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USE OF FEEDING STIMULANTS TO ENHANCE INSECT GROWTH REGULATOR-INDUCED MORTALITY OF FALL ARMYWORM (LEPIDOPTERA: NOCTUIDAE) LARVAE

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ABSTRACT

The mortality of fall armyworm (FAW), *Spodpoptera frugiperda* (J. E. Smith), larvae was significantly increased when they fed on leaves of southern pea *Vignaunguiculata* [L.] that had been treated with either of two insect growth regulators (IGRs) (RH-5992 and diflubenzuron), in combination with Konsume^R , a cottonseed flour based insect feeding stimulant. Larval mortality was increased 2 and 3 days after treatment when Konsume (10% solution) and RH-5992 at 0.001 and 0.01% active ingredient [AI] were applied in combination, respectively. Similarly, a 10% solution of Konsume enhanced the effects of diflubenzuron (0.01% AI) on FAW larvae 4, 6, and 7 days after treatment. A 5% solution of Konsume mixed with diflubenzuron (0.001% AI) resulted in significantly greater fall armyworm larval mortality 2-5 days after treatment compared with diflubenzuron alone. The feeding stimulants Nu-Lure^R, Coax^R and Konsume all performed similarily against FAW larvae when mixed with either RH-5992 or diflubenzuron. However, Nu-Lure and Coax mixed with the IGRs did not significantly increase fall armyworm mortality above that caused by the IGRs alone. The simultaneous use of a feeding stimulant, such as Konsume, may provide an effective tool to increase toxicant activity of RH-5992 or diflubenzuron, and decrease the time needed to effect death of fall armyworm larvae.

RESUMEN

Se incrementó la mortalidad larvaria de (FAW), *Spodoptera frugiperda* (J. E. Smith) cuando estas fueron alimentadas con hojas de alverja (*Vigna unguiculata* [L.]) la cual había sido tratada con dos reguladores de crecimiento (IGRs) (RH-5992 y diflubenzuron), en combinación con Konsume[R], un estimulador del apetito usando como base torta de harina de algodon. La mortalidad larvaria se incrementó 2 y 3 días despues del tratamiento cuando se aplicó la combinación de Konsume (solucion del 10%) y RH-5992 al 0.001 y 0.01% ingrediente activo. Similarmente, una solución del 10% de Konsume mezclada con diflubenzuron (0.001% IA) dieron como resultado una alta mortalidad de larvas de FAW, 2-5 días después de tratamiento comparadas con el diflubenzuron solo. Los estimulantes del crecimiento, tales como Konsume, pueden ser un arma efectiva para incrementar la actividad toxica de RH-5992 o diflubenzuron, y disminuír el tiempo necesario para causar la muerte de la larva del cogollero del maíz.

Fall armyworm, *Spodoptera frugiperda* (J. E. Smith), continues to be a major pest of corn, *Zea mays* L., in the southern United States. Recent studies in Georgia indicate that fresh market corn grown during the summer can be heavily damaged by fall armyworm larvae (Chandler & Sumner 1991). Chemical insecticides remain the most reliable form of control. Renewed interest in alternative chemical control tactics has resulted in laboratory studies to evaluate various insect growth regulators (IGRs) for use in management of fall armyworm larvae (Chandler et al. 1992a,b). These studies show that chitin synthesis inhibitors, such as diflubenzuron and teflubenzuron, when used against 1- and 7-day-old fall armyworm larvae, provide high levels of mortality (Chandler et al. 1992b). Additionally, laboratory studies evaluating RH-5992, a proprietary product, resulted in $\geq$ 90% mortality of fall armyworm 1- and 7-day-old larvae at concentrations $>$ 0.001% active ingredient [AI] (Chandler et al. 1992a). RH-5992 interferes with the normal molting process of lepidopterous larvae and acts as an agonist of insect molting hormone (Rohm and Haas Co. 1989).

The extended time required for IGRs to produce toxic effects in lepidopterous larvae, relative to that of chemical insecticides, remains a problem. Typically, chitin synthesis inhibitors induce mortality of lepidopterous larvae at the next molt following treatment. Mortality of 7-day-old fall armyworm larvae occurs within 3-4 days following treatment with lethal amounts of diflubenzuron (Chandler et al. 1992a). Pest management problems result when larvae continue to feed on plants during the interim between their treatment and death. Grower acceptance of IGRs would likely be greatly enhanced if the time to larval death could be substantially shortened.

The use of phagostimulants offers a possible method for reducing the time for IGRs to cause death. Many studies report the utility of phagostimulants to increase insect mortality associated with insecticides. Ridgway et al. (1966) demonstrated increased boll weevil, *Anthonomus grandis* Boheman, mortality on cotton following applications of a feeding stimulant mixed with a systemic insecticide. Starks et al. (1967) first used arrestant-feeding stimulants extracted from corn in combination with insecticides to control corn earworm, *Helicoverpa zea* (Boddie), and *S. frugiperda.* Their studies showed that fall armyworm larvae readily eat an extract of corn leaf mixed with Gardona[R] (tetrachlorvinphos), an organophsophate insecticide. In recent studies corn oil was found to be phagostimulatory for European corn borer, *Ostrinia nubilalis* (Hubner) (Dunkle & Shasha 1988). Further studies indicated that Coax[R], a cottonseed oil based product, was an effective phagostimulant for European corn borer, and that the addition of Coax to *Bacillus thuringiensis* Berliner increased corn borer mortality, compared with the mortality caused by *B. thuringiensis* alone (Bartelt et al. 1990). In addition, Bartelt et al. (1990) found that the addition of Coax reduced by 75% the amount of *B. thuringiensis* needed for mixing in starch granules without reducing European corn borer mortality. It appears that feeding stimulants offer opportunities for increasing the usefulness of biological/biorational insecticides. Therefore, this laboratory study was designed to compare the effectiveness of three commercially available feeding stimulants to enhance toxicity of RH-5992 or diflubenzuron for control of fall armyworm larvae.

MATERIALS AND METHODS

Comparison of Feeding Stimulants

RH-5992 2F (Rohm and Haas Co., Philadelphia, Pa.) and diflubenzuron (Dimilin 25® wettable powder [WP], Uniroyal Chemical Co., Middlebury, Conn.) were formulated in distilled water in the laboratory using 0.01% AI dilutions (100 mg/l). Bioassays were then conducted to compare the effects of various feeding stimulants either alone or mixed with each IGR on fall armyworm exposed as 1st instars. Feeding stimulants evaluated were Nu-Lure^R (Miller Chem. and Fert. Corp., Hanover, Penn.), Coax^R (CCT Corp., Litchfield Park, Ariz.), and Konsume^R (Fermone Inc., Phoenix, Ariz.). Nu-Lure is an insect feeding stimulant containing 44% hydrolyzed corn gluten meal. Coax contains a 35% AI mixture of Pharmamedia^R cottonseed flour, disaccharides, and vegetable oils. Konsume is similar to Coax but contains a 34% mixture of alcohol alkoxylate and polysaccharides in addition to cottonseed flour, disaccharides, and vegetable oils. Eight treatments were established per tested IGR (Tables 1 and 2). A single feeding stimulant was added to the tested IGR dilution at the rate of 10% total volume (3 treatments). Comparable amounts of feeding stimulant in distilled water only were used as paired comparisons with the stimulant + IGR treatment (3 treatments). Additionally, IGR only and water only treatments were used for further comparisons (2 treatments).

Neonate fall armyworm larvae were obtained from laboratory cultures at the Insect Biology and Population Management Research Laboratory in Tifton, Ga. These larvae were reared as described by Perkins (1979). The larvae were held on pinto bean diet at 24 ± 1°C for 24 h before being exposed to treated leaf surfaces thus allowing all insects to reach a uniform age and size before treatments were applied. Two-week-old greenhouse grown southern pea, *Vigna unguiculata* (L.), plants were brought into the laboratory, and mature leaves (avg. leaf area = 18.6 cm^2 + 3.2 SD) were excised from the plants. Each leaf was dipped for 3 sec in 100 ml of either distilled water or in one of the seven previously prepared IGR, IGR + feeding stimulant, or feeding stimulant alone treatments. The treated leaves were allowed to air dry for 1 hour before being exposed to larvae. The leaves were then placed in 30-ml plastic cups. Single 1-day-old larvae were placed on each leaf and the cup was capped. A total of 30 cups per treatment were set up on each test date; each test date was considered a replication. The RH-5992 test was replicated 5 times and the diflubenzuron evaluation replicated 4 times. Cups containing larvae were held in environmental cabinets in the laboratory at 24 ± 1°C, a photoperiod of 12:12 (L:D), and 50 ± 5% RH. The number of living versus dead larvae were recorded daily for each cup 3 to 7 days after treatment. Larvae were considered dead if they did not respond to touch by a dissecting needle within two probes. Live larvae were transferred back to pinto bean diet 3 days after treatment and remained on diet until the conclusion of the test, 7 days after treatment.

Comparison of Feeding Stimulant Rates

RH-5992 and diflubenzuron were formulated in distilled water in the laboratory using 0.001% AI dilutions (10 mg/l). Konsume was then added at the rate of 10, 5 and 1% total volume to the IGRs and to distilled water only. Since the above studies indicated significant increases in fall armyworm larval mortality when Konsume was mixed with both tested IGRs, it was selected for further study. The AI rates of RH-5992 and diflubenzuron were reduced to 0.001% in subsequent bioassays because of the high mortality in the first study. Eight treatments for each IGR were evaluated, including a water only treatment, an IGR only treatment, three rates of Konsume + IGR, and three rates of Konsume alone (Tables 3 and 4).

TABLE 1. CUMULATIVE MORTALITY OF FALL ARMYWORM LARVAE WHEN FED ON SOUTHERN PEA LEAVES TREATED WITH RH-5992 AND FEEDING STIMULANTS.[1]

Treatment	$\bar{x}$ + SD Percent mortality/rep at indicated days after treatment				
	3 Days	4 Days	5 Days	6 Days	7 Days
Nulure	3.8 ± 5.4	3.8 ± 5.4	3.8 ± 5.4	4.4 ± 5.0	4.4 ± 5.0
Nulure + RH-5992	88.2 ± 7.3	94.6 ± 3.9	98.0 ± 3.1	98.6 ± 3.1	98.6 ± 3.1
Coax	6.0 ± 6.6	7.4 ± 7.6	8.2 ± 7.3	8.2 ± 7.3	8.2 ± 7.3
Coax + RH-5992	88.0 ± 10.5	94.0 ± 6.6	97.4 ± 2.9	98.6 ± 3.1	98.6 ± 3.1
Konsume	8.0 ± 7.7	8.6 ± 8.9	8.6 ± 8.9	8.6 ± 8.9	8.6 ± 8.9
Konsume + RH-5992	95.4 ± 3.9*	98.2 ± 1.6	99.4 ± 1.3	100.0 ± 0	100.0 ± 0
RH-5992	84.2 ± 8.0	92.0 ± 3.7	93.4 ± 4.1	96.2 ± 1.8	96.2 ± 1.8
Water (Control)	8.0 ± 10.9	8.0 ± 10.9	8.8 ± 10.6	10.2 ± 10.1	10.2 ± 10.1

[1] *Indicates significant difference between RH-5992 (0.01% AI) treatment and indicated feeding stimulant + RH-5992 (0.01% AI) at $P \leq 0.05$ (t-test). Each treatment replicated five times with 30 larvae tested/rep/treatment.

TABLE 2. CUMULATIVE MORTALITY OF FALL ARMYWORM LARVAE WHEN FED ON SOUTHERN PEA LEAVES TREATED WITH DIFLUBENZURON AND FEEDING STIMULANTS.[1]

Treatment	x̄ + SD Percent mortality/rep at indicated days after treatment				
	3 Days	4 Days	5 Days	6 Days	7 Days
Nulure	12.8 ± 9.6	12.8 ± 9.6	13.5 ± 11.1	14.3 ± 10.6	14.3 ± 10.6
Nulure + Diflubenzuron	64.3 ± 23.2	75.8 ± 3.4	79.3 ± 5.9	80.8 ± 5.9	80.8 ± 5.9
Coax	17.5 ± 13.6	17.5 ± 13.6	17.5 ± 13.6	17.5 ± 13.6	17.5 ± 13.6
Coax + Diflubenzuron	62.8 ± 20.6	74.3 ± 11.8	80.5 ± 12.6	82.5 ± 11.1	83.3 ± 9.7
Konsume	5.0 ± 2.3	6.0 ± 2.0	6.8 ± 2.9	6.8 ± 2.9	6.8 ± 2.9
Konsume + Diflubenzuron	79.8 ± 18.3	90.0 ± 7.3**	90.8 ± 8.3*	92.5 ± 5.6**	92.5 ± 5.6**
Diflubenzuron	70.0 ± 13.1	76.8 ± 11.9	78.3 ± 10.6	79.3 ± 8.7	79.3 ± 8.7
Water (Control)	6.0 ± 4.2	6.8 ± 2.9	6.8 ± 2.9	6.8 ± 2.9	6.8 ± 2.9

[1] ** and * Indicates significant difference between Diflubenzuron (0.01% AI) treatment and indicated feeding stimulant + Diflubenzuron (0.01% AI) at $P \leq 0.05$ and $P \leq 0.10$ (t-test), respectively. Each treatment replicated four times with 30 larvae tested/rep/treatment.

TABLE 3. CUMULATIVE MORTALITY OF FALL ARMYWORM LARVAE WHEN FED ON SOUTHERN PEA LEAVES TREATED WITH RH-5992 AND KONSUME.[1]

	$\bar{x}$ + SD Percent mortality/rep at indicated days after treatment					
Treatment	2 Days	3 Days	4 Days	5 Days	6 Days	7 Days
RH-5992 +						
10% Konsume	85.4 ± 14.5*	95.4 ± 7.1	97.4 ± 4.3	98.0 ± 4.5	98.0 ± 4.5	98.0 ± 4.5
10% Konsume	20.2 ± 11.7	21.4 ± 12.2	21.4 ± 12.2	22.0 ± 12.0	22.0 ± 12.0	22.0 ± 12.0
RH-5992 +						
5% Konsume	78.0 ± 22.0	90.0 ± 13.8	90.6 ± 13.1	90.6 ± 13.1	90.6 ± 13.1	91.2 ± 12.6
5% Konsume	11.4 ± 10.0	15.4 ± 10.0	15.4 ± 10.0	15.4 ± 10.0	15.4 ± 10.0	15.4 ± 10.0
RH-5992 +						
1% Konsume	76.6 ± 20.4	94.6 ± 7.1	94.6 ± 7.1	94.6 ± 7.1	94.6 ± 7.1	94.6 ± 7.1
1% Konsume	7.4 ± 2.9	8.8 ± 2.7	9.4 ± 2.5	9.4 ± 2.5	9.4 ± 2.5	9.4 ± 2.5
RH-5992	67.4 ± 11.8	93.4 ± 6.5	94.0 ± 5.9	94.0 ± 5.9	94.8 ± 6.0	96.2 ± 5.4
Water						
(Control)	6.6 ± 5.2	10.0 ± 3.0	10.0 ± 3.0	10.6 ± 2.5	10.6 ± 2.5	10.6 ± 2.5

[1] *Indicates significant difference between RH-5992 (0.001% AI) treatment and indicated Konsume + RH-5992 (0.001% AI) at $P \leq 0.05$ (t-test). Each treatment replicated five times with 30 larvae tested/rep/treatment.

TABLE 4. CUMULATIVE MORTALITY OF FALL ARMYWORM LARVAE WHEN FED ON SOUTHERN PEA LEAVES TREATED WITH DIFLUBENZURON AND KONSUME.[1]

Treatment	$\bar{x}$ + SD Percent mortality/rep at indicated days after treatment					
	2 Days	3 Days	4 Days	5 Days	6 Days	7 Days
Diflubenzuron + 10% Konsume	57.7 ± 8.1	77.7 ± 13.7	82.0 ± 8.5	84.7 ± 6.8	87.0 ± 10.0	87.0 ± 10.0
10% Konsume	8.7 ± 5.1	10.0 ± 3.0	11.3 ± 5.1	12.3 ± 6.8	12.3 ± 6.8	12.3 ± 6.8
Diflubenzuron + 5% Konsume	64.3 ± 12.1**	82.0 ± 8.5*	84.7 ± 6.8*	87.7 ± 9.2*	87.7 ± 9.2	90.0 ± 8.9
5% Konsume	0	1.0 ± 1.7	1.0 ± 1.7	2.3 ± 4.0	2.3 ± 4.0	3.3 ± 5.8
Diflubenzuron + 1% Konsume	47.7 ± 19.7	73.0 ± 17.3	75.3 ± 15.7	77.7 ± 13.6	77.7 ± 13.6	81.0 ± 11.5
1% Konsume	5.3 ± 6.8	5.3 ± 6.8	5.3 ± 6.8	5.3 ± 6.8	5.3 ± 6.8	5.3 ± 6.8
Diflubenzuron	43.3 ± 18.0	66.7 ± 11.9	72.3 ± 9.2	75.7 ± 8.1	80.3 ± 5.8	83.7 ± 5.8
Water (Control)	3.3 ± 3.5	3.3 ± 3.5	3.3 ± 3.5	4.3 ± 5.1	4.3 ± 5.1	4.3 ± 5.1

[1] ** and *Indicates significant difference between Diflubenzuron (0.001% AI) treatment and indicated Konsume + Diflubenzuron (0.001% AI) at $P \leq 0.05$ and $P \leq 0.10$ (t-test), respectively. Each treatment replicated three times with 30 larvae tested/rep/treatment.

Neonate fall armyworm larvae were obtained and handled before the start of the bioassay in the same manner as described above. Two-week-old greenhouse grown southern pea leaves with leaf area similar to those in the above test were again used for the bioassay. Leaves were dipped into 100 ml of each solution for 3 sec and allowed to air dry for 1 h. The leaves were then put into 30 ml plastic cups. A single 1-day-old fall armyworm larva was placed on the leaf and the cup was capped. A total of 30 cups/treatment were used on each test date (replicate). The RH-5992 evaluation was replicated 5 times and the diflubenzuron test replicated 3 times. Larvae were handled and data were taken as described in the previous tests except that observations on mortality were collected daily 2 to 7 days after treatment.

Statistical Analyses

The number of dead larvae were converted into percent mortality by dividing the number of dead larvae per treatment per test date by the total number of tested larvae per treatment per test date. Means and standard deviations were calculated for all data, and a Proc GLM procedure (SAS 1985) was used to analyze specific paired comparisons for each study. Significantly different means were separated using Least Square Means. Paired means were analyzed for feeding stimulants with IGRs versus feeding stimulants alone, feeding stimulants with IGRs versus IGRs alone, one feeding stimulant with IGR versus another feeding stimulant with IGR, and one rate of Konsume with IGR versus another rate of Konsume with IGR.

Results and Discussion

Comparison of Feeding Stimulants

Three days after fall armyworm larvae were fed southern pea leaves treated with selected dosages of RH-5992 + a feeding stimulant, mortality ranged from 88.0 to 95.4% (Table 1). On days 3-7 after treatment, each feeding stimulant + RH-5992 combination yielded significantly ($P \leq 0.05$, $t > 2.0$, df = 32) greater fall armyworm larval mortality than did feeding stimulants alone. Mortality of fall armyworm larvae fed leaves treated with RH-5992 + Konsume was significantly higher ($P \leq 0.05$, $t = 2.25$, df = 32) 3 days after treatment than that of larvae fed leaves treated with RH-5992 alone. Only on 3 days after treatment was there an increase in larval mortality due to feeding stimulants alone. Larval mortality resulting from RH-5992 + Nu-Lure or Coax was comparable to ($P > 0.05$) that produced by RH-5992 alone. On each sampling date the toxicant was found to be the major factor causing fall armyworm larval mortality. Mortality resulting from larval exposure to RH-5992 alone was significantly ($P \leq 0.0001$, $t > 10.0$, df = 32) higher than that found in the water control. Mortality of fall armyworm larvae exposed only to RH-5992 ranged from 84 to 96% during the 3 to 7 day observation period (Table 1). Larval mortality in all RH-5992 treatments (with and without feeding stimulants) was ≥ 92% 4 days after treatment (Table 1). RH-5992 + Konsume, however, was the only treatment to effect 100% larval mortality during the 7-day test period. Since RH-5992 is quite active at 0.01% AI (Chandler et al. 1992a), any dramatic benefits of adding feeding stimulants were not detectable after 3 days. However, because the combination of RH-5992 + Konsume yielded 95% and 100% mortality 3 and 6 days after test initiation, respectively, Konsume should be considered as a viable option for enhancing the effectiveness of RH-5992 against fall armyworm larvae.

Increased levels of fall armyworm larval mortality were also observed when Konsume was added to 0.01% AI of diflubenzuron. Leaves treated with Konsume + diflubenzuron resulted in significantly ($P \leq 0.05$) greater larval mortality compared to diflubenzuron alone 4, 6, and 7 days after treatment (t = 2.1, 2.2 and 2.3, respectively, df = 24). The study indicated that all diflubenzuron treatments (with and without feeding stimulants) provided similar ($P > 0.05$, t < 2.0, df = 24) levels of mortality 3 days after treatment. However, the Konsume +diflubenzuron treatment resulted in approximately 10% higher mortality than did diflubenzuron alone. The addition of Konsume to the IGR treatments resulted in significantly ($P \leq 0.05$, t > 2.0, df = 24) greater fall armyworm larval mortality than did treatments containing the feeding stimulant alone. Additionally, diflubenzuron alone resulted in significantly ($P \leq 0.0001$, t > 6.0, df = 24) greater mortality of larvae than did the water treatment alone. Konsume + diflubenzuron resulted in significantly ($P \leq 0.05$) greater fall armyworm larval mortality than did Nu-lure (t = 2.3, df = 24) and Coax (t = 2.5, df = 24) + diflubenzuron 4 days after treatment. Although Konsume, when used in combination with diflubenzuron did not significantly increase larval mortality beyond that produced by the other two feeding stimulants, numerically, mortality in the treatment including Konsume remained consistently higher throughout the study (Table 2). Konsume + diflubenzuron was the only treatment which resulted in fall armyworm larval mortality > 90%. As in the above tests with 0.01% AI of RH-5992, the addition of Konsume to 0.01 % diflubenzuron resulted in significantly greater larval mortality early in the test period (4 days after treatment). Konsume + diflubenzuron also provided significantly greater fall armyworm larval mortality through the 7-day test period.

Since Coax and Konsume are otherwise chemically similar, it would appear that the addition of polysaccharides and alcohol alkoxylate in Konsume provide part of the basis for the differential response in larval mortality among the two compounds. The addition of polysaccharides and the slcohol alkoxylate to the Konsume mixture either make it more palatable to the larvae, resulting in increased rates of feeding and intake of IGR, or cause larval mortality independent of the IGR. The latter scenario is not likely, since no significant differences in mortality were observed between treatments involving Konsume and water alone (Tables 1 and 2). Based on the above studies Konsume was further evaluated to determine the influence of selected dosages of the feeding stimulant + RH-5992 and diflubenzuron when applied against fall armyworm larvae.

Comparison of Feeding Stimulant Rates

The addition of Konsume (10% total volume) to 0.001% AI RH-5992 significantly ($P \leq 0.05$, t = 2.1, df = 32) increased fall armyworm larval mortality compared to mortality caused by RH-5992 alone (85.4 versus 67.4%) 2 days after treatment (Table 3). Mortality resulting from all tested rates of Konsume + RH-5992 were similar ($P > 0.05$, t ≤ 1.0, df = 32) 2 to 7 days after treatment. Fall armyworm larval mortality reached or exceeded 90% for each RH-5992 treatment 3 days after treatment (Table 3). During the remainder of the observation period (days 3-7), no significant ($P > 0.05$, t < 2.0, df = 32) increase in fall armyworm larval mortality could be attributed to the selected dosages of the feeding stimulants. However, fall armyworm mortality was always numerically greater in the RH-5992 + 10% Konsume treatment than in any other treatments evaluated. As in the above study RH-5992 (0.01% AI) + 10% Konsume effected a significant increase in mortality on the 1st day of observations. This 1-day 27% increase in mortality could reduce larval feeding in the field and save growers substantial yield loss.

Diflubenzuron (0.001% AI) + 5% total volume of Konsume resulted in *S. frugiperda* larval mortality significantly ($P \leq 0.05$, t = 2.3, df = 16) greater than that observed with diflubenzuron alone 2 days after treatment (Table 4). Diflubenzuron + 5% Konsume yielded numerically higher levels of fall armyworm larval mortality 3-5 days after treatment than did diflubenzuron alone, but mortality was significantly higher only at $P \leq 0.10$ (t = 1.9, 1.8, and 1.8 for days 3-5, respectively, df = 16). Diflubenzuron + 1 or 10% Konsume yielded mortality similar ($P > 0.05$, t < 2.0, df = 16) to that of diflubenzuron alone throughout the study (Table 4). Konsume (10%) + diflubenzuron resulted in the second greatest amount of larval mortality throughout the study (Table 4). The addition of 5% Konsume to 0.001% AI formulations of diflubenzuron appeared to provide the most beneficial increase in fall armyworm mortality.

In conclusion, this study confirms the benefit of adding a cottonseed flour based feeding stimulant, Konsume, to IGRs RH-5992 and diflubenzuron for enhancing fall armyworm larval mortality. Increased fall armyworm larval mortality was achieved 2 to 3 days after treatment with RH-5992 and up to 6 or 7 days after treatment with diflubenzuron. The significant increases in fall armyworm larval mortality noted with RH-5992 and diflubenzuron + Konsume should make the use of these biorationals more attractive to crop managers. Additionally, the determination that feeding stimulants can improve and enhance IGR-effected mortality provides the impetus to advance the use of these compounds with IGRs toward development of environmentally sensitive area wide management programs directed against migratory pests, such as *H. zea* and *S. frugiperda*. Further research is needed to determine optimal rates of feeding stimulants, and to identify and develop new and more effective stimulants for use against foliar feeding insect pests.

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INFESTATION DYNAMICS AND DISTRIBUTION OF *NOCTUIDONEMA GUYANENSE* (NEMATODA: APHELENCHOIDIDAE) ON ADULTS OF *SPODOPTERA FRUGIPERDA* AND *MOCIS LATIPES* (LEPIDOPTERA: NOCTUIDAE)

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ABSTRACT

The infestation dynamics and distribution of an ectoparasitic nematode, *Noctuidonema guyanense* Remillet and Silvain, on moths of *Spodoptera frugiperda* (J. E. Smith) and *Mocis latipes* (Guen)e) were studied. Nematodes transfer among hosts as moths mate. Subsequent dispersal and reproduction by *N. guyanense* on new hosts results in an aggregation of nematodes on the posterior abdominal segments of *S. frugiperda* moths. On *M. latipes*, nematodes aggregate on the posterior margin of the thorax and on the first and second abdominal segments. Nematodes are rarely found on the head of moths of either species. A significant, positive correlation exists between dispersal of nematodes on *S. frugiperda* and elapsed time after the initiation of host mating.

RESUMEN

Se estudiaron la dinámica de las infestaciones y la distribución del nematodo ectoparasitico, *Noctuidoma guyanenese* Remillet y Silvain, en polillas de *Spodoptera frugiperda* (J. E. Smith) y de *Mocis latipes* (Guenee). Los nematodos fueron tranferidos cuando las polillas estaban copulando. La dispersión y la reproducción de *N. guyanense* en los nuevos hospederos resultó en una agregación de nematodos en la región posterior de los segmentos abdominales de las polillas de *S. frugiperda*. En *M. latipes*, los nematodos se agregaron en el margen posterior del torax y en el primer y segundo segmento abdominal. Los nematodos se encontraron muy raramente en la cabeza de las polillas de las dos especies. Una correlación significante existe entre la dispersión de los nematodos en *S. frugiperda* y el tiempo que pasa despuás de la iniciación de la copula del hospedero.