BOLL WEEVIL MORTALITY AND MALATHION RESIDUES ON COTTON LEAVES TREATED BY ERADICATION MIST BLOWERS

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ABSTRACT

Malathion deposition and toxicity to boll weevils, *Anthonomus grandis* Boheman, were measured on cotton leaves treated by mist blowers used by the Southeastern Boll Weevil Eradication Foundation. Leaves were sampled at 11 distances between 2.3 and 31.2 m from the paths traveled by the mist blowers. More than 50% of weevils exposed to leaves collected within 19.9 m of mist blowers spraying with the wind died within 24 hours , and more than 90% of weevils exposed to leaves collected within 9.8 m of mistblowers spraying against the wind died within 24 hours. Depositions of 0.53 and 1.63 µg malathion/cm^2 of leaf surface resulted in 50 and 90% mortality at 24 hours of treatment and depositions of 0.41 and 1.07 µg malathion/cm^2 of leaf surface resulted in 50% and 90% mortality at 48 hours, respectively. Mortality at 24 and 48 hours following treatment were closely correlated. More malathion was deposited at greater distances from the mist blowers for applications with the wind, but significant boll weevil mortality and malathion deposition were seen when spray was directed against the wind. Results of this research should lead to a more thorough understanding of how mist blowers should be used in boll weevil eradication.

INTRODUCTION

Aerially-applied malathion has been the major component used to eradicate the boll weevil, *Anthonomus grandis* Boheman, from most of the eastern and southeastern United States (Jones and Wolfenbarger 1996, Villavaso et al. 1996). Mist blowers have been widely used for treating large trees or orchards and in mosquito control, but they have generally not found favor in row crop treatment. Nevertheless, mist blowers have played an integral role in boll weevil eradication by supplementing aerial application of malathion where trees, power lines, or other obstructions interfered with satisfactory coverage. However, a clear picture of their spray coverage and the results of that coverage on boll weevil mortality has not been developed. A treatise on the fundamentals of mist blower development and operation can be found in Potts (1958).

The major purpose of this study was to determine distribution patterns of mist blower-dispensed malathion and mortality of boll weevils exposed to leaves collected within the treated areas. The amount of malathion deposited at selected distances from the blowers and boll

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weevil mortality at each distance was measured, and a correlation between malathion deposition and boll weevil mortality is presented.

MATERIALS AND METHODS

Two types of commercially available mist blowers used in eradication programs managed by the Southeastern Boll Weevil Eradication Foundation (Montgomery, AL) were tested: "Automatic" (Automatic Equipment Manufacturing Company, Pender NE), which has been the standard mist blower for the boll weevil eradication program, and "Big John" (Big John Manufacturing, Inc., Osmond, NE), a recent addition. Malathion applications were made in a 6 ha (15 acre) cotton field planted on the first day of June and located just north of Starkville, MS. Weevils used for bioassay were reared at the Gast Insect Rearing Laboratory, Mississippi State, MS..

Each blower was mounted on an expanded metal platform that replaced the bed of a 3/4 ton pick-up truck. Blowers were powered by 18-hp engines with metering pumps dispensing malathion through a TeeJet 8001 flat fan nozzle (Spraying Systems, Wheaton, IL) into the air blast which was 202 and 161 km per hr (125 and 100 mph) at point of malathion exit for the Big John and Automatic blowers, respectively. Fan speeds were ≈ 2000 rpm.

USDA reports on mist blower usage and calibration have been produced by R. G. Jones and H. E. Mabry in 1985 and 1994 (Robert G. Jones, USDA-APHIS, personal communication). Blowers in our tests were calibrated to dispense 473 ml of 95% malathion (Fyfanon, 1.17 kg/liter, Cheminova, Lemnig, Denmark) per 265.5 m of travel in a 2 min time period. Thus, vehicles traveled at a speed of 8 km per hour (5 mph).

Plots were arranged on both the leeward and windward sides of the field so blower performance could be evaluated both with and against the wind. (Eradication criteria require that mist blower use be suspended if wind speeds exceed 16.1 km per h, and operators are prohibited from directing sprays into the wind.) The travel path of the blower-mounted vehicles was 1.5 m from and parallel to the first row of cotton plants. Treatments were randomized and separated by 68.6 m. One replication consisted of each blower being operated over a 45.7 m path on both sides of the field. Replications were conducted on different areas of the same field and on three dates during the months of July and August.

To estimate the distance the spray droplets were traveling and to mark the center of each plot, oil sensitive spray cards were placed on a perpendicular line originating at the midpoint of the path each mist blower traveled over each plot. One spray card was affixed with a paper clip to an upper leaf of a plant on rows 2, 4, and every 4th row thereafter to row 40. Rows were planted on 76.2 cm centers. Visual evidence of malathion deposition on spray cards was rarely found on the highest numbered rows, and we did not collect leaves beyond the fortieth row. Within 2 h after treatment, leaves for bioassay and chemical assay were picked from 3.0 m (10 ft) sections of row on either side of each spray card in all replicates. Cotton leaves for both the bioassays and chemical assays were picked from the upper portion of the canopy.

Bioassay. For bioassays, we selected leaves about the size of the petri dishes, but excess leaf area was trimmed with scissors when necessary. Ten leaves from each row-treatment combination were placed in 15 (ht) x 100 mm (dia) petri dishes with 4-7 day old boll weevils from the Gast Insect Rearing Laboratory, Mississippi State, MS (1 weevil per leaf, 1 leaf per dish), and held at approximately 27.5° C. Mortality was recorded 24 and 48 h later.

Chemical Assay. Malathion residues were washed from 5.06 cm^2 areas of the upper and lower surfaces of 5 leaves by rinsing them in 3 ml of 100% ethanol with modified Dual Side Leaf Washers (Carlton 1992). Aliquots (2 ml) were placed in auto-sampler vials for analysis by gas chromatography. A Hewlett-Packard 5890 gas chromatograph equipped with a flame photometric detector, an auto-sampler, and ChemStation (Hewlett-Packard) software was used to quantitate malathion residues. The parameters of our residue analyses method were as follows: Injector 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 by 0.52 μm) with a 2.65 ml/min flow of helium was used. Retention time of malathion was 5.597 min. The leaf-washing procedure used removes about 60% of the malathion on the leaf surfaces (J. E. M. unpublished), so the data from GC analysis was divided by 0.6 to estimate the actual amount on the leaf surfaces.

Relationship Between Bioassay and Chemical Assay. In addition to measuring mortality and malathion residues on leaves collected at selected distances from mist blower, we were able to develop curves depicting relationships between malathion residues and boll weevil mortality at 24 and 48 h after exposure to treated leaves. Because malathion is found on both the upper and lower surfaces of cotton leaves and weevils had access to both surfaces, we used the average amount of malathion deposited on each surface as the independent variable for constructing the curves. Malathion depositions estimated to cause 50% and 90% mortality of weevils exposed to treated leaves for 24 and 48 h were calculated. Residues resulting in 0 and 100% mortality were omitted.

Statistical Analysis. Mortality and malathion residues were analyzed using SAS PROC-MIXED procedure (Littell et al. 1996) to determine if differences existed between the two mist blowers. Regression equations describing malathion deposition and boll weevil mortality expected at various distances from the mist blower, and boll weevil mortality expected with various amounts of malathion on leaf surfaces were calculated using Sigma Plot 5.0 for Windows (SPSS Inc., Chicago, IL).

RESULTS AND DISCUSSION

Bioassay. Wind speeds during the test were under the 16.1 km per hour limit established for mist blower use. Speeds ranged between 4 and 14 km per hour (2.5 and 8.8 mph). No significant differences in mortality between the two mist blowers were observed for either 24 h mortality ($F = 0.99$; $df = 1, 49$; $P = 0.16$) or 48 h mortality ($F = 0.56$; $df = 1, 49$; $P = 0.46$). Mortalities for the mist blowers at 24 h were pooled and graphed by row, with and against the wind (Fig. 1A). Sigmoidal 3 parameter curves were constructed using the following equations in which x = distance in meters from the mistblower.

$$f = 101.66/(1 + \exp(-(x - 19.75)/-4.87)) \quad \text{(with wind; } r^2 = 0.99\text{)}$$
$$f = 104.17/(1 + \exp(-(x - 8.98)/-1.83)) \quad \text{(against wind; } r^2 = 0.99\text{)}$$

Based on these equations, 24 h mortalities of greater than 50 and 90% can be expected on leaves collected within 19.9 and 9.8 m, respectively, of the paths traveled by mist blowers spraying with the wind and 9.1 and 5.6 m, respectively, of mist blowers spraying against the wind.

Mortality at 48 h after exposure closely followed mortality at 24-h. The relationship between 24 and 48 h mortality (Fig. 2) is represented by the quadratic equation in which x = percent mortality at 24 h.

$$f = 3.44 + 2.12x - 0.012x^2 \quad (r^2 = 0.97)$$

Chemical Assay. Like mortality, the amount of malathion deposited on leaves was greatest on rows near the mist blowers and diminished with distance. Once again, there was no significant difference between mist blowers ($F = 0.16$; $df = 1, 49$; $P = 0.69$) so amounts of

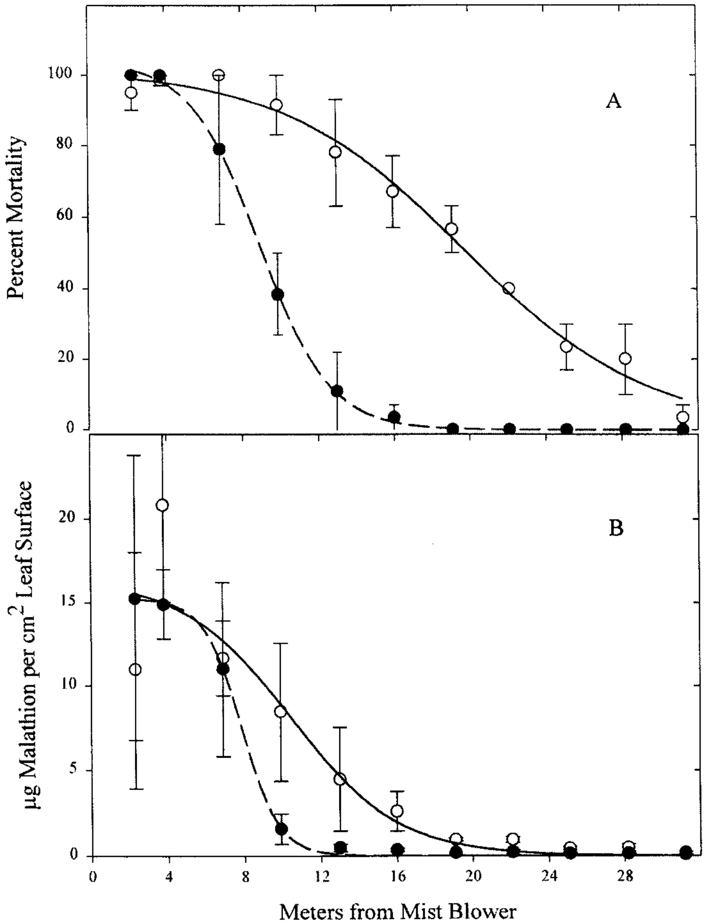

FIG. 1. (A) Percent mortality of boll weevils exposed to cotton leaves sampled at various distances from mist blowers spraying ultra low volume malathion with (open circles; solid lines) or against (solid circles; dashed lines) wind; (B) Malathion residues on cotton leaves sampled at selected distances from mist blowers spraying with or against the wind.

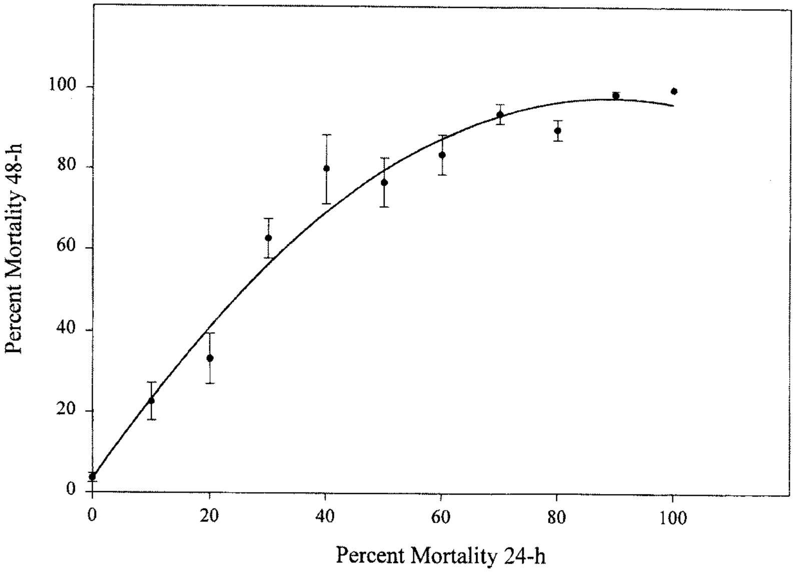

FIG. 2. Relationship between 24 and 48-hour mortality of boll weevils assayed on cotton leaves treated with malation.

malathion deposited by the blowers were pooled. Expected malathion deposition at various distances from the mist blowers spraying with and against the wind shown in Fig. 1B and is represented by the following 3 parameter sigmoidal equations in which x = distance in meters from the mistblower.

$$f = 16.45/(1 + \exp(-(x - 10.36)/-2.83)) \text{ (with wind; } r^2 = 0.87)$$
$$f = 15.24/(1 + \exp(-(x - 7.83)/-0.98)) \text{ (against wind; } r^2 = 0.99)$$

Based on these equations, malathion depositions of 0.53 and 1.63 $\mu g/cm^2$ of leaf surface could be expected at distances of 20.0 and 16.6 m, respectively, from paths of mist blowers spraying with the wind and 11.1 and 9.9 m from the paths of those spraying against the wind (Fig 1B).

Relationship Between Bioassay and Chemical Assay. Relationships between malathion deposition on cotton leaves and boll weevil mortality are seen in Fig. 3. Expected malathion depositions associated with selected rates of boll weevil mortality are represented by the following quadratic equations in which x = percent mortality.

$$f = 0.50 - 0.014x + 0.0003x^2 \text{ (24 h; } r^2 = 0.96)$$
$$f = 0.48 - 0.011x + 0.0002x^2 \text{ (48 h; } r^2 = 0.79)$$

Amounts of malathion expected to kill 50 and 90% of boll weevils exposed to treated leaves for 24 h are 0.53 and 1.63 $\mu g/cm^2$ of leaf surface, respectively. Amounts expected to kill 50 and 90% after 48 h are 0.41 and 1.07 $\mu g/cm^2$, respectively. The values reported here are reasonably close to those reported elsewhere in this supplement (Villavaso and Smith 2001)

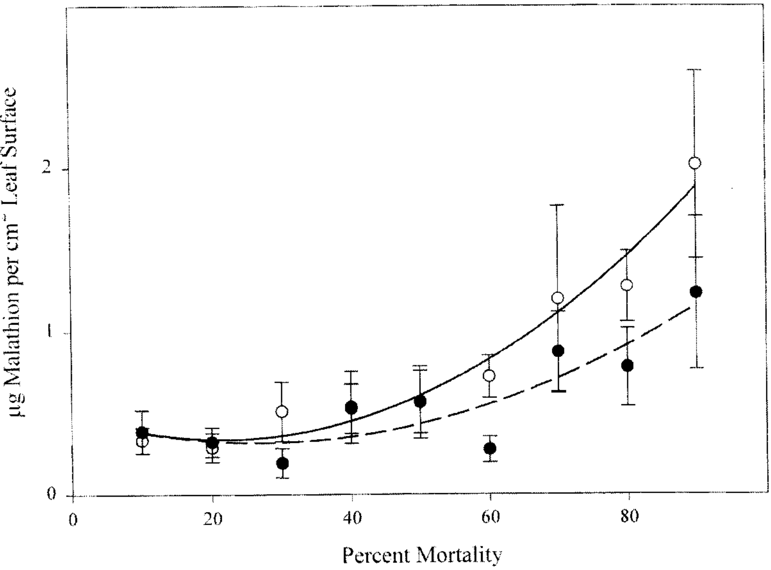

FIG. 3. Malathion residues on cotton leaves from which selected percentages of boll weevil mortality were observed at 24-h (open circles; solid line) and 48-h (solid circles; dashed line).

In summary, we have determined distances at which certain malathion residues can be expected to occur on cotton leaves treated with mist blowers of the type used by the Southeastern Boll Weevil Eradication Foundation and other boll weevil eradication organizations and mortality of boll weevils exposed to those residues. Dose-mortality curves and a curve depicting the relationship between 24 and 48 h mortality were developed from the data. Mist blowers are more effective when their spray is directed with the wind, but significant amounts of malathion will be deposited on cotton leaves should the spray be directed into the wind, and significant kill of boll weevils exposed to those leaves can be expected.

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