Bull. Environ. Contam. Toxicol. (1989) 42:30–36

Bulletin of Environmental Contamination and Toxicology

Fenvalerate Interception by and Dissipation from Sugarcane Foliage as Affected by Application Technology

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In Louisiana, a well-developed integrated pest management (IPM) system is employed to effectively control the major sugarcane insect pest, the sugarcane borer (SCB). This IPM system relies heavily on the balanced use of cultural, biological, and chemical control strategies, and its implementation has resulted in the reduction in the average number of annual insecticide applications from 12 to 2 since 1960 (Reagan 1980). These strategies include the use of borer-resistant varieties of cane, the maintenance/enhancement of naturally occurring populations of SCB predators (non-target arthropods), and the properly timed and limited use of selective insecticides. Until very recently, the organophosphate azinphosmethyl was the only insecticide, labeled for use in sugarcane, that was recommended by the Louisiana Cooperative Extension Service for general use in SCB control. However, the synthetic pyrethroid fenvalerate is now labeled and recommended for SCB control. Preliminary studies suggested that, compared with azinphosmethyl, fenvalerate was generally less harmful to non-target arthropods, more cost effective, less hazardous to the applicator, and more efficaceous for SCB control.

Aerial application of fenvalerate is of concern because of fenvalerate's acute toxicity to certain commercially important fauna in surrounding aquatic habitats (Coulon 1982, Coulon et al. 1985). Therefore, the application technology used is critical to minimizing this concern. When the pyrethroid insecticides were introduced, a renewed interest in low-volume (LV) and ultra-low-volume (ULV) spray methodology evolved using vegetable oil as the insecticide carrier. This methodology was thought to offer several potential advantages over conventional water-based spray methodology including more insecticide on target with less drift, better plant canopy penetration, and more uniform pesticide droplet size (Clower et al. 1982).

The present field study was undertaken to compare the efficacy of three finished formulations of the newly-labeled pyrethroid fenvalerate, applied aerially using conventional (water), ULV

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(oil), and LV (oil/water) technology for season-long borer control in sugarcane. This paper is primarily concerned with fenvalerate interception by and dissipation from sugarcane foliage but also focuses briefly on SCB control, effects on non-target arthropods, and sugarcane yields. Mention of a pesticide does not constitute a recommendation for use by the U.S. Dept. of Agriculture nor does it imply registration under FIFRA as amended. Names of products are included for the benefit of the reader and do not imply endorsement or preferential treatment by the U.S. Dept. of Agriculture.

MATERIALS AND METHODS

The study was conducted on the F. A. Graugnard Farm near St. James, Louisiana and consisted of 16 plots, ranging in size from 0.77 to 2.83 ha, untreated or treated aerially with one of three finished formulations of fenvalerate at a rate of 0.13 kg ha for season-long control of SCB infestations. The plots were located on a Commerce silt loam soil (fine-silty, mixed, non-acid, thermic, Aeric Fluvaquents) and were set up in a randomized complete block design with four replications. The three pesticide treatments were: (1) fenvalerate applied in water at a finished spray rate of 18.7 L ha^{-1}, (2) fenvalerate applied in once-refined soybean oil containing 7% emulsifier at a finished spray rate of 2.34 L ha^{-1}, and (3) fenvalerate applied at a finished spray rate of 9.4 L ha^{-1} in a mixture of 75% water and 25% once-refined soybean oil containing 7% emulsifier. Initial applications were made when SCB infestations reached the economic threshold (5% infested plants with live larvae in the leaf sheaths). When the economic threshold was reached in the best performing treatment, second applications were made. Aerial insecticide applications on sugarcane are directed toward the top of the plant canopy, where the SCB entry sites are.

Immediately after fenvalerate application (time 0) and at 1, 3, 5, and 7 days thereafter, 20 whole leaves were randomly collected from the tops of the plants in each plot and placed in a 0.9-L glass jar. About 500 mL 95% methanol (enough to cover the leaves) was added and the jar was sealed with a teflon-lined lid. Samples were refrigerated at 4 C until extraction and fenvalerate analysis.

The sample was allowed to come to room temperature (2 h) and the methanol solution was decanted into a 1-L graduated cylinder. The sugarcane leaves remaining in the jar were rinsed with 200 mL fresh methanol, which was then added to the graduated cylinder. The leaves were removed from the jar with forceps, placed on an aluminum foil tray, and dried at 65 C in a forced-air oven (24 h) for oven-dry weight determination. The volume of the methanol solution was adjusted to 800 mL and the solution was transferred back into its original jar for gas chromatographic analysis. A 1 mL aliquot of the methanol extract was diluted to an appropriate volume with pesticide- grade benzene and analyzed for fenvalerate as reported previously (Smith *et al.* 1983, Smith and Willis 1985). The limit of quantitative detection for fenvalerate was 0.01 $\mu g\ g^{-1}$ based on the over-dry plant weight and extraction efficiency was >95%. Fenvalerate recovery values (percent remaining) represent both enantiomeric pairs of optical isomers and were not corrected for extraction efficiency.

Standard entomological procedures were used to determine SCB control efficiency and to monitor non-target arthropod fauna (Reagan and Flynn 1980, Hensley *et al.* 1981). Twenty-five randomly selected plant stalks per plot were examined weekly for evidence of live SCB larvae in the upper leaf sheaths. SCB damage was determined at harvest by examining 75 randomly selected stalks per plot for the presence of bored internodes. Beginning two weeks prior to the first fenvalerate application, non-target arthropods were determined using two pitfall traps per plot changed every three weeks.

RESULTS AND DISCUSSION

The amounts of fenvalerate intercepted by the upper part of the sugarcane foliage are shown in Table 1. The plant load values

Table 1. Fenvalerate deposition on sugarcane foliage.

Treatment	Application Rate	Plant Load
	----$kg\ ha^{-1}$-----	----$\mu g\ g^{-1}$----
Water	0.13	18.82±3.71a[b]
Oil	0.13	19.30±3.45a
Oil/Water	0.13	28.19±3.88b

a Calculated from 8 measured values (2 applications, 4 replicate plots/application).

b Values within the same column followed by a common letter are not significantly different at P=0.05 according to the New Duncan Multiple Range Test.

for the water and oil treatments are about 67 and 68%, respectively, of the value for the oil/water treatment and would seem to indicate that not as much fenvalerate reached the top of the sugarcane canopy in the water and oil treatments. This is probably true in the case of the water treatment because conventional water-based sprays are very subject to drift and evaporative losses (Matthews 1979). We have no explanation as to why in the oil treatment not as much fenvalerate reached its target. However, another possibility does exist. Since ULV oil sprays are thought by many researchers to provide high plant canopy penetration (Clower et al. 1982), more fenvalerate may have "overshot" its target and settled on lower plant parts and on the soil surface. McDaniel (1980) reported better cotton plant canopy penetration of permethrin applied ULV in oil than applied conventionally in water. However, Southwick et al. (1983) found no differences in canopy penetration of the same compound applied similarly to the same crop.

The dissipation of fenvalerate from the upper sugarcane foliage is shown in Table 2. Fenvalerate dissipation rates for the

Table 2. Fenvalerate dissipation from sugarcane foliage as a function of time after application and application technology.

	Fenvalerate Remaining[a]			
Treatment	Day 1	Day 3	Day 5	Day 7
	%			
Water	68.86±6.49a[b]	43.06±6.06a	27.63±3.14a	13.38±0.98a
Oil	75.36±7.40ab	49.05±8.36ab	27.95±4.58a	10.99±1.60b
Oil/Water	80.34±10.76b	50.64±4.50b	33.14±3.92b	19.20±1.59c

a Mean ± standard deviation of 8 measured values (2 applications, 4 replicate plots/application).

b Values within the same column followed by a common letter are not significantly different at P=0.05 according to the New Duncan Multiple Range Test.

water and oil treatments appear to be similar to each other and faster than the oil/water treatment. After seven days the percent fenvalerate remaining in the oil/water treatment was about 1.4 and 1.7 times that in the water and oil treatments, respectively. Best-fit linear regression equations (not shown) describing fenvalerate dissipation from the sugarcane foliage for all three treatments were of the form $\ln Y=a + bX$, where Y=percent fenvalerate remaining and X=time after application. These equations described first order dissipation rates and had r^2 values >0.95. The slopes of these equations were -0.31, -0.32, and -0.28 for the water, oil, and oil/water treatments, respectively, a further indication that fenvalerate dissipation was slightly slower in the oil/water treatment. Calculated 50% disappearance times (DT_{50}) were 2.2, 2.2, and 2.4 d, respectively for the water, oil, and oil/water treatments. These DT_{50}'s are somewhat shorter than those reported in a recent review of pesticide persistence on foliage (Willis and McDowell 1987). The field half-life for pyrethroids in general on foliage was reported to be 5.3±3.6 d. Based on data in that same review, the calculated field half-life of fenvalerate on foliage would be 8.4±4.0 d. The review also stated that many of the studies cited may over-estimate half-lives for foliar-intercepted pesticides because they fail to characterize the rapid loss of pesticides from foliage immediately after application.

The effects of the fenvalerate treatments on the populations of beneficial non-target arthropod fauna are shown in Table 3. The

Table 3. Effects of treatment on non-target arthropods.

	Arthropod Abundance[a]					
Treatment	*S. Invicta*	Other Ant spp.	Total Aranea	Carabidae	Dermaptera	Gryllidae
Water	33.9	0.28	4.4	0.98	5.40	14.1
Oil	19.4	0.30	4.2	0.68	6.00	14.0
Oil/Water	20.2	1.08	5.1	0.35	5.78	16.0
Control	25.7	0.24	8.5	2.12	8.30	24.6

a Seasonal mean number of individuals/trap (2 traps/plot).

data indicate that all the fenvalerate treatments reduced the numbers of spiders collectively (total Aranea), as well as the numbers of ground beetles (Carabidae) and crickets (Gryllidae). There appeared to be no differences among the three fenvalerate treatments.

The effects of the fenvalerate treatments on SCB control and on sugarcane yield are shown in Table 4. All three fenvalerate

Table 4. Treatment effects on SCB control and sugarcane yield.

Treatment	Seasonal Mean SCB Infestation	Bored Internodes	SCB Control	Sugarcane Yield[a]
	%	%	%	$kg\ ha^{-1}$
Water	1.8a[b]	4.2a	86.0	5808
Oil	4.2a	3.8a	87.0	5751
Oil/Water	4.6a	4.2a	86.0	6014
Control	34.0b	29.6b	----	4196

a Comercially recoverable sugar.

b Values within the same column followed by a common letter are not significantly different at P=0.05 according to the New Duncan Multiple Range Test.

treatments gave about the same SCB control. The seasonal mean SCB infestation was not significantly different among the insecticide treatments but was significantly less than that of the control. The same was true of the percent bored internodes. There was an average 28% loss in commercially recoverable sugar in the control compared with the fenvalerate treatments.

In summary, fenvalerate interception by and persistence in the upper sugarcane canopy was greatest for the oil/water formulation. All three fenvalerate treatments had about the same but minor effects on some beneficial non-target arthropods. The fenvalerate treatments all gave good SCB control. Perhaps for the oil/water application technology, a lower fenvalerate application rate would give SCB control equivalent to that of the other two application technologies with fenvalerate applied at 0.13 kg ha^{-1}. Any application technology which is more efficient in depositing a pesticide on its target should be environmentally safer because potentially lower pesticide application rates could be used.

Acknowledgments. We thank F. A. Graugnard, the landowner, and Air Farm, Inc., the aerial applicator, for their cooperation, and are grateful for the able assistance of H. F. Pack, USDA-ARS, Baton Rouge, in conducting this study.

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Received February 29, 1988; accepted June 22, 1988.