DROPLET SIZE AND SPRAY VOLUME EFFECTS ON CANOPY PENETRATION AND INSECT CONTROL

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Abstract

Efficacy of lambda-cyhalothrin (Karate Z 2.08 SC) applied at three volumetric application rates and three droplet sizes for control of a natural infestation of heliothine larvae on cotton is discussed. Results generally support the conclusions of bioassays made in 1998 using the same insecticide, droplet sizes and volumetric applications rates. Droplet size did not affect larval numbers. Results pooled across droplet sizes indicated that efficacy tended to decrease as volumetric application rate increased as measured by larval counts and numbers of damaged bolls.

Introduction

Reed and Smith (1999) reviewed the literature relating to the effect of different volumetric application rates (VAR) expressed as a unit of volume per unit area (i.e. gallons per acre) and droplet sizes to insect control and pesticide deposits. Most pesticide efficacy trials are reported in terms of dosage (amount of pesticide applied per unit area) and the VAR, with little or no mention of droplet size, residual deposit, or correlation of these factors with insect mortality. As a result, droplet size and VAR are usually compounded in research results, making it impossible to separate the value of the two factors in analyzing insect mortality and pesticide efficacy data. Thus, we lack the information to make science-based recommendations for either of the two factors.

A test was initiated in 1998 to evaluate the effect of three distinct droplet sizes (121, 207, and 284 µm) applied on cotton at three volumetric application rates (6, 12 and 18 gpa). The 1998 research included application of insecticide in the field with a high clearance spray tractor, bioassays using leaf disks and third instar tobacco budworm larvae, and gas chromatograph analysis of deposits washed from leaf disks with hexane.

Results of that research was summarized as follows (See Reed and Smith, 1999). "Droplet size had no effect on budworm mortality at either canopy level. Deposits increased slightly with higher VAR at the upper canopy level and decreased slightly with higher VAR at the mid-plant canopy level. Mortality was negatively correlated with VAR at the upper canopy level. This indicates that the concentration of insecticide in each droplet (compounded in this study with VAR) may be a factor affecting larval mortality since insecticide concentration is inversely proportional to the VAR. Although some differences in insect mortality in this study were statistically significant, numerical differences between treatments were slight. However, the data indicate that lower volumetric application rates are as effective as the higher rates." General trends and means relative to droplet size and VAR are presented in Figure 1.

A test was carried out in the summer of 1999 to verify last year's findings by application of the same material at the same droplet sizes and volumetric rates on cotton naturally infested with heliothine larvae. Although drought and other factors combined to reduce heliothine numbers in the cotton in Mississippi, two applications of insecticide were applied to the trial, one of which provided some validation of the previous bioassay results.

Materials and Methods

The research was carried out on cotton, variety BXN47, planted in 38 in (96.5 cm) row-spacing on May 17, 1999 at the Plant Science Research Farm, Mississippi State, MS. At the time of insecticide applications on July 22 and July 29, cotton was approximately 40 in (104 cm) tall, with branches reaching across the middles. Heliothine populations were exceptionally low during 1999, and the reported results are from only one application.

Nine nozzle/pressure/ground-speed configurations were chosen to provide three droplet sizes and three application rates within a range of grower acceptability (Table 1). The VMD (Volume Median Diameter) of a Karate 2.08 SC solution (dosage was 0.01 lb(AI)/acre) at three volumetric application rates was determined by replicated evaluations using a Malvern laser droplet analyzer (Model 2600Lc, Malvern Instruments Ltd., Spring Lane South, Malvern, Worchester, England). The nine treatments developed from five nozzle/pressure combinations delivered the following flow rates and standard deviations (SD) expressed in ml per minute: TX-4 at 40 psi, 257 (10.3); TX-6 at 54 psi, 415 (10.5); D2-23 at 22 psi, 258 (6.2); 8001 at 30 psi, 333 (5.13); D4-25 at 17 psi, 713 (18.0). Ground speeds were calculated using these flow rates in order to deliver 6, 12 or 18 gallons per acre (gpa) (56, 112, and 168 L/ha, respectively).

Applications of insecticide were made with a high-clearance plot spray tractor using a compressed-air powered spray system. The boom was maintained at approximately 18 in (46 cm.) above the cotton terminals. Nine nozzles were spaced at 19 in (48.3 cm) along the boom with one nozzle

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placed directly over each row and one between the rows allowing full coverage of four rows. Spray pressure was determined from a pressure gauge (0-60 psi) mounted on the boom. Plot size was four 38 in (0.96 m) rows by 50 ft (15.3 m). Each plot was separated from the others by 8 rows of untreated cotton or a 12 ft (3.6 m) wide alley of cotton on the ends of the plots. Tractor speed was set using an ultrasonic speed sensor and speedometer (Micro-Trak Systems, Inc., P.O. Box 3699, Mankato, MN). Because the ultrasonic sensor was influenced by the tall foliage, the speed was set in a grassy turn row located beside the plots prior to spraying each treatment. Engine speed was constant throughout the application of any one treatment. Wind speed was negligible during application.

The statistical design was randomized complete block (four replications) with each VAR/droplet size combination considered as a treatment. One treatment was applied to the plots for all replications before the next treatment was applied to avoid continual changing of nozzles, speed and pressure settings. The first application was made to artificially infested budworms (*Heliothis virescens* F.) placed on terminals as neonates and allowed to develop to approximately the third instar before spraying with 0.01 Lb(AI)/acre (0.011 Kg(AI)/ha). There were no discernible results from this application, possibly because extreme heat may have affected efficacy of the low rate of pyrethroid. In addition, the infestation did not result in a satisfactory population. A second application of insecticide was made 8 days later applied to a natural infestation that was allowed to reach third instar. This infestation was primarily bollworm (*Helicoverpa zea).* The rate for this application was raised to 0.03 Lb(AI)/ac (0.034 kg(AI)/ha). Although the density of this population was low and a range of larval ages was present in the plots, larvae found in bolls were mostly third instar. Cotton was randomly sampled by examining 25 terminals, 25 squares and 25 bolls per plot on random plots prior to insecticide application to determine if the insect population was adequate for spraying, i.e. primarily in the third instar. Post-spray sampling of fruit was increased to 50 squares and 50 bolls at three and 10 days after treatment to evaluate efficacy. The center two rows were mechanically picked to determine yield. Means were separated by analysis of variance (Least Significant Difference option), and Pearson correlation coefficients were determined by use of the proc Corr option (SAS Institute, 1990).

Results and Discussion

Analysis of variance results from data collected three days after treatment demonstrated that although some trends could be identified (Figure 2), no significant differences could be attributed to droplet size ($P \leq 0.05$), and that significant differences occurred only as a result of VAR. The data were subsequently pooled across droplet sizes for separation of mean differences resulting from VAR and for correlation analysis. Results for larvae found in squares and bolls, total larvae in fruit, and damaged fruit is indicated in Table 2. The number of larvae in bolls in plots sprayed with 19 gpa had significantly more larvae per sample than plots sprayed with 6 gpa. The number of damaged bolls was higher in the plots treated with 12 gpa than in the 6gpa treatment. Additionally, the number of total larvae recovered from fruit was significantly smaller in the 6 gpa treatment than in the 18 gpa treatment (p=0.025), and nearly significantly smaller than the 12 gpa treatment (p=0.058). Regression analysis also indicated that VAR was slightly, but significantly correlated with the number of larvae in bolls ($R^2=0.1821$, p=0.012) and the total number of larvae recovered from all fruit ($R^2=0.182$, p=0.009). No significant differences were detected in data collected 10 days after treatment.

Summary

Results generally support the conclusions of bioassays made in 1998 using the same insecticide, droplet sizes and volumetric applications rates. Droplet size did not affect larval numbers. Results pooled across droplet sizes indicated that efficacy as measured by larval counts and numbers of damaged bolls tended to decrease as volumetric application rate increased. There were no significant differences in fruit damage or larval counts based on droplet size in this evaluation. Data indicate insecticide concentration of each droplet is an important factor in management of heliothine larvae, and that control of larvae with the pyrethroid used in this trial is as good or better at 6 gpa than at higher volumetric application rates. These results may lead to savings by growers applying insecticide at lower volumetric rates while maintaining optimum insect management.

Acknowledgements

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Table 1. Nozzle, speed and pressure combinations used to obtain three volumetric application rates with 3 distinct droplet sizes. Volume Median diameter and the percent of the spray volume occurring in droplets <= 105 µm is listed parenthetically following the nozzle designation.

VAR	**Nozzle**	**VMD (µm), % Drops<105µm**	**Speed (MPH)**	**Pressure (PSI)**
6 GPA	TX4	121 µm, 38%	3.5	40
	D2-23	207 µm, 16%	3.6	22
	8001	284 µm, 8%	4.6	30
12 GPA	TX4	121 µm, 38%	1.8	54
	D2-23	207 µm, 16%	1.8	22
	8001	284 µm, 8%	2.3	17
18 GPA	TX6	123 µm, 38%	1.9	54
	D2-23	207 µm, 16%	1.2	22
	D4-25	302 µm, 6%	3.3	17

Table 2. Insects and damage per 50 squares and bolls, three days following treatment.

GPA	Larvae in Squares	Damaged squares	Larvae in Bolls	Damaged Bolls	Total Larvae
6	0.42 a	2.33 a	0.50 a	1.92 a	0.92 a
12	1.08 a	1.67 a	0.67 ab	3.83 b	1.75 ab
18	0.75 a	2.42 a	1.33 b	3.25 ab	2.08 b
P>F	0.168	0.232	0.041	0.023	0.025

Means within a column not sharing a common letter differ significantly (LSD; p=0.05).

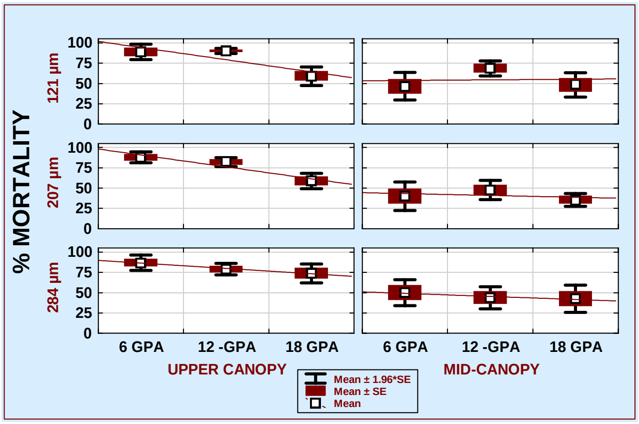

Figure 1. Efficacy trends at different droplet sizes and volumetric application rates from the 1998 field-bioassay.

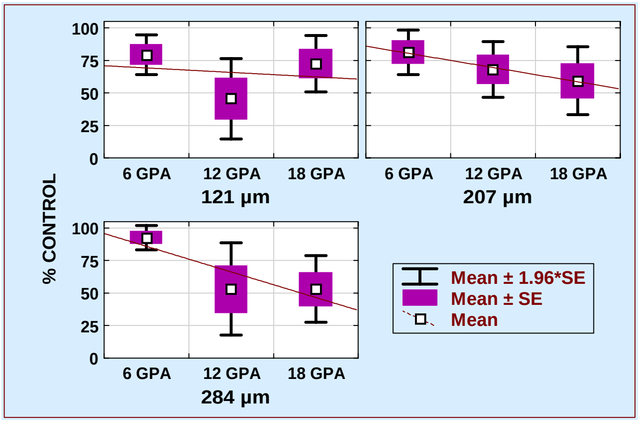

Figure 2. Efficacy trends (percent control derived by Abbot's formula) at different droplet sizes and volumetric application rates from the 1999 validation trial.