APPLICATION OF MALATHION ULV IN OILS

J. E. Mulrooney and L. A. Smith
USDA, ARS,
Application and Production Technology Research Unit
Stoneville, MS

Abstract

Aerial application tests of malathion ULV mixed in once-refined cottonseed (CSO) and horticultural mineral oils (HMO) were conducted in 1998 and 1999 to determine toxicity to boll weevils with leaf bioassays. The HMO's used in these tests were: Orchex® 796, and WS2908, an Orchex® 796 formulation with drift retardant. Mortalities showed that a 6 oz/A rate of malathion ULV mixed with 26 oz/A of CSO was as effective against boll weevils as a 12 oz/A rate of undiluted malathion ULV. In July and August 1999, efficacy of 6:26, 6:10, 7:18, 8:8, and 10:0 oz/A ratios of malathion ULV:CSO against boll weevils was determined. Results showed that 6 and 8 oz/A rates of malathion ULV can be as effective as an undiluted 10 oz/A rate for the first 2 - 3 days after treatment if the volume of the application is sufficiently high. Malathion residues accumulated on leaf surfaces during rain free periods in August after repeated applications of both undiluted and malathion ULV diluted in CSO.

Introduction

Technical malathion is presently being used as a ultra-low-volume (ULV) spray in the Boll Eradication Program. Increases in the cost of malathion ULV and it's application have encouraged research on reduced rates of malathion ULV for boll weevil control. As a result, the rate of malathion ULV has been reduced from 16 oz to 10 - 12 oz/A.

The use of oils may be a means to further reduce costs of malathion ULV application because they are less expensive than malathion. Cottonseed oil (CSO) is a vegetable oil which has been shown to enhance the application of some insecticides against pests of cotton. In a study conducted by Ochou et al. (1986), both vegetable (soybean and cottonseed) and petroleum oils synergized various pyrethroids against larvae of tobacco budworm, *Heliothis virescens* (Fab.), and adult house flies, *Musca domestica* L. Conversely, they found that the same oils were less synergistic or even antagonistic with more water-soluble organophosphorus and carbamate insecticides. Similarly, Treacy et al. (1986) demonstrated that soybean oil enhanced toxicity of the pyrethroid, cyfluthrin, against the boll weevil, *Anthonomus grandis grandis* Boheman, more than it did for selected carbamate and organophosphorus insecticides.

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While cottonseed oil has been used as an adjuvant of malathion ULV, no research has been done on the application of reduced rates of malathion ULV for boll weevil control. Neither has research been conducted on the application of malathion ULV in horticultural mineral oils (HMO) which have been shown to enhance insecticide and herbicide toxicity. Wolfenbarger and Guerra (1986) found permethrin/HMO mixtures to be more toxic to boll weevils than a permethrin/cottonseed oil mixture.

HMO's have some advantages over vegetable oils. HMO's have greater ability to penetrate insect cuticles than vegetable oils. For example, de Licastro et al. (1983) found that HMO's increased the rate of cuticular penetration by parathion formulations in the conenose bug, *Triatoma infestans* (Klug). HMO was also found to increase cuticular penetration of avermectin B1 in southern armyworm, *Spodoptera eridania* Cramer (Anderson et al. 1986). Jones et al. 1998 showed that topical applications of malathion mixed with HMO were more toxic to boll weevils than malathion mixed with CSO. HMO's are straight chain hydrocarbons that are consistent in their properties in comparison to vegetable oils which vary widely in composition. Because of their synthetic composition, HMO's can be modified for specialized applications. Exxon Chemical Co. recently developed a particle-size modifier that increases the droplet size of HMO's and should be useful for drift reduction. One disadvantage of HMO's is that they are not miscible with malathion. Therefore, a compatibility additive must be used to mix technical malathion with HMO which will increase the cost of application.

The objectives of this research were to compare the performance of CSO with that of HMO's as adjuvants for malathion ULV aerial application. Efficacy and longevity of different ratios of technical malathion:adjuvant applied ULV were also determined. Determination of residues of malathion following rainfall were also made.

Materials and Methods

Evaluation of oil adjuvants for technical malathion were conducted in field experiments during 1998 and 1999. All treatments were applied at ULV using an Air Tractor 402 aircraft. The aerial application parameters are given in Table 1. All boll weevils used in these tests were obtained from the USDA-ARS Gast Rearing Laboratory at Mississippi State, MS.

In 1998, the effects of three oil adjuvants on the efficacy of technical malathion were determined. Once-refined cottonseed oil was obtained from Yazoo Valley Oil Mill, Greenwood, MS. Orchex® 796, an EPA registered horticultural mineral oil, and WS2908A, an experimental Orchex® 796 formulation were provided by Exxon Chem.

Co., Baytown, TX. WS2908 is a blend of Orchex® 796 and a droplet size modifier. Mixing malathion ULV with both Orchex® 796 and WS2908 required a compatibility agent, HM9737, developed by Helena Chemical Co. Technical malathion (Fyfanon ULV 96.8%, Cheminova Agro, Lemvig, DK) was used in all tests.

Oil Adjuvant Test

The three oil adjuvants were mixed with technical malathion at 6.0 oz/A (208 g [AI]/ha) and applied in a total volume of 32 oz/A (2.34 L/ha). A 12 oz/A (415 g [AI]/ha) application of technical malathion was used as a standard. The treatments were applied by aircraft to 1.34 A (0.54 ha) plots on 8 and 21 September 1998 with six replicates. WS2908 was not included in the first application. Two swaths of the aircraft were made in each plot. Bioassays of treated leaves using boll weevils (3-5 d old) were conducted at 0, 1, 2, and 3 days after the first application and 1, 2, and 3 after the second application.

Cottonseed Oil: Malathion Ratio Test

In 1999, technical malathion was mixed with once refined cottonseed oil at the following ratios of ounces of technical malathion to ounces of CSO: 6:10 (0.44:0.73 L/ha), 6:32 (0.44:2.34 l/ha), 7:18 (0.51:1.32 L/ha), and 8:8 (0.58:0.58 L/ha). An application of undiluted malathion ULV at 10 oz/A (0.73 L/ha) was used as a standard. Treatments were replicated six times and applied with an Air Tractor 402 aircraft to 1.34 A (0.54 ha) plots on 12, 21, and 27 July . On 11, 16, 23, and 29 August, the 7:18 and 8:8 ratios were applied to 10 A (4.05 ha) plots in conjunction with eradication program applications. Applications by eradication program aircraft to a 10 A (4.05 ha) field on 4, 10, 13, 18, and 26 August were monitored for efficacy and residue.

Bioassay

Bioassays were conducted on treated leaves collected from the 4th node down from the terminal. Leaves were placed in plastic petri dishes (100 mm dia.) containing five boll weevils. Petri dishes containing leaves and boll weevils were held at 26.7E C and in a 12:12 photoperiod. Boll weevil mortality was determined by pinching the rostrum of the weevil at 48 h after exposure to treated leaves. Those that did not move were recorded as dead.

Residue Analysis

In 1999, malathion residues were obtained from leaves collected at the same times and manner as leaves for bioassay. Leaf disks (2.54 cm diam.) cut from leaves were rinsed in iso-octane. Residue analyses were run on a Hewlett Packard 5890 gas chromatograph equipped with a flame photometric detector and auto-sampler. The gas chromatograph was operated with Chemstation (Hewlett Packard) software. The parameters of the residue analysis method were as follows: injector temperature, 200°C; detector temperature, 200°C; oven program, 120°C initial temperature with a 25°C/min increase to 250°C for 1 min, then a 25°C/min increase to 280°C for 4 min. A Hewlett Packard Ultra-1 cross-linked methyl silicone gum phase column (25 m by 0.32 mm by 0.52 μm) with a 2.65 ml/min flow of helium was used. Retention time of malathion was 5.597 min.

Data Analysis

Data from the aerial tests of malathion were analyzed as a split plot with treatments as whole plots and time as a subplot. Treatments were in a randomized complete block design with six replicates. All data were subjected to an ANOVA using SAS's PROC MIXED (Littell et al. 1996). Least square means were separated using the PDIFF option.

Results

In 1998, comparison of oil adjuvants showed that CSO was a more effective adjuvant than Orchex® 796 or WS2980 (Table 2). Mortality of boll weevils placed on leaves treated with malathion mixed in Orchex® 796 and in WS2908 was not as high as those on leaves treated with malathion mixed in cottonseed oil. At 3 days after application, mortality of boll weevils on leaves treated with the reduced rate of malathion in CSO (92%) was not significantly different from those on leaves treated with an application of 12 oz/A of technical malathion (92%).

In 1999, all tests with technical malathion were conducted with CSO because it was the most effective adjuvant. Boll weevil mortality on leaves treated with the 6:26 and 7:18 ratios of malathion to CSO was equivalent to the 8:8 ratio, while the low-rate/low-volume (6:10) ratio produced the lowest mortality (Tables 3 and 4). Mortality was highest on leaves treated with the 10 oz/A application. Malathion residues on cotton leaves were indicative of the concentration of the mixture applied and diminished over time (Table 3). These results suggest that 6 and 8 oz/A rates of malathion can be as effective as an undiluted 10 oz/A rate for the first 2 - 3 days after treatment if the volume of the application is sufficiently high.

The longevity of malathion on the plant surface during the application program in August 1999 was unexpected (Figure 1). Malathion residues accumulated during the program until a light rain washed malathion off the leaf surface on August 21. This same trend can be seen in residues from the 7:18 and 8:8 ratio applications (Figure 2).

A cost comparison of applications of different malathion:CSO mixtures are shown in Table 5. Application of a 8:8 or a 7:18 ratio of malathion:CSO would result in a $0.20/A savings over a 10 oz/A application of technical malathion without loss of efficacy during the first two days after application.

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Table 1. Aerial application parameters for malathion/cottonseed oil mixtures.

Rate (oz/A)	Volume (oz/A)	Speed	Pressure	Nozzles Number	Nozzles Size
6	32	135	30	18	8004
6	16	135	30	18	8002
7	25	135	32	18	8003
8	16	135	30	18	8002
10	10	135	30	11	8002

Table 2. Average percent mortality (48 h) of boll weevils in leaf bioassays of cotton treated with malathion mixed in different oils on 8 and 21 September 1998.

Adjuvant	Rate (oz/A)	Days after application 0	1	2	3
CSO	6	100 a	100 a	92 b	92 a
Orchex	6	95 b	82 b	72 c	54 b
WS2908	6		64 c	51 d	37 c
Undiluted	12	100 a	100 a	100 a	92 a

Table 3. Average malathion residue ($\mu g/cm^2$) on leaves and percent mortality (48 h) of boll weevils in bioassays of leaves treated with mixtures of malathion and cottonseed oil applied at different rates and volumes by aircraft on 12, 21, and 27 July 1999.

Malathion: CSO	Days after application 0	1	2	3
		Residue		
6:26	1.98 bc	1.04 b	0.22 c	0.10 b
6:10	1.38 c	0.61 b	0.20 c	0.11 b
8:8	2.66 ab	1.94 a	0.69 b	0.20 b
10:0	2.94 a	1.66 a	1.27 a	0.77 a
		Mortality		
6:26	99 a	92 a	64 a	51 b
6:10	98 a	83 b	38 b	25 c
8:8	100 a	93 a	65 a	56 b
10:0	100 a	96 a	72 a	73 a

Table 4. Average percent mortality (48 h) of boll weevils in bioassays of leaves treated with malathion ULV at 10 oz/A and mixtures of malathion ULV and cottonseed oil applied by aircraft during August 1999.

Mal: CSO	Days after application 0	1	2	3	4	5	6
8:8	100	100	100	95	90		
7:18	100	100	99	98	90		
10:0	100	100	100	100	100	100	89

Table 5. Cost savings of reduced rates of malathion ($21.33/gal) in cottonseed oil ($2.10/gal) compared to a 10 oz/A application.

Malathion: CSO	Cost/A	Savings/A/Application
6:10	1.16	0.51
6:26	1.43	0.24
7:18	1.46	0.21
8:8	1.47	0.20
8:10	1.50	0.17
8:16	1.60	0.07
10:0	1.67	0

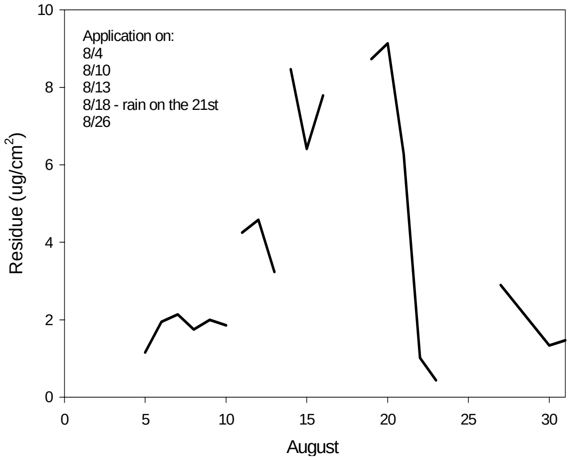

Figure 1. Malathion residues on leaves after aerial applications applied by Mississippi Boll Weevil Eradication Program aircraft during August 1999.

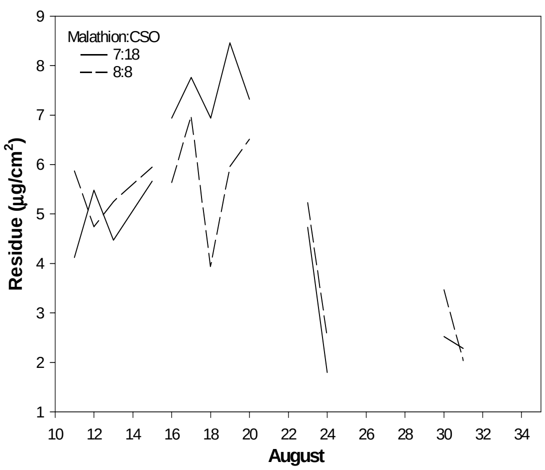

Figure 2. Malathion residues on cotton leaves after aerial application of alathion: cottonseed oil mixtures.