ACTIVITIES OF FOUR INSECT GROWTH REGULATOR FORMULATIONS OF FENOXYCARB AGAINST *PSOROPHORA COLUMBIAE* LARVAE[1]

A. A. WEATHERSBEE, III, M. V. MEISCH AND D. G. BASSI

Department of Entomology, University of Arkansas, Fayetteville, AR 72701

ABSTRACT. Four formulations of fenoxycarb were evaluated at dosages of 0.022 and 0.011 kg ai/ha against *Psorophora columbiae* larvae in rice plots. Granular formulations, at both rates, provided moderate to excellent control of larvae introduced within 24 h posttreatment. A 1.0% fenoxycarb/200 ITU *B.t.i.* granule provided 86.2% reduction of emergence from larvae introduced at 120 h posttreatment. Aside from this formulation residual activity was lacking. The liquid formulation performed moderately well at the high rate against larvae introduced within 24 h; however, residual activity rapidly diminished.

INTRODUCTION

The ricefield mosquito, *Psorophora columbiae* (Dyar and Knab), is recognized as the predominant pest mosquito in riceland areas of Arkansas. The primary reason for this distinction is that this mosquito feeds diurnally and nocturnally; whereas, other species found in the area are nocturnal feeders.

Control measures against riceland *Ps. columbiae* in Arkansas are primarily with adulticides (Weathersbee et al. 1986). Larviciding has intensified in recent years with the advent of *Bacillus thuringiensis* var. *israeliensis* (serotype H-14) formulations (*B.t.i.*) which are highly selective and active at low application rates (Hembree et al. 1980, Dame et al. 1981, Stark and Meisch 1983, Mulla et al. 1985a). Although these materials are quite effective, residual activity is short lived.

In contrast, insect growth regulators (IGRs) offer greater residual activity against larvae of many mosquitoes, and studies have shown IGRs to possess selectivity (Miura and Takahashi 1973, 1975; Mulla et al. 1985b). Mulla et al. (1975) reported that some nontarget populations were depressed by the IGR Dimilin®, but quickly recovered, while Steelman et al. (1975) showed a lack of selectivity from 4 IGRs which produced significant reductions in certain nontarget predatory insects. Significant increases in mayfly and midge populations associated with the affected predators were indicated.

Fenoxycarb, a carbamate juvenile hormone mimic, was shown to have excellent activity against floodwater mosquitoes with no significant adverse effects to nontarget organisms in the same treated plots (Mulla et al. 1985b). Miura and Takahashi (1987) observed morphogenetic aberrations in selected nontarget species from laboratory and field experiments as well as ovicidal effects against the eggs of *Notonecta unifasciata* Guerin (Hemiptera: Notonectidae), though no significant reductions were observed in density of these nontarget populations during the study. Aquatic beetles and freshwater plankton exposed to treatments were unaffected.

The IGR, fenoxycarb, is highly effective at low rates against mosquito larvae associated with rice culture, provides good residual activity, and has a fairly narrow selectivity range at rates used against developing mosquitoes. It appears to be an excellent candidate for addition to an integrated mosquito control program. The following study was conducted to evaluate the activity of 3 fenoxycarb formulations and one fenoxycarb/*B.t.i.* formulation against *Ps. columbiae* in Arkansas.

MATERIALS AND METHODS

Fenoxycarb formulations were evaluated against *Ps. columbiae* larvae in small plots during July 1987 at the University of Arkansas Rice Research and Extension Center, located near Stuttgart, AR. Plots measuring 6.1 × 6.1 m were planted in Lebonnet variety rice. Commercially accepted management practices, standard for the area, including fertilizer and herbicide applications as well as water requirements were followed. The formulations tested were ABG-6212, a 0.5% fenoxycarb sand granular formulation; ABG-6214, a 1.0% fenoxycarb corn cob base granule (10/14 mesh); ABG-6215, a 1.0% fenoxycarb/200 ITU *B.t.i.* corn cob base granule (5/8 mesh) and ABG-6231, a 2 lb/gal emulsifiable concentrate formulation.

The appropriate amounts of the liquid formulation were premixed in 2 liters of water to achieve the desired rates and applied to plots with a CO_2 pressurized hand-held sprayer. Gran-

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ular formulations were evenly distributed over each plot by hand. Each formulation was tested at 2 treatment rates with 3 replications (plots) for each treatment. The untreated check plots were replicated 6 times to insure an accurate measure of natural mortality in the plots. Treatments and checks were completely randomized. ABG-6212 was applied at rates of 5.6 and 2.8 kg/ha (5.0 and 2.5 lb/acre) while ABG-6214 and ABG-6215 each were applied at 2.8 and 1.4 kg/ha (2.5 and 1.25 lb/acre). ABG-6231 was applied at 0.094 and 0.047 liter/ha (1.28 and 0.64 oz/acre). High and low rates of each formulation corresponded to dosages of 0.022 and 0.011 kg ai/ha, respectively.

Floating cages described by Sandoski et al. (1986) each holding 10 *Ps. columbiae* 2nd-3rd instar larvae were used to monitor treatment effectiveness and residual activity. One cage was placed in each plot at 0, 24 and 120 h posttreatment. Cages were covered with cheesecloth to prevent escape of emerged adults and monitored daily for mortality and stadia of remaining individuals. Adults were counted and released daily. Monitoring continued until no live individuals remained. Percentage data based upon reduction of emergence in each plot were corrected for check reductions using Abbott's formula (Abbott 1925), transformed (arcsine), and subjected to ANOVA. Means calculated for each treatment were separated using the least-squares means (LSMEANS) procedure (SAS 1985).

RESULTS AND DISCUSSION

Results of the LSMEANS procedure are shown in Table 1. Mean percent reductions of emergence from *Ps. columbiae* larvae installed in treated and check plots at 0, 24 and 120 h posttreatment are given. Formulations 6214 and 6215, the 1% fenoxycarb on corn cob and the 1% fenoxycarb/200 ITU *B.t.i.* on corn cob respectively, provided excellent reductions (>80%) in adult emergence from larvae installed at 0 and 24 h in plots treated with the lower rate of 0.011 kg ai/ha. Residual effectiveness was lacking at 120 h in plots treated with formulation 6214 although 6215 continued to provide a mean reduction of 50.3%. Formulation 6212, the 0.5% fenoxycarb on sand granule, at 0.011 kg ai/ha provided marginal reductions (73%) of larvae introduced at 0 and 24 h but lost residual activity by 120 hours. Both initial and residual activities (<50%) were lacking from the 2 EC formulation (6231) at this rate.

The initial activities of the liquid and sand formulations were greatly increased upon raising the dosage to 0.022 kg ai/ha. Additional reductions of 37 and 22% occurred in larvae introduced at 0 h to plots treated with formulations 6231 and 6212, respectively. Activity also was enhanced at 24 and 120 h due to the increased application rate. Formulations 6214 and 6215 also provided greater activity at the higher application rate, this being detected by increased residual effectiveness at 120 hours. The increased rate of application caused a significant ($P < 0.05$) rise in residual activity of formulation 6214 at 120 h, but reduction of adult emergence remained below 50%. Only the 1% fenoxycarb/200 ITU *B.t.i.* granule, formulation 6215, provided good residual activity (86.2%) at 120 hours. This formulation also provided by far the highest residual activity at the lower application rate. Neither at the high nor low rates of formulation 6215 were the percent reductions in emergence from the 120 h larval installation

Table 1. Percent reduction of adult emergence from *Psorophora columbiae* larvae in small rice plots treated with various formulations of fenoxycarb.

Formulation	Rate	Larval installation posttreatment (h)		
		0	24	120
ABG 6212	5.6 kg/ha	95.8ABa*,**	100.0Aa	55.3Bab
0.5 granular	2.8 kg/ha	73.4Aab	73.1Aab	8.4Bbcd
ABG 6214	2.8 kg/ha	100.0Aa	97.8Aa	41.0Babc
1.0 granular	1.4 kg/ha	91.6Aab	80.1Aab	0.0Bd
ABG 6215[a]	2.8 kg/ha	95.8Aa	100.0Aa	86.2Aa
1.0 granular	1.4 kg/ha	94.4Aab	89.1Aab	50.3Aab
ABG 6231	0.094 liter/ha	85.2Aab	65.6Aab	27.3Abcd
2 EC	0.047 liter/ha	47.7Ab	46.2ABb	3.8Bcd
Check	High	18.3	16.7	28.3
	Low	10.0	10.0	10.0

* Means in the same row followed by the same upper case letter are not significantly different ($P \geq 0.05$) by LSMEANS.

** Means in the same column followed by the same lower case letter are not significantly different ($P \geq 0.05$) by LSMEANS.

[a] Fenoxycarb/200 ITU *B.t.i.*

significantly ($P < 0.05$) different from those of the 0 and 24 h installations. Reductions in 0, 24 and 120 h larval installations were 95.8, 100.0, and 86.2; and 94.4, 89.1 and 50.3% for the high and low rates, respectively.

Mortality of larvae by stadia was not tabulated; however, the following observations were made concerning the period of activity. Little activity was observed against 4th instar larvae and emerging adults. Most mortality occurred during the pupal stage for all formulations and times of larval installation with one exception. Approximately 50% mortality was observed within 48 h from larvae installed at 0 h in plots treated with formulation 6215, the 1% fenoxycarb/200 ITU *B.t.i.* granule. This was not observed in subsequent larval installations in the same plots nor was it observed in other treatments. It is likely that the *B.t.i.* in this formulation was responsible for initial mortality since *B.t.i.* activity occurs within that period.

In conclusion, formulation 6215 provided the greatest initial and residual activities against *Ps. columbiae* larvae in small rice plots. It is possible that sublethal dosages of *B.t.i.* in the mixture sufficiently weakened larvae to a point where fenoxycarb effectiveness was enhanced. The apparent synergistic effect warrants further investigation of this promising combination. The 0.5% fenoxycarb sand formulation (6212) also appeared effective at the higher of the 2 rates used in this study. Excellent control (>95%) was achieved against larvae introduced up to 24 h posttreatment and residual control remained above 55% against larval introductions at 120 hours. The 1% fenoxycarb on corn cob, formulation 6214, offered excellent initial control (>95%) at the high application rate; however, residual activity had decreased to 41% by 120 h posttreatment. The liquid formulation (6231) did not perform as well as the others. Residual activity quickly diminished even at the high rate of application. Granular formulations likely achieved greater residual effectiveness through slower fenoxycarb release rates as compared to the liquid formulation.

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