AERIAL SPRAYS OF FIPRONIL FOR CONTROL OF BOLL WEEVIL

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Abstract

Aerial electrostatic application and fipronil are potential improvements in technology for controlling and eradicating cotton boll weevil. A small field study of aerial applications of electrostatic fipronil, fipronil in ULV oil, and ULV malathion was conducted in Burleson County, TX. ULV malathion delivered more dye tracer to top-canopy cotton leaves than the other treatments. Electrostatic fipronil had higher boll weevil mortalities in leaf bioassays three days after application than the other treatments. Fipronil in ULV oil had lower spray deposits and lower boll weevil mortalities than the other treatments. These technologies need further evaluation in large-scale field studies.

Introduction

Boll weevil eradication is critical to the competitive posture of cotton. The large increases in eradication acreage in 1999, proposed increases in 2000, and the possibility of resistance with continued use of a single toxicant, all point to the need for effective alternative materials and application methods. Aerial electrostatic systems developed by USDA, ARS (Carlton et al. 1995 and 1999) have potential for improving spray deposition and reducing spray drift while maintaining or improving efficacy of crop protection materials. Our research on electrostatic charging of more than 20 insecticides showed that water-based spray mixes of fipronil took on the highest charge-to-mass ratio. Charge-to-mass ratio is a critical factor in electrostatic spray application. Rhône-Poulenc Ag Company, the manufacturer of fipronil, is seeking a label for cotton under the trade name of Regent® and expects to position the material competitively as an alternative to ULV malathion for use in the US Boll Weevil Eradication Program.

The objective of this study was to determine if the high charge-to-mass ratio of fipronil provides increased spray deposits and improved efficacy of the material against over-wintered boll weevils in monitored aerial electrostatic applications.

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Materials and Methods

The study was conducted in a 16 A cotton field in Burleson County, TX. The four treatments -- electrostatic fipronil, ULV fipronil, ULV malathion, and an untreated check -- were used in the study and the crop was subsequently destroyed under Experimental Use Permit 264-EUP-117. The relatively small acreage available for the aerial application study and the difficulty of sampling weevil populations in small plots dictated that the experimental design would be composed of one replication of each treatment with extensive sub-sampling in the treated areas. Each treatment had four sub-sampling blocks and each sub-sampling block had three sub-sampling locations. Five oil sensitive paper (OSP -- for oil-based spray mixes) or five water sensitive paper (WSP -- for water-based spray mixes) cards were each folded in half and attached to cotton leaves with a straight pin near the top of the canopy at each sub-sample location immediately prior to spray application. The folded cards had surfaces on both top and bottom of leaves for spray deposit collection. WSP and OSP were analyzed with computerized image analysis for deposited spray droplet size, droplet density, and percent area covered by spray deposits.

Six leaves from near the top of the canopy were collected from each sub-sampling location and placed in individual marked plastic bags for spray deposit analyses. All spray mixes contained 5-g/A caracid brilliant flavine FFS dye as fluorescent tracer dissolved in 1.2 oz/A methanol for quantification of spray deposits. Spray deposits on leaves were washed from leaf surfaces in methanol and the rinsates were quantified by spectrofluorometry. A Li-Cor LI 3100 area meter was used to measure leaf areas.

Two leaves from near the top of the crop canopy were collected from two sub-sampling locations in each sample block on 0, 3, and 7 DAT for weevil bioassays. Individual leaves were placed in 100 X 20-mm petri dishes on top of moistened paper pads and ten laboratory-reared weevils (Gast Facility, Mississippi State, MS) were placed on each leaf for mortality assessment. Mortality was determined 24-hours after weevil placement (Abbott 1925).

Three aerial applications (May 29, June 10-11, and June 18, 1998) of label rate (0.05 lb (AI)/A) of Regent® 2.5 EC insecticide were made (1) in 1 gpa of water with an electrostatic spray system and (2) in 16 oz/A of Prime Oil (the first application) and 12 oz/A of once-refined cottonseed oil (the second and third applications); ULV malathion was applied at 12 oz/A. An untreated check was also included in the 16 A field. The electrostatic Regent® treatment was applied with the USDA aerial electrostatic system. The Regent® in ULV oil and ULV malathion treatments were applied with the nozzle arrangement specified in contracts for the Texas Boll Weevil Eradication Foundation (TBWEF) for the Cessna AgHusky aircraft. Swath widths for all applications were 45 feet. Boom heights were 8-12 ft, except on June 18 when flight height was lowered to 5 ft for the electrostatic fipronil treatment.

Weevil populations as indicated by punctured square counts never reached economic levels, so seasonal weevil control applications were not made.

Results

Weevil Populations

Weevil populations were not detectable in the treatment blocks before the first scheduled spray date, but we decided to go ahead with the study to get deposition and bioassay data, even though the likelihood of working with native weevil populations was remote. Weevil populations remained low in the plots throughout the season, even in the untreated check plot.

Spray Deposits

Use of WSP and OSP in conjunction with fluorometric dye deposits on leaf and artificial sample surfaces permit multiple parameter assessments of spray deposits.

OSP and WSP Card analyses give measures of spray deposition parameters. These parameters computed from 1060 cards are shown in Table 1. The Treatment X Surface interaction was highly significant for all parameters except D_{min}; Treatment effect was highly significant for D_{min}. There are major differences in the Treatment applications that must be considered in evaluating these data: the electrostatic fipronil treatment was water-based and sampled with WSP — the other two treatments were oil-based and sampled with OSP; the electrostatic fipronil treatment was applied at 1 gpa — ULV malathion was applied at 12 oz/A and the fipronil in oil treatment was applied at either 12 or 16 oz/A. However, these differences do not prevent reasonable comparisons or assessments to be made. It is apparent from these data that the two oil-based treatments did not express similar atomization and deposition parameters. Droplet size was smaller and deposit volume was less for fipronil in oil than for ULV malathion.

Table 1. Deposited spray parameters on top and bottom leaf surfaces as computed from stains on WSP and OSP attached to cotton leaves at the top of the crop canopy.

Treatment	Electrostatic Fipronil		ULV Malathion		Fipronil in Oil	
Surface	Top	Bottom	Top	Bottom	Top	Bottom
Parameter						
$D_{V0.5}$, µm	135	80	109	38	55	30
Drops/cm^2	33	20	26	31	27	27
%Coverage	1.20	0.55	0.72	0.13	0.15	0.07
Vol., nL/cm^2	38.6	15.2	7.8	1.0	1.3	0.5
D_{min}, µm	6.9	7.5	3.1	2.3	1.9	1.7
D_{10}, µm	74	47	35	16	13	9
D_{max}, µm	188	110	145	53	77	43
%Vol.<100µm	26	56	43	89	78	90
%Vol.<200µm	78	85	87	99	96	98

$D_{V0.5}$ = volume median diameter, D_{min} = minimum droplet diameter,
D_{10} = mean droplet diameter, Dmax = maximum droplet diameter

Cotton Leaves sampled randomly from treated areas give reasonable quantitative measures of spray deposits. Spray deposits can be quantified by image analysis of stains on WSP and OSP and by fluorometric analysis of leaf wash rinsates. Previous experience has shown that fluorometric analysis usually gives a superior quantification. Fluorometric data from the study are shown in Table 2. Treatment means for both dye deposits and spray deposits were significantly different. Since the same amount of dye per acre was applied in all sprays, the dye deposit measurements give an indication of the efficiency of delivery of simulated active ingredients to leaf surfaces. More dye was deposited on leaf surfaces with the 12 oz/A ULV malathion treatment than with the fipronil in 12-16 oz/A oil or the electrostatic fipronil in 1 gpa of water. The high spray deposit with the electrostatic fipronil treatment reflects the higher 1 gpa spray rate as compared to the 12-16-oz/A spray rate for the other two treatments. The ULV malathion and the fipronil in oil treatments, with similar spray rates applied, indicate that the ULV malathion treatment gave higher active ingredient deposits and spray deposits.

Table 2. Spray deposits on cotton leaves as computed from fluorometric analyses of leaf wash rinsates.

Treatment	Electrostatic Fipronil	ULV Malathion	Fipronil in Oil
Parameter			
Dye Deposit, ng/cm^2	24.7	36.1	11.8
Spray Deposit, nL/cm^2	18.7	2.6	1.1

There was a significant date by treatment interaction for spray deposit, Table 3. The differences in spray deposit for fipronil in oil for the 16 oz/A spray rate on May 29 compared to 12 oz/A spray rate on June 10 and June 18 are indicated by trend but the differences are not significant. The major factor contributing to the interaction is the higher deposits from the electrostatic fipronil treatment on June 18 and May 29. These differences may be related to other application conditions or meteorological differences that were not accounted for in the study. A possible reason for the higher spray deposits with the electrostatic fipronil treatment on June 18 was the lower boom height that was selected to determine if electrostatic spray release closer to the canopy would improve spray deposits. There were instances on this date of the aircraft wheels impacting cotton leaves at the top of the canopy when these applications were made.

Table 3. Average spray deposits, nL/cm^2, for three treatments on three application dates.

Treatment	Electrostatic Fipronil	ULV Malathion	Fipronil in Oil
Date			
May 29	16.1 b	3.1 d	1.9 de
June 10-11	9.3 c	1.7 de	0.4 e
June 18	30.7 a	2.9 d	1.0 e

Means followed by the same letter or group of letters are not significantly different based on Fisher's Protected LSD at 0.05.

Weevil Mortality -- Laboratory Bioassay

Weevil mortalities in laboratory bioassays were highly variable but the electrostatic fipronil and ULV malathion treatments both gave above 95 percent weevil mortality on the day of spray application, Table 4. Mortality from the fipronil in oil treatment was lower than for the other two treatments on all of the bioassay days. Electrostatic applications of fipronil gave significantly higher weevil mortalities than the ULV malathion treatment 3-d after spraying. Effectiveness of the three treatments had dissipated 7-d after treatment application.

Table 4. Percent boll weevil mortality in laboratory bioassays.

Treatment	Electrostatic Fipronil	ULV Malathion	Fipronil in Oil
DAT			
0	97	95	77
3	50	33	18
7	2	2	1

Discussion

It is apparent from the data analyses that a problem occurred with deposition of the treatment with fipronil in oil. There was considerable discussion among project leaders on the appropriate vegetable oil to use as the diluent for this treatment. We had previous experience with Prime Oil and used it for the first application date. However a decision was made to use once-refined cottonseed oil for subsequent applications. It is logical to think, based on perusal of all of these data, that flow rate of the fipronil in cottonseed oil was lower than ULV malathion. However, a SATLOC Flow Control was used to control flow rate during application. It is not expected that viscosity differences between the two oil-based spray mixes would make a significant difference in flow rate monitored by the flow controller. Reed et al. 1998 and Mulrooney et al. 1998 both report good results with fipronil in oil for control of boll weevil. Differences in atomization properties of different vegetable oils could account for differences in results between this and other studies. This matter warrants further study if general recommendations are made for vegetable oil as a ULV diluent for fipronil.

Summary

Electrostatic aerial spray systems have been developed and offer potential for increased spray deposits and reduced spray drift. Fipronil was shown to be readily adaptable to electrostatic charging and a label for use on cotton is being pursued by the manufacturer for possible use as an alternative toxicant in boll weevil eradication programs. A small field study was designed to compare electrostatically applied fipronil, fipronil in ULV oil, and ULV malathion. Electrostatic fipronil had higher boll weevil mortalities on day 3 after spray application than the other treatments. Fipronil in ULV oil gave lower boll weevil mortalities on days 0 and 3 after spray application than either electrostatic fipronil or ULV malathion. Large scale field studies with electrostatic fipronil are warranted based on this preliminary study.

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