SURVIVAL OF CONSECUTIVE GENERATIONS OF CIGARETTE BEETLES REARED ON MEDIA CONTAINING LESS THAN 1 PPM METHOPRENE

by
Herman J. Benezet
R. J. Reynolds Tobacco Company

Abstract

Kabat® or methoprene is a potent insect growth regulator which will control cigarette beetle populations when incorporated into tobacco at the recommended dose of 5 ppm. This dose of methoprene will prevent emergence of the first generation of cigarette beetles. It was found that doses below 1ppm, although they did not significantly affect adult emergence, did control the second generation of cigarette beetles. Cigarette beetles were allowed to oviposite on media containing methoprene at levels of 0.66, 0.33, 0.15 and 0 ppm. Only the 0.66 ppm level significantly reduced cigarette beetle emergence. F-1 generation adults were transferred to new containers and given the opportunity to oviposite. No larvae developed in containers where beetles had been reared on media containing 0.66 and 0.33 ppm methoprene. A significant reduction in the number of emerging F-2 adults was found even at the 0.15 ppm level. Since adults do not feed significantly, damage at the lower doses, 0.66 and 0.33, will be no greater than at the recommended higher dose, 5 ppm. The ultimate test is the effectiveness of methoprene to control the cigarette beetle on tobacco. Control of the F-1 generation on tobacco at 1.04 and 0.60 ppm methoprene was 79 and 12% respectively. Control was obtained at the F-2 generation at these concentrations.

Introduction

Kabat® or methoprene is a potent insect growth regulator. It is registered for control of cigarette beetle populations in stored tobacco. At the recommended dose of 10 ppm, it is very effective in preventing development of the insect at the pupal stage. This concentration gives residual activity for up to four years (3). Although it is highly effective, cost has slowed its incorporation into many control programs. Even at the newer recommended dose of 5 ppm, cost is still a problem.

The juvenile hormone of the insect also controls vitellogenesis and oocyte development. Marzke et al. (4) found that exposing sexually mature females of the cigarette beetle to methoprene resulted in a dose-dependent decrease in reproduction. They indicated that the effect was manifest during late embryogenesis.

The purpose of the present study was to evaluate effects of rearing cigarette beetles on very low levels of methoprene. Since metamorphosis and emergence were relatively unaffected, particular emphasis was given to development of the second generation.

Materials and Methods

Methoprene was incorporated into corn meal or tobacco shred as technical Kabat®. It was sprayed on the media in ethanol using a drum mixer. Samples were assayed to determine exact methoprene concentrations.

There were two strains of cigarette beetle used in this study:

1. CR reared on corn meal and yeast
2. USF reared on tobacco

The parent generation was allowed to oviposite on untreated (control) or treated media. Cultures contained 150 male and female beetles and were in triplicate. These cultures (first generation) were incubated and adults allowed to emerge. Beetles from these cultures were transferred to fresh untreated media and given the opportunity to oviposite (second generation). In this case, cultures contained 50 male and female beetles and were replicated at least five times. In some cases, mass cultures were set up using 600 male and female beetles. All cultures were incubated at 28°C, 70% RH and observed for egg laying, larval development, pupation, and emergence rate.

Results

The preliminary study evaluated CR cigarette beetles at two methoprene levels, 0.82 and 0.36 ppm (Table 1). At the higher concentration, control of first generation emergence was 78.8%. Control at the lower level was poor, only 16.3%. When adults were given the opportunity to oviposite, no second generation developed.

This study was repeated using a wider range of methoprene concentrations (Table 2). At a dose of 6.0 ppm, methoprene effectively controlled first generation emergence. At 0.66 ppm, control was moderate, 71%. At the two low concentrations, 0.32 and 0.15 ppm, there was very little control, 10%. There was no second generation where beetles had been reared on media containing 0.66 and 0.32 ppm methoprene. Control was erratic with beetles reared at 0.15 ppm. Control ranged from 0 to 80%. These groups were also reared in mass cultures. Beetles reared at 0.66 and 0.32 ppm methoprene produced no

progeny. No eggs could be found in these cultures. The second generation from beetles reared at 0.15 ppm methoprene was 41.9% of the control population.

The ultimate test is the effectiveness of methoprene to control the cigarette beetle on tobacco. Tobacco was treated with methoprene at the following levels: 2.40, 1.04, 0.60, and 0.23 ppm. At 2.40, there was complete control at the first generation (Table 3). Control was less effective at 1.04 and 0.60 ppm, 79% and 12% respectively. There was no decrease in emergence rate at the low level (0.23 ppm). No eggs were layed by beetles reared on media containing 1.04 ppm methoprene. The second generation of beetles reared on media containing 0.60 ppm was reduced, 82.4%. Progeny of the second generation of beetles reared at 0.23 ppm methoprene was significantly increased, 26.3% more than controls.

Conclusions

Methoprene will control cigarette beetle populations when incorporated into these growth media (tobacco) at levels as low as 0.5 ppm. Gross morphological abnormalities are the primary action above 1 ppm. It effectively interferes with the transformation of the mature larvae to the adult stage. At doses below 1 ppm, a more subtle effect becomes apparent. Although pupation and emergence of adults seems normal, no second generation develops. The insect juvenile hormone controls insect development in several areas. One area is oogenesis primarily during vitellogenesis. In insects which do not normally feed as adults (cigarette beetles) this process occurs in late larval and pupal stages. In most cases, a maturation is even required in the adult stage before eggs are ready to be fertilized. Methoprene at low concentrations may have specific action during oogenesis. This action would be masked at higher concentration because of the lethal effect. Juvenile hormone analogues have shown deleterious effect on oogenesis in arthropods. Necrosis of oocytes in premeiotic stages were reported in the immature spider crab (2). Hydroprene inhibited oocyte development when applied topically to the red cotton bug causing death and resorption of oocytes in some insects (5). Extremely low levels of methoprene stimulated higher population of cigarette beetles in this study. Methoprene has been shown to stimulate synthesis of vitellogenesis and other proteins *in vitro* (1).

Action of methoprene on insects is diverse. More precise mode of action studies are required in this area. Use of low levels of methoprene for practical control of the cigarette beetle on tobacco will require precise application equipment. Laboratory studies are encouraging but larger scale evaluations are needed.

Table 1. Preliminary methoprene evaluation for control of cigarette beetles reared on cornmeal-yeast media.

Concentration (ppm)	% emergence (S.D.)	
	1st generation	2nd generation
0.82	21.2 (6.7)	0 (0)
0.36	83.7 (17.4)	0 (0)
Control	100 (18.5)	100

Table 2. Dose related effects of methoprene on first and second generation cigarette beetles reared on cornmeal-yeast media.

Concentration (ppm)	%emergence (S.D.)	
	Tst generation	2nd generation
6.00	0	--
0.66	29.0 (2.6)	0
0.32	90.4 (7.4)	0
0.15	89.9 (5.5)	61.8 (25.3)
Control	100 (9.1)	100 (14.4)

Table 3. Dose related effects of methoprene on first and second generation cigarette beetles reared on tobacco.

Concentration (ppm)	% emergence (S.D.)	
	1st generation	2nd generation
2.40	0	---
1.04	21	0 (0)
0.60	88	17.6 (12.1)*
0.23	120	126.3 (11.2)*
Control	100	100 (12.4)

*Significantly different from control 99.9%

References

[1] Abu-Hakima, R., Vitellogenin synthesis induced in locust Locusta migratoria fat body by juvenile hormone analog in vitro, Experimentia 37, 1309-1311 (1981).

[2] Hinsch, G. W., Effects of juvenile hormone mimics on the ovary in the immature spider crab Libinia emarginata, Int. J. Invertebr. Reprod. 3, 237-244 (1981).

[3] Manzelli, M. A., Management of stored-tobacco pests, the cigarette beetle (Coleoptera:Anobiidae) and tobacco moth, (Lepidoptera:Pyralidae) with methoprene, J. Econ. Ent. 75, 721-723 (1982).

[4] Marzke, F. O., Coffelt, J. A., and Silhacek, D. L., Impairment of reproduction of the cigarette beetle, Lasioderma serricorne (Coleoptera:Anobiidae) with the insect growth regulator, methoprene, Ent. Exp. and Appl. 22, 294-300 (1977).

[5] Revathy, D., Thakur, S. S., Rao, B. K., and Ram, G. M., Effect of a juvenile hormone analogue, hyroprene on the female reproductive organs of the red cotton bug, Dysdercus koenigii (F.) Current Science 51, 576-577 (1982).