

ENHANCEMENT OF TRANSFER OF TECHNICAL MALATHION FROM COTTON
LEAVES TO BOLL WEEVILS USING COTTONSEED OIL

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ABSTRACT

Transfer tests of technical malathion alone and in mixtures of different ratios of cottonseed oil (CSO) were conducted in the laboratory. A Potter spray tower was used to treat cotton leaves excised from plants grown in a greenhouse. Mixtures of malathion:CSO were applied first at constant volume and then at constant rate. CSO was found to enhance transfer of malathion from cotton leaves into boll weevils. Mortality and the amount of malathion transferred to weevils were related to the rate of malathion, the amount of CSO in the mixture, and the volume applied. A three-parameter modified Weibull Function was found to best fit the data. Two types of data were fit. First, maximum cumulative mortality was found to increase with increasing volumes of malathion and a steady state of insecticide transfer to the boll weevil was reached within 5 - 15 cm of travel across a treated cotton leaf. The distance at which half of the maximum cumulative mortality occurred increased as the volume of application increased. Also the rate of cumulative mortality over distance traveled increased when malathion was mixed with CSO. All mixtures except the 1:1 ratio of malathion:CSO had greater maximum cumulative mortalities than an undiluted application of malathion. The highest ratio, 1:9, produced the greatest maximum cumulative mortality (99%) and transferred the greatest amount of malathion from cotton leaves to boll weevils. The second type of data modeled by the cumulative Weibull function was the malathion residue that was transferred to boll weevils as they traveled various distances across leaves treated with various mixtures. Cumulative malathion residue on boll weevils for each treatment followed similar trends as cumulative mortality.

INTRODUCTION

The use of oils as adjuvants for insecticides increased with the popularity of ultra-low-volume application of insecticides to cotton in the early 1980's. Oil diluents have been proposed to have several advantages over water as a carrier. These include a more uniform droplet size, better

Jandel Scientific). The average area (\pm STD) contacted by an untreated boll weevil as it travels 1.0 cm was estimated to be 0.026 (\pm 0.012) mm².

Data Analysis. Cumulative mortality and cumulative insecticide residue were regressed on distance traveled using a Weibull cumulative distribution function to model cumulative mortality (y_1) or cumulative insecticide residue (y_2):

$$F(y_i) = \max[1 - 1/\exp(\text{distance}/\mu)^{\text{rate}}] \quad (1)$$

The estimates of parameters from the Weibull function (eqn 1) describe the following:

max - maximum cumulative mortality (%) or maximum cumulative insecticide residue (μg).

μ - distance (cm) traveled by the weevil at which half of the maximum mortality or half the maximum insecticide transfer occurs.

rate - slope of the curve.

F tests were used to compare estimates of these parameters for each treatment.

RESULTS AND DISCUSSION

Test 1. Maximum cumulative (max) mortality increased ($F = 20.91$; $df = 2, 76$; $P < 0.05$) with increasing volume of malathion as expected (Table 1, Fig. 1). The highest max cumulative mortality was produced by the highest rate applied, 177.1 mg(AI). All malathion rates reached a plateau. The leveling off of insecticide transfer indicates that a steady state is reached at which no additional insecticide is transferred in spite of increased travel across the leaf. A steady state was reached within 5 - 15 cm of travel across the leaf.

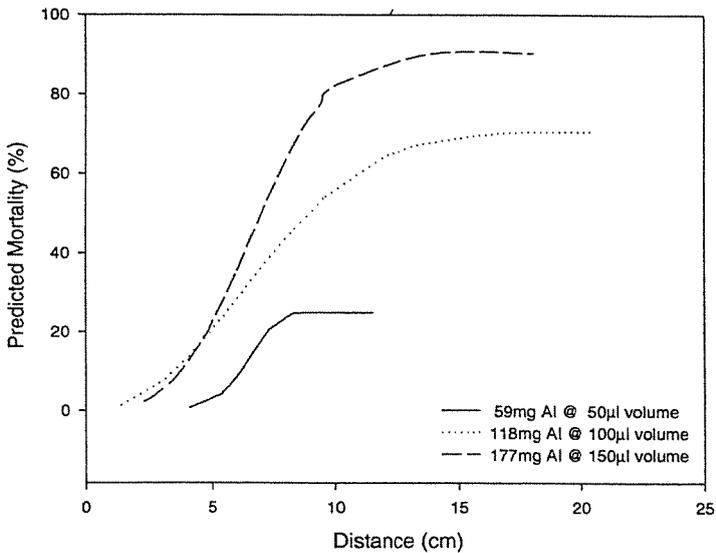


FIG 1. Predicted mortalities (cumulative) of boll weevils after crawling over the surface of leaves treated with different volumes of malathion ULV in Test 1.

The value of μ for the 177.1 mg(AI) treatment was 7.54 cm. This means that a level of 45% mortality, or one half the maximum mortality of 90%, would occur if weevils traveled 7.54 cm over a cotton leaf treated with 177.1 mg(AI) or a 150 μ l volume. Comparisons of μ 's showed no significant differences. The numerically shortest μ occurred when weevils walked over cotton leaves treated with 59 mg(AI); however, this μ only resulted in 12% mortality.

Rate is the slope of the curve. The highest ($F=10.36$; $df=3,76$; $P<0.05$) rate among the treatments was that of the 59 mg treatment.

Maximum cumulative residue transferred to the weevil increased ($F=549.24$; $df=3,144$; $P<0.05$) with increasing volume applied (Table 1, Fig. 2). μ increased ($F=12.46$; $df=3, 144$; $P<0.05$) with increasing volume, while rate decreased ($F=94.84$; $df=3, 144$; $P<0.05$).

Test 2. There were differences between treatments in the amount of malathion deposited on the leaf even though the same rate of malathion was applied with each treatment. Percentage recovery of malathion from cotton leaves with iso-octane washes was 97 - 103%. Therefore, differences in the amount recovered from the leaf were due to application constraints rather than efficiency of the residue recovery method. The greatest amount of malathion (12.13 μ g) was recovered from leaves treated with technical malathion (Table 2). The lowest amount of malathion (6.75 μ g) was recovered from leaves treated with the 1:4 mixture ratio of malathion:CSO. It is not known why this decrease in deposition for the 1:4 ratio occurred. There were no significant differences in leaf residues between the other three malathion:CSO mixtures.

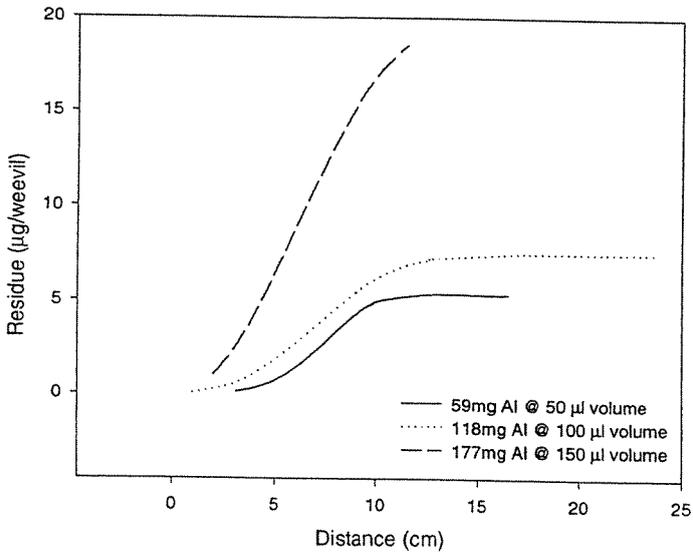


FIG 2. Predicted malathion residue (cumulative) transferred to boll weevils from leaves treated with different volumes of malathion ULV in Test 1.

TABLE 2. Estimated Parameters of Weibull Function^a of Cumulative Boll Weevil Mortality (%) and Malathion Residue (μg) Recovered from Boll Weevils Regressed over Distance Traveled across Cotton Leaves Treated with a Constant Rate (39 mg) of Malathion ULV Mixed with Different Volumes of Cottonseed Oil.

Ratio (malathion:CSO)	Volume Applied (μl)	Deposition on Leaf ($\mu\text{g}/\text{cm}^2$)	Max ^b		Mu ^c (cm)		Rate ^d	
			Mortality	Residue	Mortality	Residue	Mortality	Residue
1:9	330	8.48 b ^e	99 a	2.94 a	7.23 a	5.88 c	2.64 d	3.95 a
1:4	165	6.75 c	67 b	1.73 c	5.92 b	5.55 d	4.44 b	3.76 ab
1:1.5	82	7.12 bc	41 c	2.03 b	4.97 c	6.10 ab	3.45 c	3.28 bc
1:1	66	8.45 b	16 d	1.34 d	4.78 c	6.27 a	17.92 a	4.10 a
undiluted	33	12.13 a	19 d	1.07 e	6.24 ab	6.00 bc	6.34 b	2.50 c

^a $F(y_i) = \max[1 - \exp(\text{distance}/\text{mu})]^{\text{rate}}$

^bMaximum cumulative mortality (%) or maximum cumulative insecticide residue (μg).

^cDistance (cm) traveled by the weevil at which half of the maximum mortality or half the maximum insecticide transfer occurs.

^dSlope of the curve.

^eMeans in a column not followed by the same letter are significantly ($P < 0.05$) different as determined by PDIFF (Littell et al. 1996).

Test 3. When a constant volume was applied, maximum cumulative boll weevil mortality was related to the concentration of malathion in CSO (Table 3, Fig. 5). This would be expected since lower amounts of malathion were applied when a constant volume of 100 μ l of each mixture was sprayed onto each leaf. The highest ($F=24.65$; $df=4, 94$; $P<0.05$) mortality (81%) occurred when boll weevils crawled across leaves treated with 100 μ l of undiluted technical malathion (118 μ g). The lowest mortalities were observed in weevils exposed to leaves treated with 1:9 and 1:4 ratios, which were the more dilute mixtures of malathion and CSO. Maximum cumulative residue found on the weevil was also related to the amount of technical malathion applied to the leaf (Table 3, Fig. 6). The greatest ($F=62.50$; $df=4, 93$; $P<0.05$) maximum cumulative residue, 4.58 μ g, was found on weevils that had crawled over leaves treated with 118 mg of undiluted technical malathion. While the lowest residue, 1.28 μ g, was recovered from weevils placed on leaves treated with 14 mg of malathion mixed in a 1:9 ratio with CSO.

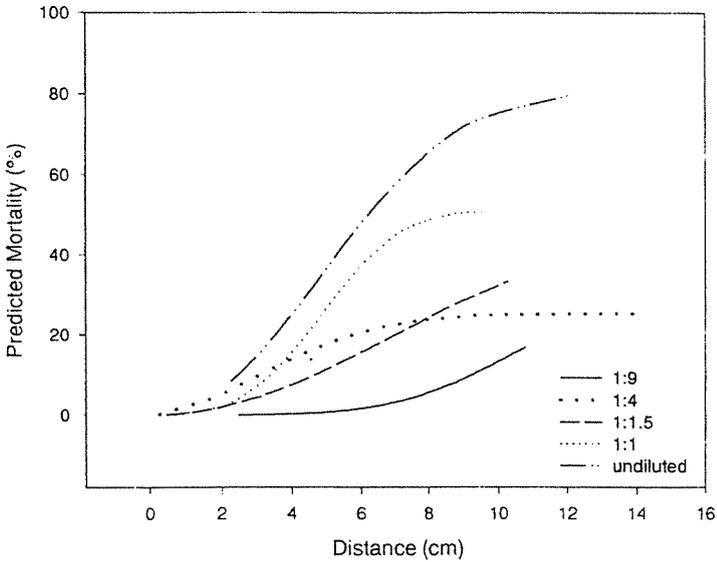


FIG 5. Predicted mortalities (cumulative) of boll weevils after crawling over the surface of leaves treated with different ratios of malathion:cottonseed oil applied at constant volume in Test 3.

Cottonseed oil seems to be aiding the movement of malathion into the weevil. For example, when 118 mg of undiluted malathion was applied to the leaf in the constant volume (100 μ l) test, maximum cumulative residue found on the weevil was 4.58 μ g. Mortality of weevils crawling over these leaves was 81%. When 39 mg of malathion was mixed in a 1:9 ratio with CSO in the constant rate test and applied at 330 μ l to leaves, maximum cumulative residue found on the weevil was 2.94 μ g, yet maximum cumulative mortality of weevils crawling over the leaves was 99%.

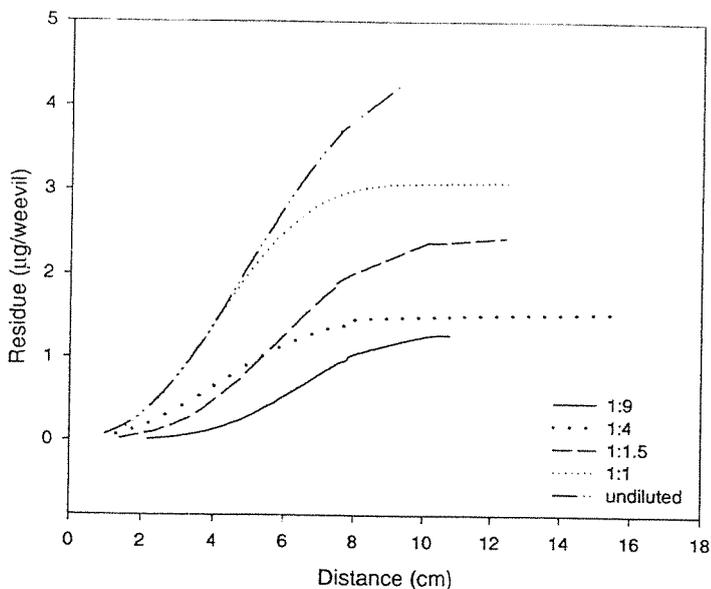


FIG 6. Predicted malathion residue (cumulative) transferred to boll weevils from leaves treated with different ratios of malathion ULV:cottonseed oil applied at constant volume in Test 3.

A measure of contact angles of malathion:CSO droplets on a paraffin substrate showed that malathion:CSO mixtures had contact angles that ranged from 24 - 28° compared to 43° for undiluted malathion (unpublished data). The lower the contact angle the greater the affinity of the liquid for the solid substrate and the greater the spread of the liquid over the surface. Increasing the spread of malathion:CSO mixtures should increase the amount of malathion entering the weevil.

This research was designed to investigate the relationship between rate and volume of application and how these variables affect the transfer of malathion from cotton leaves to boll weevils. The rates and volumes used were 10 - 80 and 13 - 130 times greater, respectively, than those used in the field. These high rates and volumes were necessary in order to obtain an observable response from boll weevils crawling short distances (0 - 20 cm) across cotton leaves treated with malathion.

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