ai/acre. Malathion 88.8 and 127.2 ml/min, was applied at 16 km/h at 5 psi. Malathion was also applied at 254.4 ml/min at 32 km/h and 7 psi. RE/MA dosage rates were 20 ml of resmethrin/3.8 liters of malathion (1:183) and 40 ml of resemthrin/3.8 liters of malathion (1:95) applied at 127.2 ml/min at 16 km/h and 5 psi. Forty ml of resmethrin/3.8 liters of malathion at 59.2 ml/min, 16 km/h and 4 psi was also applied.

After treatment, the mosquitoes remained in the treatment cages and received raisins soaked with water. Mortalities were recorded at 1, 12, and 24 hr posttreatment. All mortalities were corrected by Abbott's formula. The PY/MA and RE/MA studies were statistically analyzed by Duncan's multiple range test with (P = 0.05).

RESULTS AND DISCUSSION

Results of field cage studies to evaluate synthetic pyrethroid and pyrethrin mixtures along with conventional unmixed applications are presented in Table 1. At the 15.24 m swath width, control means did not differ significantly among 13 of the treatments and ranged from 64% to 100% control. Similar results were obtained at 30.48 and 60.96 m; however, at swath widths of 91.44 m differences became more pronounced. The following insecticides and flow rates were most effective and were not significantly dif-

Table 2. Efficacy of various insecticides and insecticide combinations applied by ULV cold aerosol against *Anopheles quadrimaculatus* and *Culex quinquefasciatus* contained in cages, at the Rice Research and Experiment Center, Stuttgart, Arkansas, 1977 and 1978.[1]

Insecticide and dosage (ml/min)	% mortality 12 hours posttreatment			
	Swath width (m)			
	15.24	30.48	60.96	91.44
Permethrin 29.6	100 a	100 a	100 a	100 a
Permethrin 14.8	100 a	100 a	100 a	96 a
Pyrethrin 88.8	100 a	100 a	100 a	96 a
Resmethrin 269.2, [a] 16 km/h	100 a	97 a	96 ab	96 a
Resmethrin 269.2, [a] 16 km/h[2]	—	—	68 abc	62 cd
Malathion 127.2, 5 psi	90 ab	100 a	94 ab	93 a
PY/MA (1:6) 118.3	100 a	100 a	100 a	100 a
Malathion 88.8, 5 psi	99 a	93 ab	95 ab	89 abc
RE/MA (1:183) 127.2	99 a	100 a	100 a	100 a
RE/MA (1:95) 59.2	98 a	100 a	98 a	99 a
RE/MA 127.2, 6 psi	100 a	100 a	98 a	95 a
RE/MA (1:95) 59.2	84 ab	91 ab	76 bc	69 bc
RE/MA (1:95) 127.2[2]	67 bc	74 ab	82 abc	32 e
PY/MA (1:7) 88.8	100 a	100 a	98 a	91 ab
PY/MA (1:7) 118.3	92 ab	86 ab	94 ab	83 abc
Malathion 127.2, 5 psi[2]	48 c	39 c	17 e	30 e
Malathion 88.8, 6 psi	96 ab	92 ab	91 ab	98 a
PY/MA (1:6), 88.8	96 ab	80 ab	88 ab	84 abc
Malathion 127.2, 7 psi	91 ab	60 bc	63 bc	52 de

[1] Means followed by the same letter are not significantly different P = 0.05.
[2] These compounds were administered against *Cx. quinquefasciatus*.

Table 3. Efficacy of various insecticides and insecticide combinations applied by ULV cold aerosol against *Anopheles quadrimaculatus* and *Culex quinquefasciatus* contained in cages, at the Rice Research and Experiment Center, Stuttgart, Arkansas, 1977 and 1978.[1]

Insecticide and dosage (ml/min)	% mortality 24 hours posttreatment			
	Swath width (m)			
	15.24	30.48	60.96	91.44
Permethrin 29.6	100 a	100 a	100 a	100 a
Permethrin 14.8	100 a	100 a	100 a	95 ab
Pyrethrin 88.8	100 a	100 a	100 a	98 ab
Resmethrin 269.2, [a] 16 km/h	100 a	96 ab	94 ab	97 ab
Resmethrin 269.2, [a] 16 km/h[2]	100 a	92 abc	68 de	61 d
Malathion 127.2, 5 psi	99 a	99 a	95 a	98 ab
PY/MA (1:6) 118.3	100 a	100 a	100 a	100 a
Malathion 88.8, 5 psi	100 a	97 a	100 a	89 abc
RE/MA (1:183)	100 a	100 a	100 a	100 a
RE/MA (1:95)	98 a	99 a	100 a	100 a
Malathion 127.2, 6 psi	100 a	100 a	100 a	98 ab
RE/MA (1:95) 59.2	93 a	92 abc	80 bcd	75 bcd
RE/MA (1:95) 127.2[2]	56 b	60 dc	76 dc	34 e
PY/MA (1:7) 88.8	100 a	100 a	100 a	98 ab
PY/MA (1:7) 118.3	95 a	91 abc	100 a	91 abc
Malathion 127.2, 5 psi[2]	50 b	53 d	18 f	31 e
Malathion 88.8, 6 psi	95 a	100 a	98 a	100 a
PY/MA (1:6), 88.8	99 a	80 abc	87 abc	88 abc
Malathion 127.2, 7 psi	94 a	71 bdc	80 bcd	59 de

[1] Means followed by the same common letter are not significantly different at P = 0.05.
[2] These compounds were administered against *Cx. quinquefasciatus*.

ferent; permethrin 29.6 and 14.8 ml/min, pyrethrin 88.8 ml/min, PY/MA (1:6) 118.3 ml/min, RE/MA (1:183) 127.2 ml/min, and resmethrin 269.2 ml/min. Mixtures of PY/MA (1:6) 118.3 ml/min and RE/MA (1:183) 127.2 ml/min were competitive and gave acceptable control. Malathion at 88.8 ml/min and 5 psi was effective at all but the 91.44 m swath, where control decreased to only 52%.

After 12 hr posttreatment, control percentages increased for most compounds (Table 2). Again, perhaps the best separation may be observed at 91.44 m where RE/MA (1:95) 127.2 ml/min and malathion 127.2 ml/min failed to provide effective control against *An. quadrimaculatus*. This was also true of results observed 24 hr posttreatment (Table 3).

Culex quinquefasciatus were as expected more difficult to kill than *An. quadrimaculatus*. The results indicate that these *Cx. quinquefasciatus* are resistant to organophosphorous insecticides as reported by Moseley et al. (1977). Only resmethrin 269.2 ml/min provided significantly greater mortalities in *Cx. quinquefasciatus* than for *An. quadrimaculatus* for the treatments at 91.44 m at 12 hr and 60.96 and 91.44 m at 24 hr posttreatment.

Malathion 127.2 ml/min against *Cx. quinquefasciatus* was significantly lower than malathion 127.2 ml/min against *An. quadrimaculatus* and provided the least control of all compounds. RE/MA 1:95, at 127.2 ml/min was significantly higher than malathion only at 127.2 ml/min at the 30.48 m and 60.96 m swath at 12 and 60.96 m at 24 hr.

Malathion dosages of 88.8 ml and 127.2 ml/min at 5 psi were equally effective against *An. quadrimaculatus*. Malathion at 88.8 and 127.2 ml/min and 6 psi were not

significantly different from the same dosage rates of malathion at 5 psi for the 12 and 24 hr observations. At the higher pressure rates, the % mortality of malathion was reduced. Malathion at 6 and 7 psi at 1 hr posttreatment at the 30.48, 60.96 and 91.44 m swaths was less effective than at 5 psi. Malathion at 7 psi was less effective at all times and swath widths than at 5 and 6 psi. The higher pressure rates could have interfered with the ULV generator particle size control.

Synthetic pyrethroid-organophosphorus mixtures provide the quick knockdown of pyrethroids while retaining the residual of the organophosphorus insecticides, if mixed in these proportions. There was indeed variability in the 2 earlier observations; however, at 24 hr posttreatment the mixtures were similarily effective as the compounds alone.

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