AERIAL ELECTROSTATIC EC MALATHION 5 FOR BOLL WEEVIL CONTROL

I. W. Kirk, W. C. Hoffmann and S. J. Harp
USDA, ARS, Areawide Pest Management Research
College Station, TX

Abstract

Boll weevil remains a significant cotton pest in many cotton production regions, and aerial applications of malathion are a significant control measure in boll weevil eradication programs. Aerial electrostatic spray systems offer possibility of increased spray deposits and reduced drift of water-based low volume sprays. A field study was conducted to compare electrostatically applied EC malathion to ULV malathion for spray deposits, weevil mortality, and fruit damage. Electrostatic applications gave higher weevil mortality on the day of application but persistence of the water-based electrostatic spray was lower than the oil-based ULV spray, which resulted in higher fruit damage for the electrostatic spray application.

Introduction

Cotton production areas that are still infested with boll weevils need technologies that can assist in conventional control or eradication programs. Agricultural aircraft make a sizeable percentage of conventional weevil control applications and most of boll weevil eradication program applications. Research scientists in USDA programs on improving pesticide application technology have developed an aerial electrostatic system that has potential for improving spray deposits, reducing spray drift, and maintaining or improving insect control. Malathion was one of the early insecticides used for boll weevil control, and ULV malathion has been the insecticide of choice in boll weevil eradication programs. However, ULV malathion is not inductively chargeable with the USDA aerial electrostatic system. Attempts to adjust formulation resistivity and increase chargeability of ULV malathion for aerial electrostatic application have not been successful. Spray mixes of EC malathion and water are readily chargeable but have not been used in boll weevil eradication programs because of the required higher volume of water-based spray mixes and pH-dependent hydrolysis of the active ingredient in water emulsions. The objective of this study was to compare efficacy of aerial electrostatically charged EC malathion 5 in a pH-controlled 1 gpa spray mix with efficacy of aerial ULV malathion applied in accord with the protocol of the Texas Boll Weevil Eradication Program (TBWEP).

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1205-1207 (2000)
National Cotton Council, Memphis TN

Methods

The study was conducted in two adjacent 10-acre cotton fields in Robertson County, TX. Each field served as a replicate block for the two aerial treatments, Table 1. Preliminary study plans included field sampling for spray deposition parameters, field sampling for weevil populations and fruit damage, and laboratory bioassays for weevil mortality estimates. Relatively low native weevil populations during late July and August when the applications were made and the high manpower requirements for field weevil sampling prompted us to forgo sampling for field weevil populations. Consequently, we will only report deposition, fruit damage, and bioassay methods and data.

Table 1. Aerial spray treatments for field study.

Insecticide Treatment	AI rate, lb/acre	Spray Rate	Airspeed, mph	Swath Width, Ft
ULV Malathion	1	13 oz/acre	120	45
Electrostatic EC Malathion 5	1	1 gal/acre	120	45

Aerial Spray Applications

Four spray applications were made on 6-day intervals beginning on July 30. Prespray samples were collected immediately prior to spray applications on the same day the sprays were applied. Post spray samples were collected immediately following spray applications (DAT 0), 3 days after spray application (DAT 3), and 6 days after spray application (DAT 6). For spray applications on August 5, 11, and 17 – the previous DAT 6 and the prespray DAT 0 samples were one and the same, Table 2.

Table 2. Spray application and sampling date schedule for field study.

Spray Application	Prespray DAT 0	Post Spray DAT 0	Post Spray DAT 3	Post Spray DAT 6
July 30	July 30	July 30	August 2	August 5
August 5	August 5	August 5	August 8	August 11
August 11	August 11	August 11	August 14	August 17
August 17	August 17	August 17	August 20	August 23

All spray applications were made with a Cessna AgHusky with SATLOC GPS swath guidance and flow control. Active boom width on both treatments was limited to 75% of wingspan. The pilot-targeted height of flight was 5-8 ft above crop canopy for both treatments. The ULV malathion treatment was applied in accord with the TBWEP protocol with exception of swath width. Ten 8002SS nozzles (calibrated at 40 psi) oriented 90º to the flight path (straight down) were used. The EC malathion 5 treatment was applied in a tap-water-based spray mix with pH adjusted to 6. Eighty-eight electrostatic nozzles (Carlton 1999) with TXVK6 orifices (calibrated at 70 psi) and a bipolar charging protocol were used with inboard nozzles on each boom separated by 6 ft.

Spray Deposits

Twenty top-canopy leaf samples were collected at random locations across the treatment areas in each replication on each sample day and placed in individually marked plastic bags. The bags were placed in light-tight coolers and transported to the laboratory for analysis. Twenty ml ethanol was pipetted into each bag, the bag was agitated, and an aliquot of rinstate was poured into GC vials. Leaves were removed from the bags and leaf areas were measured on a Li-Cor LI 3100 Area Meter so deposits per unit area could be assessed. Malathion in the rinsate samples was quantified using a Hewlett-Packard 6890 gas chromatograph with flame ionization and a J&W DB-1 dimethylpolysiloxane column (30 m X 0.32 mm X 0.25 μm) with a 2 ml/min flow of helium. The chromatograph and auto sampler were operated with Hewlett-Packard's Chemstation software. The operating parameters for the chemical analysis were: injector temperature – 120°C, detector temperature – 250°C, oven program – 60°C initial temperature held for 2 min, then the temperature was ramped 30°C/min to 220°C, a 5°C/min increase to 230°C, a 35°C/min to 300°C, then held for 2 min. The retention time of the malathion was 9.08 min. The oven was allowed to cool before the next sample was injected.

Twenty 24 X 76 mm water sensitive paper (WSP) cards were folded in half and attached to top-canopy leaves in each electrostatic malathion treatment immediately prior to spray application. The cards were collected as soon as the spray dried after application. The cards were placed in plastic sleeves, transported to the laboratory, and computerized image analysis measurements made on the top leaf surface of the cards (Stermer et al. 1988 and Franz 1990). A similar procedure was used for the ULV malathion treatments except that 48 X 76 mm oil sensitive paper (OSP) cards were used.

Damaged Fruit

Twenty plants were selected at random in each treatment replication, cut at ground level, placed in plastic bags, and transported fieldside. Bolls and squares were removed from each plant and placed in individually marked plastic bags. These bags were taken to the laboratory, each fruit form was examined for weevil damage, and percentages of damaged bolls and squares determined.

Leaf Bioassays

Ten top-canopy leaves were collected at random locations in each treatment replication on each sample day, placed in paper bags, and transported to the laboratory. The same numbers of no-treatment cotton leaves were processed as checks. Individual leaves were placed in 4-in-diameter, 1/2-inch-deep petri dishes. The whole leaves were placed on top of 4-in diameter moistened paper towels, ten USDA Gast Facility weevils were placed on the leaves, and the dishes were covered with petri dish covers. Covered dishes were maintained at 80ºF on laboratory bench tops. Weevil mortality was counted 24 hours after placement.

Results

Spray Deposits

Cotton Leaves give reasonable quantitative measures of spray deposits when leaves are sampled randomly from treated areas and spray deposits are washed from leaves and rinsates are analyzed by analytical methods. Gas chromatographic measures of malathion from cotton leaves sampled in the study are shown in Table 3.

Table 3. Malathion (ng/cm^2) on cotton leaves from four spray applications, at three times after spray application.

Spray Application Date	ULV Malathion DAT			Electrostatic EC Malathion 5 DAT		
	0	3	6	0	3	6
July 30	7.46 ab	3.45 c	0.25 de	7.27 ab	0.61 de	--
August 5	1.53 d	--	0.17 de	3.85 c	--	0.03 e
August 11	7.09 ab	1.05 de	0.64 d	6.30 b	0.54 d	0.00 e
August 17	7.33 ab	3.59 c	0.80 d	7.91 a	0.06 e	0.00 e

-- Missing and incomplete data due to GC malfunction.
Means followed by the same letter are not significantly different by Fisher's Protected $LSD_{0.05}$.

Malathion deposits were relatively consistent for the two treatments on three of the four application dates. The deposits on August 5 for both treatments were significantly lower than on the other three dates (A problem was noted with sticking check valves on the spray boom, which we believe was the cause of lower deposits on that day.). With the exception of August 5, there were no significant differences between the two application methods in the amount of malathion deposited on the day of spray application. However, the amounts of malathion present on days 3 and 6 after spray application were significantly lower for the electrostatic EC malathion 5 application. Malathion applied as ULV oil is apparently more persistent on cotton leaves than when applied in a water-based EC low-volume spray mix.

WSP and OSP Cards produce spray deposit stains that can be analyzed for various parameters. Droplet size, droplet density, and percent coverage data for the cards from this study are shown in Table 4.

Table 4. Deposited spray parameters on top leaf surfaces as computed from stains on WSP and OSP attached to cotton leaves at the top of the crop canopy.

	Treatment	
Parameter	ULV Malathion	Electrostatic EC Malathion 5
$D_{V0.5}$	120 b	153 a
Drops/cm^2	27 b	44 a
% Coverage	0.74 b	1.46 a

$D_{V0.5}$ = volume median diameter
Means in a row followed by the same letter are not significantly different by Fisher's Protected $LSD_{0.05}$.

Spray droplet size as indicated by volume median diameter was significantly lower for the ULV malathion treatment than for the electrostatic EC malathion 5 treatment. This difference is primarily due to the different spray nozzles, spray mixes, and pressures used with the different treatments. The number of droplets per unit area and percent coverage from the two application methods generally reflect the higher spray rate associated with the electrostatic EC malathion 5 treatment.

Damaged Fruit

There were no significant interactions for percentages of boll and square damage between the malathion treatments and spray date as the season progressed. The percentage of bolls damaged by weevil feeding or oviposition punctures was significantly lower for the ULV malathion treatment when averaged over the four sample dates. The percentages of squares damaged by weevil feeding were not significantly different for the two malathion treatments when averaged over the four sample dates (Table 5).

Table 5. Percent fruit damage.

	ULV Malathion	Electrostatic EC Malathion 5
Percent Damaged Squares	14.3 a	17.6 a
Percent Damaged Bolls	4.2 b	7.2 a

Means followed by the same letter in a row are not significantly different by Fisher's Protected $LSD_{0.05}$.

Leaf Bioassays

There was a significant interaction between treatments and sampling day after spray application for percent boll weevil control, Table 6. The electrostatic EC malathion 5 treatment had higher mortality on the day of application than the ULV malathion treatment, but significantly lower mortalities on days 3 and 6 after spray application.

Table 6. Percent boll weevil mortality compared to a check for two malathion treatments for three periods after spray application.

Days After Application	ULV Malathion	Electrostatic EC Malathion 5
0	88.7 b	97.0 a
3	56.1 c	29.8 e
6	43.1 d	29.0 e

*Means followed by the same letter are not significantly different by Fisher's Protected $LSD_{0.05}$.

Boll weevil mortality for ULV malathion dropped significantly on days 3 and 6 after spray application, but did not drop as much as observed for the electrostatic EC malathion 5 treatment.

Discussion

Malathion deposit, boll weevil bioassay, and damaged boll and square data give a relatively consistent story on performance of the two malathion treatments for boll weevil control. Both application methods deposit equivalent amounts of malathion, but the amount of malathion present on days 3 and 6 after application was significantly lower when applied in water by the electrostatic system. Boll weevil mortality in leaf bioassays was significantly higher on the day of spray application for the electrostatic water-based application, but was significantly lower than the ULV application on days 3 and 6 after spray application, which corresponds with the amounts of malathion present, based on gas chromatography data. Higher boll weevil mortality for the electrostatic EC malathion 5 treatment, as reflected in leaf bioassays on the day sprays were applied indicates higher susceptibility of boll weevils to the spray deposit parameters for that application method as compared to the ULV malathion treatment. Lower boll damage associated with the ULV malathion application is apparently due to extended persistence of malathion in oil on leaf surfaces as compared to the water-based electrostatic application. These data indicate that application of malathion with the aerial electrostatic system would give improved early knock-down of boll weevils, but that ULV applications of malathion would give higher boll weevil mortality over a six-day spray application interval. The 1 gpa spray rate for the EC malathion 5 electrostatic application system as compared to the 12 oz/acre spray rate for the conventional ULV malathion application system could have some economic disadvantage for the electrostatic application system in large-acreage eradication programs. However, if full loads of ULV malathion are not used, there would be less concern about the higher spray rate for the electrostatic application sysem.

Summary

Electrostatic aerial spray systems offer potential for increased spray deposits and reduced spray drift from water-based spray mixes. This study was conducted to determine the feasibility of the electrostatic system for applying a water-based EC malathion spray mix as compared to the conventional ULV malathion sprays used in boll weevil eradication programs. Spray deposit results show similar deposits of malathion for both systems, but the electrostatic water-based sprays are not as persistent as the oil-based ULV sprays of malathion. The boll weevil bioassay results show higher weevil mortality from the electrostatic water-based sprays on the day of spray application but significantly lower weevil mortalities on days 3 and 6 after spray application. The fruit damage data show higher percentages of boll damage sustained with the electrostatic application. These results show some initial efficacy benefit for the electrostatic system, but more rapid degradation of malathion from the water-based spray offset the initial benefit as shown by the fruit damage data.

Acknowledgments

Appreciation is expressed to Stratta Brothers, Hearne, Texas, for cooperative use of commercial cotton fields for conducting this study. Appreciation is also expressed to Osama El-Lissy and Phil Hopkins, TBWEP, for providing the ULV malathion and to Weldon H. McFarland, Terra, for providing the EC malathion 5 for use in this study. Hal Tom piloted the aircraft. Phil Jank, Charlie Harris, and Carlos Garza processed samples.

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