SPRAY DROPLET PENETRATION IN COTTON CANOPY USING AIR-ASSISTED AND HYDRAULIC SPRAYERS

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Abstract

The effectiveness of three sprayer configurations, air-assisted, over-the-top, and drop-nozzle sprayers, was evaluated using four different insecticides to control lepidopterous insect pests in cotton. Seed cotton yields during 1998 were negatively correlated with insect damage counts. Bioassays of leaves from the top, middle, and bottom of plants treated with Tracer with the three sprayer types indicated that all three sprayers provided coverage in the top of the plant, but the air-assist sprayer provided the best coverage throughout the plant while the over-the-top sprayer had the poorest coverage in the bottom of the plant. Air-assist and drop nozzle sprayers had good coverage in the middle of the plant.

Introduction

The success of the boll weevil eradication program has reduced the amount of conventional insecticides used in cotton insect management. However, there is still potential for major crop damage by lepidopterous insects that can cause substantial losses in cotton across the southern United States. Using conventional insecticides to control lepidopterous insects may be severely curtailed due to environmental concerns and by failure to re-register products for use in cotton. Lack of registered conventional insecticides and/or development of insecticide resistance could lead to crop loss when outbreaks of lepidopterous pests occur.

Industry has developed a wide spectrum of viruses (e.g. Gemstar), fungi (e.g. Naturalis-L), and numerous bacterial products(Bt's) that have promise for use in managing lepidopterous insects. These biological/biorational insecticides could provide alternatives to conventional insecticides in cotton pest management. They could effectively reduce lepidopterous pest populations below economic damaging levels while protecting beneficial insect populations. However, a need currently exists in the development and evaluation of methods to effectively apply these biological/biorational insecticides to cotton. Improved efficiency via getting more active ingredient to the target in an effective manner could improve performance, prolong the effective activity, and provide higher economic net returns that would result in wide acceptance of biological/biorational insecticides by growers.

Application technology has been developed in recent years to improve pesticide deposition and leaf coverage. Mulrooney and Skjoldager (1997) found that air-assistance application of insecticides significantly enhanced the efficacy of boll weevil and beet armyworm control in cotton compared with conventional application methods. An air-assisted sprayer provided greater canopy penetration and deposit of fluorescent dyes/markers on Mylar sheets and water-sensitive papers in cotton than over-the-top and drop-nozzle sprayers (Womac et al.1992). The air-assisted sprayer also increased deposition of bifenthrin on leaves and squares located within the canopy compared to other sprayers. Howard et al. (1994) reported that three air-assisted sprayers deposited more bifenthrin on both the upper and under-side of leaves in the middle of the cotton canopy and had a higher percent coverage than conventional over-the-top hydraulic sprayers. Therefore, air-assisted sprayers should improve the performance of biological/biorational insecticides which require direct contact with the insect for effective control, since they have improved canopy penetration and leaf coverage.

The objective of the study was to compare the application effect of three sprayer methods (air-assisted, over-the-top, and drop-nozzles) on the effectiveness of Biocot or Dipel, Gemstar, Scout Extra, and Tracer on lepidopterous insect pests in cotton.

Methods and Procedures

Application of Insecticides

Field tests were conducted in plots 8 rows wide by 50 ft long of DPL-5415 cotton at the Coastal Plain Experiment Station, Tifton, Georgia during 1997 and 1998. The experimental design was a randomized complete block with the treatments arranged in a 3 x 5 factorial of application methods and insecticides with four replications. Application methods were 1) air-assist(Berthoud row crop sprayer delivering air at 120 miles/hr) with two blue nozzles operating at 15 psi delivering 20 gpa, 2)over-the-top with two TX-6 hydraulic nozzles operating at 60 psi delivering 8.3 gpa, and 3)hydraulic drop nozzles with one TX-10 hydraulic nozzle on each side (15 inch drops) and one over-the-top of the row operating at 80 psi delivering 14.5 gpa. Insecticides included Biocot at 1 qt/A, in 1997 and Dipel DF at 1 lb/A in 1998, and Gemstar at 10 oz/A, Scout X-tra at 0.019 lb-ai/A, and Tracer 4SC at 0.0625 lb-ai/A in 1997 and 1998. An untreated control was included as a check. Application dates in 1997 were July 22 and 29, August 5, 15, and 20. In 1998 plots were over sprayed with Karate at 0.02 lb-ai/A on July 9, 15, and 21 using the over-the-top sprayer treatment and insecticides were applied on July 28, August 4, 11, 18, 25 and September 1. Total number of bolls, *Heliothis* damaged bolls, worm damaged squares, and

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seed cotton yield per acre were determined to evaluate treatment effects. Data were analyzed by ANOVA (SAS Institute Inc., 1989) and treatment means separated by Waller-Duncan or Fishers LSD (P=0.05).

Bioassay of Applied Insecticide Residue

Leaf bioassays were conducted in 1998 on August 4, 18, and 25 using foliage from the Tracer treated plots. The experimental design was a randomized complete block design with four replications where treatments were arranged in a 3 by 4 factorial to evaluate efficacy by plant location and application method. On the treatment day, after the spray solution had dried on the leaves, five leaves were randomly sampled from the top, middle, and bottom of the cotton plants in each plot treated with Tracer and the untreated check plots. Leaves were trimmed to fit into 100-mm diameter sterile petri dishes containing a 75-mm diameter filter paper disk that had been moistened with distilled water to prevent premature leaf desiccation. Ten 5-d-old beet armyworm (BAW), Spodoptera exigua (Hübner),larvae obtained from the USDA-ARS-IBPMRL insect rearing facility in Tifton, GA were placed on each leaf sample. Five petri dishes were used for each plant location in the plots. Petri dishes were held in an environmental chamber at 24 degrees C at 50 % RH and 12:12 (L:D) photophase. BAW larvae in each dish were examined 48 and 72 h after test initiation, and the number of live larvae was recorded. SAS Proc Mixed procedures(SAS Institute Inc., 1989) were conducted on mortality data for application methods and leaf position. Means were separated by Fishers LSD (P=)0.05)

Results

Field Data 1997

There were no differences in total bolls or damaged bolls among application method or insect control materials in 1997. Worm damaged squares were lowest in plots treated with Biocot, but all treatments had significantly lower damage than the untreated check (Table 1). A significant application method x insecticide interaction was noted for yield of seed cotton in 1997(Table 1). Seed cotton yield was significantly lower when Biocot was applied with the air-assist or drop-nozzle sprayers than yield when the material was applied over-the-top, and yield was significantly lower when Scout X-tra was applied with the air-assist sprayer than yield with either the over-the-top or drop nozzle sprayers (Table 1). Plots treated with Scout X-tra, regardless of the application method, had better yields than untreated plots. Low insect infestations during the 1997 cotton season did not provide enough damage to adequately differentiate the impact of sprayer system or control material.

Field Data 1998

There were no significant differences in total bolls or damaged bolls for application method or insecticides in 1998. Plants treated with Tracer had significantly less damaged squares than plants treated with either Dipel or untreated (Table 2). Plants treated with the drop-nozzle sprayer overall had significantly less damaged squares than plants treated with the over-the-top sprayer. Tracer treated plots had significantly higher seed cotton yields than Dipel and untreated plots. Drop-nozzle sprayer plots yielded significantly more seed cotton than plots sprayed with over-the-top which was not consistent with the yield data from 1997. The analysis of damaged squares and seed cotton yields in 1998 for methods and insecticides showed that higher yields were associated with low worm damaged squares and that low yields were followed by high values of worm damaged squares for sprayer methods and also for insecticides (Table 2).

Bioassay of Applied Insecticide Residue

There was a significant application method X canopy location interaction for the laboratory bioassay with Tracer for each of the three sample dates. All leaves treated with Tracer regardless of application method and location in the plants had significantly higher BAW mortality than from untreated plots. Leaves from untreated plots had higher BAW mortality on August 4 than on August 18 and 25 possibly indicating that there was some residual carry over from the blanket treatments on leaves collected on August 4 (Table 3). The air-assist sprayed leaves had as high or higher BAW mortality in the middle than in the top of plants except on August 25 when mortality from the top leaves was significantly lower than that for the middle and bottom leaves. Limitations for height above the canopy with the tractor mounted air-assist sprayer probably resulted in spray materials being blown or directed past the top of plants during application. The air-assist sprayer had lower BAW mortality on leaves in the top and higher BAW mortality on leaves in the bottom of the plant than over-the-top and drop-nozzle sprayers. Mortality of BAW on leaves from plots sprayed with the over-the-top sprayer was significantly lower for leaves from top to middle to bottom of the plant canopy. Plots sprayed with the sprayer equipped with drop-nozzle had significantly lower BAW mortality on leaves in the bottom of the plant than in the top and middle of the plant. BAW mortality was not significantly different between top and middle of plants for drop-nozzle sprayer. The over-the-top sprayer had the lowest BAW mortality on leaves of all sprayers in the middle of the plants.

Summary

Although these tests were characterized by relatively low insect infestations, a significant negative correlation was noted for seed cotton yields and insect damaged squares in 1998. Bioassays with leaves indicated that air-assist sprayers can distribute spray materials throughout cotton plants to provide good leaf coverage to most leaves in the top, middle and bottom of plants. The air-assist sprayer had better leaf coverage in the bottom of cotton plants than over-the-top and drop-nozzle sprayers. Air-assist and drop-nozzle sprayers provided good coverage on leaves in the middle of plants. All three sprayers, when adjusted properly, could provide acceptable coverage in the top of cotton plants to squares and bolls where insect protection is critical.

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Disclaimer

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References

Howard, K.D., J.E. Mulrooney, and L.D. Gaultney. 1994. Penetration and deposition of air-assisted sprayers. ASAE paper 941024, ASAE St. Joseph, MI.

Mulrooney, J.E., and Lars Skjoldager. 1997. Evaluation of an air-assisted ground sprayer for control of boll weevil(Coleoptera: Curculionidae) and beet armyworm (Lepidoptera: Noctuidae). Southwestern Entomologist 22(3):315-322.

SAS Institute, Inc. 1989. SAS User's Guide: Statistics, Version 6, 4th Ed.;Vol 2. Cary, North Carolina, SAS Institute Inc.

Steel, R.G.D., and J.H. Torrie. 1960. Principles and Procedures of Statistics. McGraw-Hill Book Company, Inc. New York, NY.

Womac, A.R., J.E. Mulrooney, and W.P. Scott. 1992. Characteristics of air-assisted and drop-nozzle sprayers in cotton. Transactions of ASAE 35(5):1369-76.

Table 1. Damaged squares and seed cotton yields in cotton treated with five selected insecticides applied by three sprayer methods, in 1997.

	Sprayer Methods[1]			
Insecticide[2]	Air-assist	Over-top	Drop-nozzle	Mean
	Damaged Squares/100			
Biocot	0	1	0	0.33 b
Gemstar	0	1	3	1.33 b
Scout X-tra	2	2	0	1.33 b
Tracer	1	2	1	1.33 b
Untreated	7	2	5	4.67 a
Mean	2.0 a	1.6 a	1.8 a	
	Seed Cotton Yield (lb/A)[1]			
Biocot	2207 ab B	2527 b A	2093 b B	2376
Gemstar	2216 ab A	2383 b A	2365 b A	2321
Scout X-tra	2436 a B	2889 a A	2827 a A	2717
Tracer	2236 ab A	2210 b A	2374 b A	2273
Untreated	1960 b A	2143 b A	2405 b A	2169
Mean	2222	2430	2413	

[1] Values in columns followed by common lower case letters (insecticide effects) or values in rows followed by common upper case letters (sprayer methods effects)are not significantly different by Waller-Duncan Test (P=0.05).

[2] Insecticides treatments were Biocot at 1 qt/A, Gemstar at 10 oz/A, Scout X-tra at 0.019 lb-ai/A, Tracer 4SC at 0.0625 lb-ai/A, and untreated. Application dates were July 22, 29, and August 5, 15, and 20.

Table 2. Damaged squares and seed cotton yields in cotton treated with five selected insecticides applied by three sprayer methods, in 1998.

	Sprayer Methods			
Insecticide[2]	Air-assist	Over-top	Drop-nozzle	Mean
	Damaged Squares/100[1]			
Dipel	2.0	7.0	2.0	3.7 a
Gemstar	1.0	3.0	0.0	1.3 ab
Scout X-tra	5.0	4.0	0.0	3.0 ab
Tracer	0.0	0.0	0.0	0.0 b
Untreated	3.0	6.0	0.0	3.0 a
Mean	2.2 ab	4.0 a	0.4 b	
	Seed Cotton Yield (lb/A)[1]			
Dipel	1634	1394	1779	1602 b
Gemstar	1869	1612	2047	1843 ab
Scout X-tra	1786	1539	2265	1863 ab
Tracer	2138	2182	1877	2065 a
Untreated	1630	1790	1710	1710 b
Mean	1811 ab	1703 b	1936 a	

[1] Values in columns followed by common lower case letters (insecticide effects) or values in rows followed by common upper case letters (sprayer methods effects)are not significantly different by Waller-Duncan Test (P=0.05).

[2] Insecticides treatments were Dipel DF at 1 lb/A, Gemstar at 10 oz/A, Scout X-tra at 0.019 lb-ai/A, Tracer 4SC at 0.0625 lb-ai/A, and untreated. Application dates were July 28 and August 4, 11, 18 and 25.

Table 3. Percent beet armyworm mortality on cotton leaves treated with Tracer applied air-assist, over-the-top, drop- nozzle sprayers, or untreated check at the top, middle and bottom of cotton plants on three dates in 1998.

Sprayer method	August 4[1]	August 18[1]	August 25	Means[2]
Air-assist, Top	81 ab[3]	84 ab	54 b	73 a
Air-assist, Mid	92 a	91 a	87 a	90 a
Air-assist, Bot	76 b	74 b	83 a	78 a
Over-top, Top	92 a	79 a	89 a	87 a
Over-top, Mid	75 b	64 a	63 b	68 b
Over-top, Bot	55 c	28 b	39 c	41 c
Drops, Top	87 a	92 a	82 a	87 a
Drops, Mid	86 a	90 a	89 a	88 a
Drops, Bot	60 b	48 b	53 b	54 b
Untreated, Top	12 a	2 a	1 a	5 a
Untreated, Mid	13 a	2 a	1 a	6 a
Untreated, Bot	19 a	2 a	1 a	8 a
LSD	14.6	16.8	16.8	18.7

[1]LSD adjusted to reflect the results of square root transformation data.
[2]Means are the average of the three sample data. LSD is the weighted average of the three sampled LSD, Steel and Torrie, 1960.
[3]Values in columns for each sprayer method followed by common letters are not significantly different according to Fishers LSD test (P=0.05).