TOXITY AND PERSISTENCE OF HEXAFLUMURON TO THE VELVETBEAN CATERPILLAR *Anticarsia gemmatalis* HÜBNER, 1818 (LEPIDOPTERA: NOCTUIDAE) IN SOYBEANS

Luís A. Foerster[1]

RESUMO

Toxicidade e persistência de hexaflumuron à lagarta da soja *Anticarsia gemmatalis* Hübner, 1818 (Lepidoptera: Noctuidae)

Experimentos de campo foram realizados durante três safras de soja no Centro-Sul do Paraná para avaliar a eficiência do inibidor do crescimento hexaflumuron a lagartas grandes (>1,5 cm) de *A. gemmatalis*. Dosagens de 5g, 10g, 20g e 40g i.a./ha foram comparadas com dosagens semelhantes de diflubenzuron e com 45g, 60g, 90g, 120g e 180g i.a./ha de clorpirifós. A 5g e 10g i.a./ha hexaflumuron não foi eficiente, e nas maiores dosagens os resultados foram variáveis em função do clima durante os períodos experimentais. Sob condições de seca prolongada e de altas temperaturas, sua eficiência foi baixa, possivelmente pela volatilização e/ou degradação de hexaflumuron. Nos dois últimos anos, com temperaturas amenas e maior umidade, hexaflumuron mostrou-se altamente efetivo nas dosagens de 20g e 40g i.a./ha. Oscilações semelhantes foram registradas na eficiência de clorpirifós. Diflubenzuron mostrou-se altamente efetivo, independentemente das condições climáticas, sendo pelo menos duas vezes mais tóxico que hexaflumuron para lagartas grandes de *A. gemmatalis*. Na dosagem de 10g i.a./ha, diflubenzuron forneceu porcentagens de controle semelhantes às obtidas com hexaflumuron a 20g i.a./ha. Em condições climáticas adversas, a dosagem de 5g i.a./ha de diflubenzuron foi significativamente mais eficiente que qualquer das dosagens de hexaflumuron.

Aplicações efetuadas logo após o aparecimento das primeiras lagartas foram mais eficientes que tratamentos idênticos realizados próximo ao auge da infestação, para todos os inseticidas. Misturas de clorpirifós e hexaflumuron ou diflubenzuron não aumentaram a eficiência dos tratamentos em relação aos produtos aplicados isoladamente. PALAVRAS-CHAVE: *Anticarsia gemmatalis;* hexaflumuron; soja.

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[1] Depto. de Zoologia, UFPR. Caixa Postal 19.020, 81531-970 Curitiba, PR, Brasil, Bolsista do CNPq.

ABSTRACT

Field experiments were conducted in Paraná State, Brasil during three soybean seasons to evaluate the efficiency of the insect growth regulator hexaflumuron against large (> 1,5cm) larvae of *A. gemmatalis*. Dosages of 5g, 10g, 20g and 40g a.i./ha were compared to similar dosages of diflubenzuron and to dosages ranging from 45g to 180g a.i./ha of chlorpyriphos. At 5g and 10g a.i./ha hexaflumuron was not effective; at 20g and 40g a.i./ha its efficiency varied according to climatic conditions; prolonged drought and high temperature impaired its action either by degradation and/or by volatilization, whereas under milder conditions of temperature and humidity its efficiency was significantly increased. Similar variation in efficiency was recorded for chlorpyriphos. Diflubenzuron was not affected by climatic conditions and was at least twice as toxic as hexaflumuron. At 10g a.i./ha diflubenzuron provided control rates similar to the ones obtained with hexaflumuron at 20g a.i./ha. Under unfavourable weather conditions for hexaflumuron and chlorpyriphos, the dosage of 5g a.i./ha of diflubenzuron was more effective and showed longer effect than either chlorpyriphos at 180g or hexaflumuron at 40g a.i./ha.

Treatments applied the beginning of larval attack were more efficient than similar treatments made close to the peak of larval incidence, resulting in this case in a proportionality higher number of survivors. Mixtures between chlorpyriphos and either growth inhibitor did not improve the efficiency of the treatments in comparison to the products alone. KEYWORDS: *Anticarsia gemmatalis;* Hexaflumuron; soybeans.

INTRODUCTION

Hexaflumuron is an insect growth regulator whose toxity has been shown to a number of species of various insect orders. It is highly efficient against the European corn borer *Ostrinia nubilalis* Hübner, (ASCHER *et al.*, 1987), the leafminer *Liriomyza trifolii* (Burgess) (ASCHER *et al.*, 1989), the sugarcane borer *Diatraea saccharalis* F. (SANTOS *et al.*, 1991) and the stored product beetles *Tribolium castaneum* (Herbst) and *Sitophilus orizae* L. (ISHAAYA *et al.*, 1986; AMMAR, 1988). In soybean, hexaflumuron was not efficient against the budworm *Epinotia aporema* (Walsingham) (ROCHA, 1991), and no results are available on its toxicity to *A. gemmatalis*.

Field experiments were conducted during three soybean seasons to evaluate the toxicity of hexaflumuron against large (>1,5 cm) larvae of *A. gemmatalis*. Its efficiency was compared to different dosages of diflubenzuron and chlorpyriphos; the effects of application dates and climatic conditions on the efficiency of the treatments are discussed.

MATERIAL AND METHODS

The experiments were conducted during the soybean season of 1986 through 1988 at Lapa, Paraná State (Lat. 25° 44' S; Long. 49° 25' W) on Bragg (1986/87) and FT 2 (1988) soybeans. The treatments (Tables 1-5) were applied at the flowering stage (1986, 1987) and at the end of the vegetative stage (1988) using a CO_2-pressurized knapsack sprayer calibrated for an output of 100 ℓ of weather/ha. Each treatment was replicated four times in a randomized block desing. Plots were 10m long and 10 rows wide; two samples were taken in the six central rows of each plot, using the ground cloth method. Data were submitted to analysis of variance and the means were classified by Duncan's multiple range test at 5% probability level. In 1987, in addition to the larval counts, the consumption of foliage in each treatment was visually estimated by three persons independently at the end of the experiment, 22 days after insecticide application.

RESULTS AND DISCUSSION

Due to an extended period of drought between the end of 1985 and the beginning of 1986, the first larvae of *A. gemmatalis* only appeared in the end of January when the crop was in the flowering stage. Two experiments with similar treatments were conducted this year; in the first one the insecticides were applied soon after the detection of the first larvae, with an average of 1.5 - 2.1 large larvae/sample (Table 1), and the second one when the larval population was above 10 specimens/sample, 10 days after the first experiment (Table 2). Diflubenzuron provided the best results up to 24 days after application (d.a.a.), even when its lowest dosages are compared to the highest ones of clorpyriphos and hexaflumuron (Table 1). Chlorpyriphos at 90g and 180g a.i./ha was effective up to 10 d.a.a., but heavy reinfestations of large larvae were recorded after 17 d.a.a. At 45 g a.i./ha larval ressurgence occured after 10 days, despite its significant action at 3 and 6 d.a.a.

Hexaflumuron was the least toxic compound to large larvae of *A. gemmatalis* and the control rates obtained with the dosage of 40g a.i./ha was comparable to the one recorded for diflubenzuron at 5g a.i./ha (Table 1).

Similar treatments applied under a high populational density were comparatively less efficient, allowing the survival of a large proportion of large larvae (Table 2), Thus, when the mean number of large larvae in the intreated control was above 40 specimens/sample 17 d.a.a. in the first experiment, percentages of control with diflubenzuron ranged from 79% to 94%, with less than 10 larvae/sample, whereas at the same populational level in the second experiment, similar treatments with diflubenzuron provided control percentages between 63% and 73%, resulting in more than 10 large larvae/sample in all treatments (Table 2).

In 1987 the highest dosages of hexaflumuron (20g and 40g a.i./ha) were repeated and compared to chlorpyriphos at 60g and 120g a.i./ha and to mixtures of chlorpyriphos and the two growth inhibitors (Table 3). Contrary to the previous year, both dosages of hexaflumuron were able to reduce the population of large larvae well below the economic injury level up to 20 days after treatmens. Similar results were obtained with chlorpyriphos, despite the fact that both dosages were lower than the two highest ones used in the previous year. Considering that both experiments were conducted under similar conditions of crop phenology and larval populational density, the only variable to affect the efficiency of the insecticides was the weather; in 1987 the experiments was conducted under mild temperatures and high humidity due to better distribution of rains. Under theses circumstances the rate of degradation and/or volatilization of both products were considerably smaller than in the previous year, resulting in high control percentages. GUILLEBEAU *et al.* (1989) observed similar variation in the efficacy of pyrethroids in cotton against the boll weevil *Anthonomus grandis* Boheman, in relation to the climate; experiments conducted at high temperatures and bright days were significantly less effective than similar treatments applied under mild temperatures and better distribution of rains.

The use of mixtures between chlorpyriphos and growth inhibitors did not increase the efficiency of the treatments in relation to the products applied individually (Table 3); thus the use of mixtures is not justified. The percentage of defoliation estimated at the end of the experiment confirms the efficacy of the insecticides in 1987 (Table 4); all treatments had less than 10% of foliar reduction, compared to 30% defoliation recorded in the untreated control. Again, no differences were found between the insecticides applied individually or in mixtures, regarding the amount of defoliation.

In the 1988 soybean season climatic conditions were similar to the previous year, and both hexaflumuron and chlorpyriphos repeated the good results obtained in 1987, up to 22 d.a.a. (Table 5). After 27 days, chlorpyriphos at 180g a.i./ha and hexaflumuron at 20g and 40g a.i./ha did not differ statistically from the control; however at this point the crop was reaching the podfilling stage and the number of large larve/sample was below the economic injury level for *A. gemmatalis.* Diflubenzuron at 10g and 20g a.i./ha repeated the high control percentages recorded in 1986, indicating that its efficiency is not related to climatic factors. No statistical differences were found between the dosages of 10g and 20g a.i./ha of diflubenzuron until 33 d.a.a. (Table 5). Previous results (HEINRICHS & SILVA, 1978) have shown that dosages of diflubenzuron as low as 5g a.i./ha cause significant reductions in larval populations of *A. gemmatalis,* as observed in 1986; thus the use of 10g a.i./ha still holds a safety margin sufficient to provide a satisfactory control cases of misapplication of diflubenzuron.

TABLE 1- Mean number of large (>1,5cm) larvae of *Anticarsia gemmatalis* Hübner, 1818 per sample and percentage of control at different intervals after application. (Average of eight samplings/treatment). Lapa, PR, Brazil, 1986.

Treatment	Dosage g a.i./ha	Pre count	3 DAYS		6 DAYS		10 DAYS		17 DAYS		24 DAYS	
			No[1]	%	No	%	No	%	No	%	No	%
Chlorpyriphos	45	2,13	4,00 b	23,81	2,75 abc	63,93	14,50 ef	42,29	33,25 ef	25,91	11,50 bcde	9,80
	90	2,00	3,75 b	28,57	2,25 abc	70,49	7,13 bcd	71,64	34,63 ef	22,84	18,38 cde	0,00
	180	1,75	1,38 a	73,81	1,25 ab	83,61	2,00 a	92,04	26,13 de	41,78	25,38 e	0,00
Diflubenzuron	5	2,13	5,00 bc	4,76	1,13 a	85,25	8,50 cde	66,17	9,50 bc	78,83	6,50 abc	49,02
	10	1,50	3,00 ab	42,86	1,00 a	86,89	5,50 bc	78,11	9,25 bc	79,39	3,50 ab	72,55
	20	1,88	2,75 ab	47,62	1,75 abc	77,05	3,75 ab	85,07	3,88 ab	91,36	1,75 a	86,27
	20	1,88	2,25 ab	57,14	0,63 a	91,80	1,75 a	93,03	2,75 a	93,87	3,00 a	76,47
Hexaflumuron	5	1,50	8,00 c	0,00	6,38 de	16,39	25,00 g	0,50	37,63 ef	16,16	20,25 de	0,00
	10	1,88	3,63 ab	30,95	4,13 bcd	45,90	17,38 f	30,85	43,88 f	2,23	14,63 cde	0,00
	20	1,50	3,13 ab	40,48	4,88 cde	36,07	11,38 def	54,73	25,00 de	44,29	8,00 abcd	37,25
	40	2,13	3,50 ab	33,33	2,88 abc	62,29	9,63 cde	61,69	16,00 cd	64,34	7,50 abc	41,18
Control		2,13	5,25 bc	-	7,63 e	-	25,13 g	-	44,88 f	-	12,75 bcde	-
$F'_{0,05}$		0,1460 N.S.	3,4605**		5,6667**		20,3374**		15,8382**		4,7114**	
C.V.		38,06	22,20		29,90		17,70		19,70		33,47	

[1] Means followed by the same letter do not differ at the 5% level according to Duncan's multiple range test.

TABLE 2 - Mean number of live *Anticarsia gemmatalis* Hübner, 1818 larvae (>1,5cm) per sample and percentage of control after 5 and 15 days from application. (Average of eight samplings/treatment). Lapa, PR, Brazil, 1986.

Treatment	Dosage g a.i./ha	Pre-count	5 DAYS		15 DAYS	
			No[1]	%	No	%
Chlorpyriphos	45	18,00	22,13 cde	48,99	9,50 cd	10,59
	90	19,50	14,75 abc	65,99	5,13 abcd	51,76
	180	10,50	8,88 a	79,54	1,63 a	84,70
Diflubenzuron	5	12,75	16,13 abcd	62,82	1,25 a	88,23
	10	17,25	11,88 ab	72,62	2,75 abc	74,12
	20	12,50	14,75 abc	65,99	1,13 a	89,41
	40	13,75	11,63 ab	73,20	1,25 a	88,23
Hexaflumuron	5	18,00	28,00 de	35,45	7,50 bcd	29,41
	10	14,00	33,25 ef	23,34	2,63 ab	75,29
	20	19,25	26,63 de	38,61	2,75 ab	74,12
	40	16,50	21,38 bcde	50,72	3,75 abcd	64,71
Control	-	14,75	43,38 f	-	10,63 d	-
F'0,05			8,2297**		3,0289**	
C.V.			16,55		44,23	

[1] Means followed by the same letter do not differ at the 5% level according to Duncan's multiple range test.

TABLE 3 - Mean number of live *Anticarsia gemmatalis* Hübner, 1818 larvae (>1,5cm) per sample and percentage of control at different intervals after application. (Average of eight samplings/treatment). Lapa, PR, Brazil, 1987.

Treatment	Dosage g a.i./ha	3 DAYS		6 DAYS		10 DAYS		15 DAYS		20 DAYS	
		No[1]	%	No	%	No	%	No	%	No	%
Hexaflumuron	40	9,00 c	48,20	1,50 ab	91,67	2,88 c	87,89	3,50 cd	84,27	2,00 c	73,33
	20	9,00 c	48,20	2,63 ab	85,42	2,88 c	87,89	4,50 cd	79,78	1,75 bc	76,67
Hexaflumuron + Chlorpyriphos	40 + 60	4,13 ab	76,26	0,38 a	97,92	1,50 abc	93,68	2,13 bc	90,45	0,50 abc	93,33
	20 + 60	4,63 ab	73,38	1,25 ab	93,05	1,38 abc	94,21	4,63 cd	79,21	1,65 abc	78,33
Chlorpyriphos	120	2,63 a	84,89	1,88 ab	89,58	3,33 bc	85,98	6,13 d	72,47	1,75 bc	76,67
	60	7,00 bc	59,71	3,13 b	82,64	1,63 abc	93,16	12,63 e	43,26	5,00 d	33,33
Diflubenzuron + Chlorpyriphos	40 + 60	4,75 ab	72,66	0,38 a	97,92	0,25 a	98,94	0,38 ab	98,31	0,00 a	100,00
	20 + 60	3,38 a	80,57	0,50 a	97,22	0,63 a	97,37	0,00 a	100,00	0,13 ab	98,33
Control	-	17,38 d	-	18,00 c	-	23,75 d	-	22,25 f	-	7,50 d	-
F' 0,05		12,2486**		13,1397**		26,2230**		13,2810**		10,8540**	
C.V.		16,97		34,97		26,34		13,17		28,54	

[1] Means followed by the same letter do not differ at the 5% level according to Duncan's multiple range test.

TABLE 4 - Percent defoliation of soybeans 22 days after insecticide treatment. (Average of 12 evaluations/treatment). Lapa, PR, Brazil, 1987.

Treatment	Dosage g a.i./ha	Defoliation[1] %
Hexaflumuron	40	5,42 b
	20	4,67 ab
Hexaflumuron + Chlorpyriphos	40 + 60	2,83 a
	20 + 60	2,92 a
Chlorpyriphos	120	5,50 b
	60	8,08 c
Diflubenzuron + Chloryriphos	40 + 60	3,33 a
	20 + 60	2,75 a
Control		29,33 d

[1] Means followed by the same letter do not differ according to Duncan's multiple range test at the 5% level.

TABLE 5 - Mean number of live *Anticarsia gemmatalis* Hübner, 1818 larvae (>1,5cm) per sample and percentage of control at different intervals after application. (Average of eight samplings/treatment). Lapa, PR, Brazil, 1988.

Treatment	Dosage g a.i./ha	3 1/2 DAYS		7 DAYS		13 DAYS		17 DAYS		22 DAYS		27 DAYS		33 DAYS	
		No[1]	%	No	%	No	%	No	%	No	%	No	%	No	%
Hexaflumuron	20	2,00 a	76,83	3,25 b	61,76	4,13 a	76,06	6,00 d	67,12	8,50 b	63,44	9,63 c	20,61	5,88 ab	0,00
	40	2,00 a	76,83	0,88 a	89,65	2,00 a	88,41	4,00 c	78,08	6,25 b	73,12	5,75 bc	52,60	9,50 bc	0,00
Diflubenzuron	10	1,13 a	86,91	1,00 a	88,24	0,63 a	96,35	0,63 a	96,55	1,75 a	92,47	2,88 ab	76,49	4,75 ab	0,00
	20	1,63 a	81,11	0,50 a	94,12	0,25 a	98,55	0,75 ab	95,89	1,25 a	94,62	0,88 a	92,82	1,75 a	48,22
Chlorpyriphos	180	2,00 a	76,83	0,75 a	91,18	0,25 a	98,55	1,63 b	91,07	10,13 b	56,43	12,13 c	0,00	15,13 c	0,00
Control		8,63 b	-	8,50 c	-	17,25 b	-	18,25 e	-	23,25 c	-	12,25 c	-	3,38 a	-
F'0,05		14,1687**	-	30,3939**	-	6,7513**	-	93,0172**	-	18,4400**	-	7,8230**	-	6,9180**	-
C.V.		19,75		17,95		51,60		12,40		21,99		26,89		27,65	

[1] Means followed by the same letter do not differ at the 5% level according to Duncan's multiple range test.

CONCLUSIONS

The results obtained during the three soybeans seasons show that hexaflumuron is at least twice less toxic to *A. gemmatalis* than diflubenzuron, and that its efficiency, unlike that of diflubenzuron is impaired by hot and dry climate. Applications made in the beginning of the larval attack were more efficient than similar treatments made near the populational peak. Mixtures of chlorpyriphos and either growth inhibitor did not improve the efficiency of the treatments in relation to the products alone.

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