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OVICIDAL PROPERTIES OF FENOXYCARB AGAINST THE FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

Ovicidal effects of fenoxycarb, ethyl[2-phenoxyphenoxyethyl] carbamate, against the fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), egg masses of different ages were investigated in laboratory studies. Egg mass age was a critical factor in the activity of the juvenoid against FAW eggs. Percent eclosion was significantly ($P \leq 0.05$) lower in egg masses treated on Day 1 of oviposition than in masses treated on either Day 2 or Day 3 postoviposition. Mean (± SE) percent eclosion of eggs treated on Day 1 was 86.9 (± 12.1), 30.5 (± 1.2), 10.8 (± 0.7), and 17.4 (± 2.7) following application of fenoxycarb at 0, 50, 100, and 200 gm AI/ha, respectively. Mean percent eclosion of eggs treated with fenoxycarb on Day 2 or Day 3 ranged from 76.1 to 89.0 and did not differ significantly ($P \leq 0.05$) from the untreated checks (83.4% and 93.5%). No delayed developmental effects in either developmental rate, prepupal weight, or adult fecundity were noted in the fenoxycarb treatments.

RESUMEN

Se estudió en el laboratorio los efectos ovicidas de fenoxycarb ethyl [2-phonoxyphenoxyethyl] carbamato, en contra de posturas de huevos de diversas edades de cogollero (FAW) *Spodoptera frugiperda* (J. E. Smith). La edad de las posturas de huevos fué un factor crítico en la actividad de este juvenoide contra los huevos de FAW. El porcentaje de eclosión fue significativamente ($P < 0.05$) mas bajo en aquellos huevos tratados el día de oviposición comparado con aquellos huevos tratados el día 2 o el día 3 después de la oviposición. El procentaje promedio (± SE) de eclosión de huevos tratados en el día fué de 86.9 (± 12.1), 30.5 (± 1.2), 10.8 (± 0.7) y 17.4 (± 2.7) después de una aplicación de fonxycarb al 0, 50, 100 y 200 gramos IA/ha, respectivamente. El porcentaje promedio de eclosión de huevos tratados con fenoxycarb en el día 2 o el día 3 fluctuó entre el 76.1 a el 89.0% pero no difirió significativamente ($P < 0.05$) de los controles tratados (83.4% y 93.5%). No se observaron efectos tardíos de fenoxycarb en la tasa de desarrollo, el peso de prepupas o la fecundidad de los adultos.

The fall armyworm (FAW), *Spodoptera frugiperda* (J. E. Smith), is a persistent pest of agricultural crops in the southeastern United States and other areas of the Western Hemisphere. FAW immatures are polyphagous but reportedly prefer grasses (Luginbill

1928). Insecticidal control is often necessary to protect forage and grain crops (Young 1979, Andrews 1980). Conventional chemical insecticides have proven effective against immatures when formulations and application techniques were appropriate for the host crop and its stage of development (Young 1979, Pitre 1986).

Development of resistance to selected insecticides has been reported. Carbaryl, trichlorfon, methyl parathion, and ethyl parathion have been reported to be ineffective against FAW (Bass 1978, Young 1979, Andrews 1980, Pitre 1986). Other insecticides including diazinon and certain synthetic pyrethroids provide erratic or poor control in selected crops and locations (Harrell et al. 1977, Bass 1978, All et al. 1983). Commercial formulations of *Bacillus thuringiensis* Berliner also have proven ineffective against FAW (Gardner & Fuxa 1980, Gardner et al. 1986, Gardner 1988).

Insect growth regulators (IGRs) based on juvenile hormone analogs have not been thoroughly evaluated against FAW. Recent studies with fenoxycarb, ethyl [2-(*p*-phenoxyphenoxy)ethyl]carbamate (Dorn et al. 1981), have demonstrated morphogenetic (Gancey et al. 1989, Mulye & Gordon 1989) and chemosterilant (King & Bennett 1989, Chen & Borden 1989) effects. Some IGRs also are ovicidal (Staal 1975). The objective of this study was to determine the ovicidal effects of fenoxycarb against FAW.

Methods

Fall armyworm eggs were obtained from a laboratory colony. Larvae were maintained on a semisynthetic diet (Burton & Perkins 1972). The fenoxycarb used in the study was ABG-6231 (Lot No. 06-063-BR) provided by Abbott Laboratories (North Chicago, IL). This chemical is a proprietary product of Maag Agrochemicals Inc. (Vero Beach, FL).

Egg masses were collected at 0800 h for 3 consecutive days. Individual masses were separated by cutting the underlying cheesecloth which served as an ovipositional substrate. Masses were individually weighed to determine the approximate number of eggs and transferred to 30-ml clear plastic creamer cups. The cups were labelled with the egg mass weight and oviposition date and stored at 25°C.

On Day 3 egg masses were grouped according to the ovipositional date. Only masses with weights correlating with 150 to 250 eggs per mass (Lynch et al. 1983) were used for the study. Within each age category, egg masses were randomly assigned to 1 of 5 treatment groups. The treatments were: fenoxycarb at 50, 100, and 200 gm AI/ha; chlordimeform at 140 gm AI/ha; and an untreated control. The chlordimeform was formulated as Galecron 4E. Treatments were applied as an aqueous spray with Potter Precision Laboratory Spray Tower (Burkard Manufacturing Co. Ltd., Rickmansworth, Hertfordshire, England). Each treatment for days 1-3 was replicated 5X in 2 consecutive generations. Each replicate contained 3 to 5 egg masses.

After treatment the egg masses were air dried and returned to their plastic cups and rearing chamber. Larval eclosion was monitored twice daily. When hatching had ceased for a minimum of 3 consecutive days, egg masses were examined microscopically to determine numbers of eggs per mass and the corresponding percentage eclosion. Neonates were individually transferred to 30-ml clear plastic creamer cups each containing 10 ml of semisynthetic diet and were checked daily until death or pupation. In those treatments with at least 10 male and 10 female survivors, 20 pupae (10 female: 10 male) were placed in a 3-liter container. Emerging moths were fed on stale beer. All egg masses oviposited from these adults were collected, weighed, and percent eclosion determined.

The analysis of variance procedure of the Statistical Analysis System (SAS Institute 1985) was used to compare percent eclosion of treated and control egg masses. Larval mortality and fecundity of survivors in response to ovicidal treatment also were analyzed. Means were separated by Duncan's (1951) multiple range test when significant ($P \leq 0.05$) F-ratios occurred within a comparison.

TABLE 1. PERCENT ECLOSION OF FALL ARMYWORM EGGS RECEIVING OVICIDAL SPRAYS AT DIFFERENT EGG MASS AGES.[1]

Ovicide[2] (gm AI/ha)	% eclosion of eggs treated on egg mass age		
	Day 1	Day 2	Day 3
Fenoxycarb (50)	30.5 ± 12.3 a	84.7 ± 7.4 b	88.2 ± 7.1 b
Fenoxycarb (100)	10.8 ± 6.6 a	85.8 ± 5.6 b	87.3 ± 6.3 b
Fenoxycarb (200)	17.4 ± 6.9 a	76.1 ± 8.1 b	89.0 ± 3.8 b
Chlordimeform (140)	17.6 ± 11.9 a	51.6 ± 13.5 a	66.3 ± 10.3 a
Untreated check	86.9 ± 12.1 a	83.4 ± 6.0 a	93.5 ± 5.2 a

[1]Means (± SE) within a row followed by the same letter are not significantly different ($P \leq 0.05$; Duncan's [1951] multiple range test).

[2]Ovicides applied as aqueous sprays through Potter Precision Laboratory Spray Tower with 5 replicates/treatment and 3 to 5 egg masses/replicate.

RESULTS AND DISCUSSION

Egg mass age was a critical factor in the activity of fenoxycarb as an ovicide against FAW. Percent eclosion was significantly ($P \leq 0.05$) lower in egg masses treated on Day 1 of oviposition (10.8% to 30.5%) than in masses treated on either Day 2 (76.1% to 85.8%) or Day 3 (87.3% to 89%) postoviposition (Table 1). Reduced eclosion also occurred following application of chlordimeform, a conventional insecticide/ovicide; however, percent eclosion for this treatment did not differ significantly ($P \leq 0.05$) with respect to egg mass age.

Sensitivity of lepidopteran eggs to IGRs was initially reported by Riddiford & Williams (1967). Staal (1975) noted that IGRs disrupt embryonic development resulting in nonemergence only when applied to insect eggs prior to the blastokinesis phase of development. The activity of fenoxycarb against FAW eggs also appears restricted to these early phases of embryogenesis.

While delayed larval development and mortality following eclosion from IGR-treated eggs has been reported (Staal 1975), no discernable effects were observed among larvae eclosed from egg masses treated in this study. Numbers of larvae totalled 1520, 1037, 1229, 916, and 1150 for the untreated checks, chlordimeform, fenoxycarb (50 gm AI/ha), fenoxycarb (100 gm AI/ha), and fenoxycarb (200 gm AI/ha), respectively. Mean (± SE) larval mortality for the untreated checks was 17.6% (± 4.3). Larval mortality in the ovicide treatments did not deviate significantly ($P \leq 0.05$) from that level. Larval developmental rates were consistent across all treatments with mean prepupal weights of 252.8 (± 1.9) mg for the untreated checks, 260.4 (± 1.9) mg for the chlordimeform treatment, and 253.9 (± 2.2), 251.9 (± 2.2), and 252.0 (± 2.5) mg for the respective 50,

TABLE 2. PERCENT ECLOSION OF FALL ARMYWORM EGGS IN RESPONSE TO OVICIDAL SPRAYS WHEN SUMMED OVER EFFECTS OF EGG MASS AGE.

Ovicide (gm AI/ha)	% eclosion[1]
Fenoxycarb (50)	67.8 ± 8.6
Fenoxycarb (100)	61.3 ± 10.1
Fenoxycarb (200)	60.9 ± 9.0
Chlordimeform (140)	45.2 ± 8.4
Untreated check	81.3 ± 5.3

[1]No significant differences among treatment means (± SE) as determined by analysis of variance (F = 1.59, df = 8).

100, and 200 gm AI/ha rates of fenoxycarb. Fecundity and percent eclosion of eggs produced by adults developing from the treated egg masses also did not differ significantly. Delayed developmental effects in larvae hatching from fenoxycarb-treated eggs did not occur in this study. These data are supported by Riddiford (1972) who noted that the IGR dose required to illicit delayed developmental effects may be 3X to 10X higher than the dose required to prevent eclosion.

Fenoxycarb disrupts the embryonic development of FAW eggs as evidenced by reduced eclosion. Unfortunately, practical utility is restricted because only young eggs are sensitive to the fenoxycarb. Table 2 presents mean (± SE) percent eclosion in response to the ovicide treatments when summed over the effects of egg mass age. Assuming an equal distribution of 1 to 3-day-old egg masses within a crop field, a single fenoxycarb application at either of the three test rates will not significantly reduce eclosion of FAW eggs in that field. Daily applications of fenoxycarb at 50 to 200 gm AI/ha beginning when oviposition is first detected in the field could potentially reduce eclosion by approximately 55 to 75% (Table 1).

Acknowledgments

Technical assistance in this study was provided by D. J. Kinard, A. F. Pendley, and R. D. Harrison. R. L. Nichols critically reviewed the manuscript during its preparation.

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USE OF PYRETHROIDS, METHOMYL, AND CHLORPYRIFOS TO CONTROL FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE) IN WHORL STAGE FIELD CORN, SWEET CORN, AND SORGHUM

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ABSTRACT

It is important to identify new insecticides with efficacy for the fall armyworm, *Spodoptera frugiperda* Smith, to allow greater flexibility in management programs and to retard the development of resistance. Field trials showed all rates tested of the pyrethroid insecticides tralomethrin, flucythrinate, and cyhalothrin to be as effective as manufacturers' recommended rates of chlorpyrifos and methomyl against fall armyworm in whorl stage sweet corn, field corn, and sorghum. Permethrin, cypermethrin, fenvalerate, esfenvalerate, fluvalinate, and cyfluthrin gave erratic control of fall armyworm injury in field corn and sweet corn compared with chlorpyrifos and methomyl; these insecticides were comparable with other treatments against fall armyworm in whorl stage sorghum.

RESUMEN

Para una mejor flexibilidad en los programas de manejo del cogollero, *Spodoptera frugiperda* (J. E. Smith), es importante identificar nuevos insecticidas eficaces. Ensayos de campo demostraron que las dosis de los insecticidas piretroides, tralomethrin, flucythrinate, y cyhalothrin fue tan efectiva en el control del cogollero en el maíz dulce, maíz de campo y sorgo, como las dosis recomendadas por los fabricantes de chlorpyrifos y methomyl. Permethrin, cypermethrin, fenvalerate, esfenvalerate, fluvalinate y cyfluthrin dieron un control erratico del cogollero en maíz de campo y en maíz dulce comparado