

LOW DOSAGES OF MALATHION FOR BOLL WEEVIL ERADICATION  
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ABSTRACT

Aerially-applied malathion at ultra-low-volume (ULV) rates of 0.58, 0.88, and 1.17 liters per ha (8, 12, and 16 oz per acre) killed at least 90% boll weevils, *Anthonomus grandis grandis* Boheman, immediately after application and at least 80% at 24 and 48 h after application, unless rainfall occurred. After 48 h, effectiveness declined, but greater than 60% mortality could be expected at 72 h after application. A lower rate of 0.29 liters per ha (4 oz per acre) killed 55-62% of exposed weevils up to 48 h after application. Toxicity of the four rates was compared by placing boll weevils in petri dishes with leaves collected from cotton plants at selected times after malathion application. Rainfall of as little as 1.3 mm (0.05 in.) reduced the effectiveness of all treatments significantly indicating that malathion should be reapplied as soon as possible after rainfall.

INTRODUCTION

Malathion is the most costly single component of current eradication programs. A 0.15 liter per ha (2 oz./acre) reduction in malathion rate saves about 74 cents per ha (30 cents per acre) per application. With many applications over millions of acres, substantial savings to cotton producers are realized. The superiority of the standard rate [1.17 liters (ULV) per acre (16 oz per acre)] over lower rates had not been adequately demonstrated. In fact, early studies showed no difference in mortality of boll weevils in the field following applications of 0.58, 0.88, or 1.17 liters per ha (8, 12, and 16 oz per acre; Cleveland et al. 1966). Another study showed no difference between the 0.58, 0.88, and 1.17 liter rates, and 0.29 liters per ha (4 oz per acre) was effective (Hopkins & Taft 1967). A third study, however, suggested evidence that the 1.17 liter rate was more effective for control of the boll weevil in October, that a break in the degree of control occurred between 1.17 and 0.88 liters, and that the 1.17 liter per ha rate would be necessary in a reproduction-diapause program (Harris et al. 1972). The potential for significant cost savings prompted a series of more recent studies to determine if the standard boll weevil eradication rate of 1.17 liters per ha (16 oz. per acre) could be lowered (Mulrooney et al. 1995, Mulrooney et al. 1996, Jones et al. 1996, Villavaso et al. 1996).

Toxic effects of malathion diminished to unacceptable levels 48 hours following application or after rainfall of as little as 12.7 ml (0.5 in; Hopkins and Taft 1967). Nemecek and Adkisson (1969) also reported significant reductions in toxicity of ULV malathion to boll weevils following 25.4 mm (1 in) of simulated rainfall and slight reductions in toxicity of plants subjected to dew. A recent study showed no significant differences in either malathion residues or boll weevil mortality between dry and dew-laden plants following aerial applications of 0.88

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L per ha (Kirk et al. 1997).

If eradication could be accomplished with rates of malathion below the currently used rate of 1.17 liters per ha, considerable sums of money would be saved. Also, the effects of malathion on beneficial insects and the environment in general could be reduced. In this paper, we present results of a two-year study of the effectiveness of ULV malathion at rates of 0.29, 0.58, 0.88, and 1.17 liters per ha. Data on the effects of rainfall in amounts much lower than previously reported are also presented.

## MATERIALS AND METHODS

Boll weevils used in the study were from two sources: a laboratory colony reared at the Gast Insect Rearing Laboratory, USDA, ARS, Mississippi State, MS and native weevils captured in pheromone traps (Dickerson 1986) in Webster County, Mississippi. The malathion formulation used for the 3 laboratory tests comparing susceptibility of laboratory-reared and native trap-captured boll weevils was Cythion® RTU (0, 0-dimethyl phosphorodithioate of diethyl mercaptosuccionate; 42% ai; American Cyanamid Co., Wayne, NJ). Field-applied malathion was FYFANON® ULV (95%; 1.17-kg/liter; CHEMINOVA, Lemvig, Denmark).

*Laboratory tests.* A laboratory comparison of the susceptibility of laboratory and native strain boll weevils was made using the technique of Haynes (1994). Five 102- $\mu$ g drops of a 1:2 mixture of Cythion RTU (46.2% malathion; American Cyanamid Co., Ag. Div., VPC Venture, Wayne, NJ) to cottonseed oil were applied with a 5-microliter pipette to the top surfaces of freshly picked cotton leaves placed in 100 (dia) X 15 mm petri dishes. Each drop contained approximately 15.6  $\mu$ g of malathion for a total of 77.8  $\mu$ g per leaf.

Twenty-five 2-d-old laboratory-reared boll weevils and 25 trap-captured native boll weevils (Webster County, MS) of unknown age and undetermined sex were placed in separate petri dishes containing the malathion-treated cotton leaves. Dishes containing the leaves and boll weevils were held at 30° C, and boll weevil mortality was noted 24-h after they had been placed in the dishes. Untreated leaves and oil-only leaves were used as controls. The test was replicated five times.

*Field tests.* Tests were conducted in 1995-96 on leased land adjoining the Delta Research and Extension Center, Stoneville, MS and on commercially grown cotton near Tribbett, MS. In 1995, malathion was aerially-applied at rates of 0.58, 0.88, and 1.17 liters per ha (8, 12, and 16 oz per acre); in 1996, the 1.17 liter rate was replaced with a rate of 0.29 liters per ha (4 oz per acre). Application was made using an Air Tractor 402 - air speed, 225 km/h; pressure 262 kPa; 4, 9, 13, and eighteen 8002 flat-fan nozzles (Spraying Systems, Wheaton, IL) for the 0.29, 0.58, 0.88, and 1.17 liters rates, respectively.

Each application consisted of two to three 27-row swaths. Row spacing was approximately 1 m; treatments were separated by 27 rows. Treatments were applied eight times starting at pinhead square stage in mid June and continuing until mid September of 1995 and five times between mid July and late August of 1996.

To evaluate malathion toxicity, leaves were picked from treated plants at 0, 24, 48, and 72 hours after application. The leaves that would fit snugly into 100-mm petri dishes were placed in those dishes, and 2-d-old laboratory-reared weevils were placed on the leaves - one leaf per dish, one weevil per leaf. Dishes were held at approximately 27°C, and mortality was noted 24 hours later. Additionally, we were able to observe the effect of rainfall on malathion toxicity on two occasions during the course of this study.

*Statistical Analysis.* Data were analyzed using SAS PROC-MIXED procedure (Littell et al. 1996) to determine if differences existed between malathion rates and susceptibility of the laboratory-reared and trap-captured native strains.

## RESULTS AND DISCUSSION

*Laboratory tests.* Mortality in the oil only and untreated control averaged 2.4 and 0% for the laboratory-reared weevils and 4.8 and 2.4% for the native weevils. The oil control was used to compute Abbott's formula adjustments (Abbott 1925) for the malathion-treated weevils of the two strains. Significantly more native trap-captured boll weevils (64%) than laboratory-reared boll weevils (42%) died when exposed to 5 drops of malathion on the surface of cotton leaves ( $P = 0.492$ ,  $F = 5.36$ )

*Field Tests.* In 1995, mortality of boll weevils placed on leaves was similar for 0.58, 0.88, and 1.17 liters treatments (Table 1). No significant differences ( $P > 0.05$ ) between the rates were seen for the 4 time periods, but a trend toward increased mortality with increased rate was apparent 0 and 24 h following treatment. Inexplicably, fewer weevils exposed to leaves from the highest rate died at 48 and 72 hours after treatment.

**TABLE 1. Percent Mortality of Boll Weevils Confined for 24 Hours in Petri Dishes with Leaves from Malathion-treated Cotton Plants -- 1 Leaf per Dish, 1 Weevil per Leaf. Malathion Was Aerially-Applied at Rates of 0.58, 0.88, and 1.17 Liters per Ha - 1995**

Liters malathion per hectare	Hours after malathion application			
	0	24	48	72
0.58	90a	80a	85a	65a
0.88	98a	94a	80ab	62b
1.17	100a	98a	65ab	35b

Row means followed by different letters are different at  $P \leq 0.05$ .

Letters do not apply to column means none of which were significantly different.

Between 0 and 72 h after treatment and between 24 and 72 h after treatment, significant declines in mortality occurred for the 1.17 and 0.88 liter per ha rates (Table 1;  $P = 0.0015$  and  $0.0020$ ,  $t = 3.95$  and  $3.83$ , respectively; and  $P = 0.0021$  and  $0.043$ ,  $t = 3.79$  and  $3.43$ , respectively). A significant decline in mortality between 0 and 72-h after treatment was not observed for the 0.58 liter per ha rate. At all rates, mortality became erratic and notable declines occurred after 48 h following treatment (Villavaso et al. 1996).

In 1996, rainfall prevented us from obtaining data past 48 h after treatment. Significantly less mortality was observed for the 0.29 liter per ha rate than the 0.58 for all three time periods after treatment ( $P = 0.0018$ ,  $0.0005$ , and  $0.0005$ ;  $t = 5.42$ ,  $5.14$ , and  $4.56$  for 0, 24, and 48 h after treatment, respectively; Table 2). Similarly, significantly less mortality was observed for the 0.29 liter per ha rate than for the 0.88 liter per ha rate at all three time periods after treatment ( $P = 0.0010$ ,  $0.0017$ , and  $0.0040$ ;  $t = 6.08$ ,  $4.31$ , and  $3.45$  for 0, 24, and 48 h after treatment, respectively). A significant decline in mortality occurred in the 0.88 liter per ha treatment between 0 and 24 h and between 0 and 48 h after treatment ( $P = 0.0050$  and  $0.039$ ;  $t = 3.39$  and  $2.22$ , respectively). The 0.29 and 0.58 liter per ha treatments did not show declines in mortality between 0 and 48 h after treatment.

Our cotton plots received rainfalls of 1.3 and 2.5 mm (0.05 and 0.10 in.) during 1995 tests. Leaves were collected before and after these rainfalls, and mortality was noted by the procedure used in field tests above (Table 3). Mean pre-rain mortality of 98% was significantly different from the post-rain mortality of 38% ( $P = 0.0086$ ;  $t = 6.2$ ;). Hopkins & Taft (1967) had

TABLE 2. Percent Mortality of Boll Weevils Confined for 24 Hours in Petri Dishes with Leaves from Malathion-treated Cotton Plants -- 1 Leaf per Dish, 1 Weevil per Leaf. Malathion Was Aerially-Applied at Rates of 0.29, 0.58, and 0.88 Liters per Ha - 1996

Liters malathion per hectare	Hours after malathion application		
	0	24	48
0.29	62a	55a	55a
0.58	95b	90b	95b
0.88	99bx	83by	85by

Column means followed by different a,b letters are different at  $P \leq 0.05$ .

Row means followed by different x,y letters are different at  $P \leq 0.05$ .

reported a drastic decrease in malathion toxicity to boll weevils following rainfall of 12.7 mm (0.5 in); however, our findings indicate that significant decreases in toxicity can be expected following much less rainfall. These findings should alert boll weevil eradication personnel of the importance of reapplication of malathion following even light rainfall.

TABLE 3. Mortality of Boll Weevils Confined for 24 Hours in Petri Dishes with Leaves from Malathion-treated Cotton Plants That Were Subjected to Rainfall of 1.3 and 2.5 Mm -- 1 Leaf per Dish, 1 Weevil per Leaf. Malathion Was Aerially-Applied at Rates of 0.88, and 1.17 Liters per Ha - 1995

Malathion rate (liters per ha)	Rainfall (mm per ha)	Percent mortality		Difference
		Before rain	After rain	
0.88	1.3	95	40	55
1.17	1.3	95	60	35
0.88	2.5	100	20	80
1.17	2.5	100	31	69
Mean	--	98	38	60

Before and after rain means significantly different at  $P \leq 0.05$ .

Our results here led us to conclude that reducing the rate of malathion applied for boll weevil eradication from 1.17 to 0.88 liters per ha should give adequate results for boll weevil eradication. Environmental savings might also be noteworthy. As a result of this study and others (Mulrooney et al. 1995, Mulrooney et al. 1996, Jones et al. 1996, Villavaso et al. 1996) and the need to reduce the cost of eradication, the 0.88 liter per ha of malathion has been widely accepted as adequate for eradication (in Texas, Louisiana, and Arkansas, for example). To further reduce eradication costs, Mississippi adopted a rate of 0.73 liters per ha (10 oz. per acre).

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