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OVICIDAL AND LARVICIDAL ACTIVITIES OF THREE INSECT GROWTH REGULATORS AGAINST THE COTTON LEAFWORM *Spodoptera littoralis* (BOISD.)

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ABSTRACT

The present work was conducted to evaluate the ovicidal and larvicidal activity of three insect growth regulators, flufenoxuron, chlorfluazuron and lufenuron against the cotton leafworm *Spodoptera littoralis* (Boisd.). Data indicate the important role played by age of eggs in determining the ovicidal activity against cotton leafworm *S. littoralis* eggs. In general, data indicated the superior ovicidal activity of lufenuron on egg masses followed by flufenoxuron and chlorfluazuron according to the toxicity index. While the field recommended rate of the tested IGR's caused reduction in the percent of hatchability compared with check. Regarding the efficacy of tested IGR's on 2nd and 4th instars larvae of *S. littoralis,* data cleared that lufenuron proved to be the most effective tested IGR against 2nd instar larvae of *S. littoralis* (Boisd.) followed by chlorfluazuron and flufenoxuron, respectively. In a different trend, flufenoxuron was the most effective followed by lufenuron and chlorfluazuron against 4th instar larvae of *S. littoralis.* The general mean of cumulative mortality could be arranged in following order: lufenuron, chlorfluazuron and flufenoxuron against the 2nd & 4th instars larvae under field – laboratory condition. In field efficacy of tested IGR's in 2012 season, data showed that the initial effects of chlorfluazuron and lufenuron were most striking, which was causing 95.21 and 90.44% reduction, respectively. While the lowest obtained with flufenoxuron which caused 64.91% reduction in population density than control. At ninth day, no significant differences were obtained among all tested IGR's.

INTRODUCTION

Insect growth regulators (IGR's) are a unique class of insecticides with selective effects on various life stags of some order of insects. Chitin synthesis inhibitors (CSIs) are group of IGR's that interfere with the formation of new cuticle, (Hoffmann and Lorenz 1998). CSIs, such inhibit the production of chitin, a major component of the insect exoskeleton. Insects treated with CSIs become unable to synthesize new cuticle, and therefore unable to successfully molt into the next stage. CSIs may be toxic to other arthropods, and IGR metabolites may have adverse effects on vertebrates due to their ability to bind to certain members of the nuclear hormone receptor family. Their comprehensive effects and high selectivity as well as lower toxicity to non-target animals and the environment provide new tools for integrated pest management (Huang, *et al.,* 2008). The cotton leafworm *Spodoptera littoralis* (Boisd.) has its importance as one of the destructive phytophagous lepidopterous pests in Egypt where it causes various ravages not only for cotton plants bout also for other field crops and vegetables (Hosny *et al.,* 1986). Ministry of Agriculture in Egypt doesn't recommend using conventional insecticide applications during the egg masses period so as to conserve the natural enemy populations, meanwhile using insect growth regulators is

considered as the possible alternative way for controlling the newly hatched larvae (Raslan, 2002).

The objective of this research was to evaluate ovicidal and larvicidal activity of three insect growth regulators, flufenoxuron, chlorfluazuron and lufenuron against the cotton leafworm *S. littoralis* (Boisd.) under laboratory and field conditions.

MATERIALS AND METHODS

I- Tested Insecticides:

The present work was conducted to study ovicidal and larvicidal activity of three IGR's against the cotton leafworm *S. littoralis* (Table 1).

Table1. Active ingredient and field recommended rate of tested IGR's.

Common name	Tread name	Chemical name	field rate
Flufenoxuron	Ageron 10%DC [a]	*N*–[[[4-[2-chloro-4-(trifluoromethyl)phenoxy]-2-fluorophenyl] amino] carbonyl]-2,6-difluorobenzamide	200 ml/fed.
Chlorfluazuron	Capris 5%DC [b]	N–[[[3,5-dichloro-4-[[3-chloro-5-(trifluoromethyl)-2-pyridinyl]oxy] phenyl] amino] carbonyl]-2,6-difluorobenzamide	400 ml/fed.
Lufenuron	Match 5%DC [c]	*N* –[[[2,5-dichloro-4-(1,1,2,3,3,3-hexafluoroethoxy) phenyl] amino] carbonyl]-2,6-difluorobenzamide	100 ml/fed.

[a, c] The National Company For Agrochemicals Production ,Agrochem Co., Egypt.
[b] Elhelb Pesticides & Chemicals Co., Egypt.

II- Laboratory experiments:

A- Cotton leafworm strain:

A laboratory strain of the cotton leafworm *S. littoralis* (Boisd.) was maintained under constant conditions of 25°C±1 and 70 ± 5% RH and kept of any contamination with chemicals till the time of study in order to obtain a susceptible and homogenous strain as described by El-Defrawi *et al.,* (1964).

B-Treatments:

1- Egg treatments:

The ovicidal effects of IGR's were tested against *S. littoralis* egg masses, aged 24,48 and 72 hrs old, which obtained from the mass- reared colony according to the method described by Abd El Aziz and Sharaby,1997. Different concentrations of the insecticide were prepared. Three replicates were tested for each concentration. For each concentration, piece of Tafla, *Nerium oleander* leaves with counted egg mass on it dipped for 30 seconds, and then the treated egg masses allowed drying and putting in Petri dish until

hatching. The control one was dipped in water and left to dry. However once the eggs in the control experiment had hatched out, the eggs in insecticide treatments was observed under binocular and the rate of unhatched was noted for each concentration. From which the corresponding concentration probit lines (LC-p lines) were computed in addition to determine 50 and 90% mortalities, in addition, the efficacy of different compounds was measured by comparing the tested compound with the most effective compound by using the following equation Toxicity index = LC_{50} of the most effective compound / LC_{50} of the tested compound x 100 (Sun, 1950).

The percent of hatchability and sterility was recorded after treatment *S. littoralis* egg masses, aged 24, 48 and 72 hrs old, with the field recommended rate of three tested IGR's.

2- Larval treatments:

A series of concentrations (in water) for each IGR was prepared on the active ingredient (a.i) based on ppm by diluting the commercial formulation. Castor-bean leaves were dipped for 30 seconds in each concentration then left to dry for one hour. The 2^{nd} and 4^{th} instars larvae were confined with treated leaves in glass jars covered with muslin for 48 hrs. Test also included a non treated control in which leaves were dipped in water (as a check). Treated leaves were then removed and fresh untreated leaves provided for three days. Four replicates (each of 10 larvae) were tested for each concentration. Daily inspection was carried out for all treatments and mortality percentages were recorded until the 4^{th} day after treatment. The average of mortality percentage was corrected using Abbott's formula (1925). The corrected mortality percentage of each compound was statistically computed according to Finney (1971). Fifty and ninety percent mortalities were estimated from LC-p lines; slope values of tested compounds were also estimated. Also, Toxicity index was measured by comparing the tested compound with the most effective compound (Sun, 1950).

III- Laboratory- field experiment:

With the purpose of evaluate the efficacy and residual effects of tested IGR's against the 2^{nd} and 4^{th} instars larvae of the cotton leafworm *S. littoralis* (Boisd.) under field condition of Aga district, Dakahlia Governorate in cotton field (Variety Giza 86). The area divided into four treatments, three of them treated with tested IGR's, while the 4^{th} treatment served as a control. Each treatment contain four replicates (42 m^2 each) were used / plot. Spraying was applied on 4^{th} of July during 2012 cotton season by using knapsack sprayer provided with one nozzle delivering (200 liters water / feddan). Samples of leaves were collected at random from each of treated and untreated plants. Samples were taken immediately after one hour of spraying and then after 24 hrs (First interval); at the fifth and the sixth day (Second interval) and at the tenth and eleventh day (Third interval) from application .The collected leaves were instantly transferred to the laboratory and introduced to each group larvae for each starved 2^{nd} and 4^{th} instars larvae in glass jars covered with muslin cloth, each jar contained ten larvae and five replicates. Treated leaves were then removed and fresh untreated leaves provided. Mortality

percentages were assessed treble, following treatment for 3, 6 and 9 days at each interval and corrected with the same previous technique.

IV- Field experiment:

Experiments were conducted at Aga district, Dakahlia Governorate during 2012 season to evaluate the field efficacy of three tested IGR's; flufenoxuron, chlorfluazuron and lufenuron with the recommended rate on the cotton leafworm *S. littoralis* (Boisd.). The field was cultivated with Giza 86 cotton variety and the normal agricultural practices were applied. The experimental area was divided into plots of 42 m^2 each and the treatments were arranged in randomized complete blocks with four replicates each. Plots were isolated from each other by unplanted corridors (1 m width) that separated replicates. A knapsack sprayer was used to spray the chemical dilutions. The volume of spray solution was 200 liters /feddan. The number of larvae of the cotton leafworm *S. littoralis* (Boisd.) was recorded on 25 plants at random from the inside rows of each plot before spray and often 3, 6 and 9 days and so the percent of reduction was calculated by using Henderson and Tilton (1955) equation.

V- Statistical analysis:

Data were calculated analyzed using analysis of variance technique (ANOVA) followed by Least Significant Difference (LSD). Probability of 0.05 or less was considered significant. All statistical analysis was done with CoHort Software 2004.

RESULTS AND DISCUSSION

I- Laboratory experiments:

A- Ovicidal activity of tested IGR's:

Data concerning the efficacy of tested IGR's indicate the important role played by age of eggs in determining the ovicidal activity against cotton leafworm *S. littoralis* eggs (Table 2). In general, data indicated the superior ovicidal activity of lufenuron on egg masses, aged 24, 48 and 72 hrs with LC_{50} values 71.3, 187.6 and 233.3 ppm, respectively. flufenoxuron showed moderate effect with LC_{50} values 208.1, 346.9 and 430.0 ppm, while chlorfluazuron was the least toxic gave 267.8, 540.1 and 660.7 ppm on egg masses, aged 24, 48 and 72 hrs, respectively.

Regarding the efficacy of tested IGR's on percentage of hatchability and Sterility of *S. littoralis* eggs, aged 24, 48 and 72 hrs, it is clearly obvious that the field recommended rate of the tested IGR's caused reduction in the percent of hatchability compared with check (Table 3). Data indicate the high effect of all tested IGR's on eggs aged 48 hrs followed by 24 and 72 hrs old, and flufenoxuron caused the high percent of Sterility on eggs aged 48 hrs reach 53.46%.

B- Larvicidal activity of tested IGR's:

The present data in Table (4) showed that Lufenuron proved to be the most effective IGR against 2^{nd} instar larvae of the laboratory strain of the cotton leafworm *S. littoralis* (Boisd.) followed by Chlorfluazuron and

Flufenoxuron, respectively, showing the LC_{50} values of 0.0007, 0.0016 and 0.002 ppm, respectively. However, LC_{90} reached 115.70, 73.04 and 121.49 ppm, respectively. The toxicity index were 43.75 and 35.00% for chlorfluazuron and flufenoxuron (Based on LC_{50} of lufenuron 100.0%), respectively.

In a different trend the efficacy of tested IGR's, flufenoxuron was the most effective IGR giving LC_{50} value of 16.38 ppm followed by lufenuron giving LC_{50} value of 27.48 ppm with toxicity index of 59.61%, while chlorfluazuron recorded the least toxic IGR it gave LC_{50} value of 60.41 ppm with toxicity index of 27.11 % against 4th instar larvae of *S. littoralis.* However, LC_{90} reached 3058.11, 9191.14 and 30877.24 ppm of previous tested IGR's, respectively.

II- Laboratory- field experiment:

The aim of this study was to assessment the initial and residual effects of tested IGR's against the 2nd and 4th instars larvae of the cotton leafworm *S. littoralis* (Boisd.) under field – laboratory condition. Data in Table (5) show that the percentage larval mortalities of flufenoxuron, chlorfluazuron and lufenuron were 73.7, 96.2 and 97.2% against 2nd instar and 68.6, 90.8 and 91.9% against 4th instar after three days from feeding on treated leaves at first interval, respectively. With extending feeding period for nine days flufenoxuron caused cumulative mortality 94.2 and 87.2%, while chlorfluazuron and lufenuron were more effective with mortality percentage of 100% after six days from feeding against the 2nd and 4th instars larvae.

The data declared that all tested IGR's gave the same trend of effect but with low level percent of mortalities at the second and the third intervals against the 2nd and 4th instars larvae. The general mean of cumulative mortality could be arranged in following order: lufenuron, chlorfluazuron and flufenoxuron with values of 100.0 & 88.8, 96.4 & 89.1 and 73.7 & 68.8 against the 2nd & 4th instars larvae, respectively. With regard to the aforementioned results, all tested IGR's provided higher mortality of second instar larvae than the fourth larval stages.

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III - Field efficacy of the tested IGR's

All treatments significant reduced the population density of the cotton leafworm, *S. littoralis* compared with control (Table 6). Concerning the initial effect (after three days of spraying), chlorfluazuron and lufenuron were most striking, which was causing 95.21 and 90.44% reduction, respectively. While the lowest obtained with flufenoxuron which caused 64.91% reduction in population density than control. At ninth day, no significant differences were obtained among all tested IGR's.

The efficacy of the tested IGR's could be arranged according to the general mean of reduction percentage in a descending order as follows: chlorfluazuron, lufenuron and flufenoxuron they were 97.37, 85.19 and 79.97%, respectively.

Table 5: Accumulated corrected mortality on 2nd and 4th instar larvae of the cotton leafworm, *S. littoralis* fed on cotton leaves after treated with tested IGR's at indicated time intervals.

Treatments	Corrected percent larval mortality at three time intervals									General mean of cumulative
	First interval			Second interval			Third interval			
	3 days	6 days	9 days	3 days	6 days	9 days	3 days	6 days	9 days	
2nd instar larvae										
Flufenoxuron	73.7	89.9	94.2	42.8	53.4	74.3	34.8	36.5	52.8	73.7
Chlorfluazuron	96.2	100.0	-	73.4	94.8	98.2	71.2	78.2	91.0	96.4
Lufenuron	97.2	100.0	-	88.6	100.0	-	78.5	84.7	100.0	100.0
4th instar larvae										
Flufenoxuron	68.6	82.3	87.2	32.3	34.5	61.7	20.3	46.2	57.5	68.8
Chlorfluazuron	90.8	100.0	-	74.8	86.5	93.0	36.3	62.9	74.2	89.1
Lufenuron	91.9	100.0	-	87.5	100.0	-	22.1	59.6	66.4	88.8

Table 6: Field efficacy of the tested IGR's against the cotton leafworm, *S. littoralis*.

Treatments	Before spraying	Mean number and reduction percentage after spraying						General mean	
		3 days*		6 days		9 days			
		N	R%	N	R%	N	R%	N	R%
Flufenoxuron	324.00 ^{B}	8.50 ^{B}	64.91 ^{b}	2.25 ^{B}	82.51 ^{b}	0.75 ^{B}	92.48 ^{a}	3.83 ^{B}	79.97 ^{b}
Chlorfluazuron	729.75 ^{A}	3.75 ^{B}	95.21 ^{a}	0.75 ^{B}	98.17 ^{a}	0.25 ^{B}	98.75 ^{a}	1.58 ^{B}	97.37 ^{a}
Lufenuron	457.50 ^{AB}	3.00 ^{B}	90.44 ^{a}	2.50 ^{B}	83.88 ^{b}	1.25 ^{B}	81.25 ^{a}	0.75 ^{B}	85.19 ^{b}
Check	627.00 ^{AB}	61.25 ^{A}		24.75 ^{A}		13.50 ^{A}		33.17 ^{A}	
LSD 0.05	310.99	16.71	19.03	6.13	12.38	3.92	25.04	8.12	12.00

(*) initial effects

The present results agree with Abdel-Aal and Abdel wahab (2007) found that one or two days old eggs were affected than that of three days old in case of lufenuron. It is of interest to note that after treating eggs of different ages with lufenuron, normal development of the embryo took place and the failure of the egg hatch could be explained by the known mode of action of the chitin synthesis inhibitors, where the chitin synthesis was blocked and the larvae probably cannot use its muscles to free itself from the egg wall (Watson *et al.,* 1986). Also, Saenz de Cabezon *et al*. (2006) found that the chitin synthesis inhibitor lufenuron was highly active against *Lobesia botrana*

eggs with greater effect on 1-day old eggs than on the other ages. Abdel-Megeed *et al.* (2009) found that the newly laid eggs proved to be more sensitive than older ones when they studied the activity of two nonsteriodal ecdysone agonists against the cotton leafworm, *S. littoralis* (Boisd). Sallam (1999) indicated that ovicidal activity of the tested 1GR, flufenoxuron in eggs deposited by *S. littorals* that outcome from treating 2nd or 4th instar larvae could be due to disturbance in cuticle formation of the embryo, developed embryos were enabled to perforate the surrounding vitelline membrane, it could be due to a weakened chitinous mouth parts that was insufficiently rigid to affect hatching. Kandil *et al.* (2012) reported that the percentage of hatchability of treated eggs of *Pectinophora gossypiella*, were 49.6, 51.0 and 53.0 for lufenuron, chlorfluazuron and chromafenozide, respectively oppose to 97% in untreated control. Also, the incubation period of *P. gossypiella* eggs when treated by lufenuron and chromafenozide nearly require 2 times long with low hatchability % than control. Zidan *et al.* (2013) tested six insect growth inhibitors (IGIs) and regulators (IGR's) were tested in the laboratory for their curative and preventive ovicidal properties on the cotton leaf worm, *S. littoralis* (Boisd.). Both emamectin benzoate and chlorpyrifos exhibited remarkably high curative ovicidal effectiveness against *S.littoralis* 24 hrs old eggs whereas each of the IGIs lufenuron and chlorfluazuron recorded moderate curative ovicidal activity. Likeswise, each of emamectin benzoate ,lufenuron and profenfos acts a excellent preventive ovicidal products with an LC_{50} of 0.23, 1.47 and 1.6 ppm, respectively.

The efficacy of different tested compounds against the 2nd and 4th instars larvae of the cotton leafworm *S. littoralis* (Boisd.) varied tremendously according to theinstar of larvae and the chemical structure of the tested IGR's, Also chlorfluazuron and lufenuron were recorded high toxic to 2nd instar larvae of the field strain of *S. littoralis* followed by flufenoxuron (Anwar and Abd El-Mageed, 2005).

Generally in this study, 2nd instar larvae was more sensitive to the three tested IGR's than 4th instar larvae of *S. littoralis*, moreover the effect at the end of the nine day from treatment (feeding period for 48 hrs on treated leaves and seven days on untreated leaves) was remarkably higher compared with the effect at the third day from treatment (feeding period for 48 hrs on treated leaves). Bayoumi *et al.* (1998) found that that 3rd instar was more sensitive to chlorfluazuron and flufenoxuron, compared with 5th instar of *S. littoralis*, regardless of the strain used. Percentage accumulative mortality varied according to the compound, concentration, larval instar and/or strain studied. El-Ghareeb (1988) found that the LC_{50} for chlorfluazuron for 3rd instar larvae of *S. littoralis* fed on treated leaves was 0.0085 ppm and toxicity decreased with larval age. El-Ghareeb (1992) found that chlorfluazuorn was more toxic than diflubenzuron against 3rd and 5th instars larvae of *S. littoralis* in the laboratory. The enhanced toxicity of flufenoxuron to *S. littoralis* compared with diflubenzuron can probably be attributed to its slower metabolism and reduced excretion (Clarke and Jewess 1990). In this respect, the high potency of chlorfluazuron against *S. littoralis* and various insects, together with its low toxicity to man and the environment, renders this

compound a potential control agent for important agricultural pests (Ishaaya *et al.,* 1986).

Lufenuron required less time at lower concentration as compared to the other insecticides of this group tested. Although a high level of resistance has been observed against the lufenuron (Sudhakaran 2002) yet it has proved as an effective insecticide against *S. littoralis* (Boisd.). Bakr *et al.* (2013) found that lufenuron was the more toxic against 2nd larval instars at sub-lethal concentrations LC_{25} and LC_{50} (0.3 and 0.6 ppm, respectively) than tebufenozide (1.1 and 1.5 ppm, respectively). But LC_{90} level was the same in the two IGR's. With respect to 4th larval instar, lufenuron induced the higher toxic effect at all sub lethal doses than tebufenozide. Sammour *et al.* (2008) found that *S. littoralis* adults obtained from exposing 5th instar larvae to chlorfluazuron and leufenuron treatments resulted in a very low percentage of fecundity which ranged between (33.3 to 53.4%). They added that egg hatchability was also significantly reduced; it ranged between (44.5 to 61.7%) for chlorfluazuron and (59.7 to 73%) for lufenuron compared to (94.7%) for control.

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التأثير الإبادى لثلاث مبيدات تتبع منظمات النمو الحشرى ضد بيض ويرقات دودة ورق القطن

ليلى رجب على الجوهرى
قسم المبيدات - كلية الزراعة - جامعة المنصورة- مصر

أجرى هذا البحث بهدف دراسة التأثير الابادى لثلاث مبيدات تتبع منظمات النمو الحشرى وهى فلوفينوكسيرون، كلورفلوزيرون و ليفينيورون ضد بيض ويرقات دودة ورق القطن. اشارت النتائج الى الدور الهام الذى يلعبه عمر البيض المعامل فى تحديد النشاط الابادى على البيض. وقد سجل مركب ليفينيورون أعلى كفاءة على البيض يليه فلوفينوكسيرون ثم كلورفلوزيرون. اشارت النتائج ايضا الى ان معدل التطبيق الحقلى لجميع المركبات المختبرة قد سببت خفض فى نسبة فقس البيض مقارنة بتجربة الكنترول. اشارت النتائج أيضاً أن التأثير الإبادى للمركبات المختبرة على العمر اليرقى الثانى والرابع لدودة ورق القطن أن مركب ليفينيورون قد أعطى أعلى سمية على العمر اليرقى الثانى فى حين سجل مركب فلوفينوكسيرون أعلى درجة سمية على العمر اليرقى الرابع وذلك وفقاً لدليل السمية. ويمكن ترتيب المركبات المختبرة تبعاً لكفائتها فى التجربة المعملية الحقلية كالتالى: ليفينيورون ، كلورفلوزيرون ثم فلوفينوكسيرون. وقد سجل كلا من كلورفلوزيرون و ليفينيورون أعلى نسبة خفض فى تعداد يرقات دودة ورق القطن حقلياً موسم 2012 بنسبة 95.21 و 90.44 % على الترتيب بينما سجل مركب فلوفينوكسيرون أقل نسبة خفض 64.91% وذلك بعد 3 أيام من الرش ، ولم يلاحظ اى فروق معنوية بين المركبات الثلاثة المختبرة عند اليوم التاسع من الرش.

قام بتحكيم البحث

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Table 2: Toxicity of three tested IGR's on cotton leafworm, *S. littoralis* eggs.

Treatments	24 hrs old						48 hrs old						72 hrs old					
	LC_{50}(ppm) its limits at 95%		LC_{90}(ppm) its limits at 95%		Slope	Toxicity index(%)	LC_{50}(ppm) its limits at 95%		LC_{90}(ppm) its limits at 95%		Slope	Toxicity index(%)	LC_{50} (ppm) its limits at 95%		LC_{90}(ppm) its limits at 95%		Slope	Toxicity index(%)
Flufenoxuron	208.1		5077E+4		0.24 ± 0.05	34.3	346.9		6844E+4		0.24 ± 0.05	54.1	430.0		5237E+3		0.31 ± 0.04	54.3
	43.5	4934.9	361127.8	1450E+10			100.0	1203.3	1973E+4	2374E+5			146.0	2207.3	326412.7	4712E+5		
Chlorfluazuron	267.8		1521998.1		0.34 ± 0.04	26.6	540.1		1484E+5		0.24 ± 0.05	34.7	660.7		245559.8		0.50 ± 0.05	35.3
	97.4	736.4	553453.8	4185494.8			133.1	2192.8	3657E+4	6028E+5			373.3	51960.5	148008.4	4762E+5		
Lufenuron	71.3		945.5		1.14 ± 0.09	100.0	187.6		4299.8		0.94 ± 0.07	100.0	233.3		36590.7		0.58 ± 0.05	100.0
	56.1	91.6	604.4	1717.1			76.1	764.0	3705.7	74569.3			157.7	345.3	24723.5	54154.3		

Table 3: Direct effect of three tested IGR's at concentrate equivalent the field recommended rate on hatchability and sterility of cotton leafworm, *S. littoralis* eggs

Treatments	Conc. (ppm)	24 hrs old				48 hrs old				72 hrs old			
		Mean number of Eggs	Mean Eggs Hatched	Mean % Hatchability	% Sterility	Mean number of Eggs	Mean Eggs Hatched	Mean % Hatchability	% Sterility	Mean number of Eggs	Mean Eggs Hatched	Mean % Hatchability	% Sterility
Flufenoxuron	100	37.33	25.67	68.60 [a]	20.91	39.33	16.00	38.89 [b]	53.46	56.67	41.00	72.35 [a]	14.22
Chlorfluazuron	100	28.33	19.67	72.53 [a]	16.38	60.00	37.33	63.07 [ab]	24.53	55.67	39.33	70.65 [a]	16.23
Lufenuron	25	46.33	29.67	67.57 [a]	22.10	52.00	31.33	52.59 [ab]	37.07	58.67	38.67	65.91 [a]	21.85
Check	00	35.33	30.67	86.74 [a]	00	47.00	39.33	83.57 [a]	00	72.33	61.00	84.34 [a]	00
LSD 0.05				21.02				32.14				26.04	

% Sterility = (1- The mean % hatchability of eggs treated with tested IGR/ The mean % hatchability of eggs in Check) x 100

Table 4: Susceptibility of 2nd and 4th instars larvae of the laboratory strain of cotton leafworm, *S. littoralis* to tested IGR's.

Treatments	2nd instar larvae						4th instar larvae					
	LC_{50}(ppm) its limits at 95%		LC_{90}(ppm) its limits at 95%		Slope	Toxicity Index (%)	LC_{50} (ppm) its limits at 95%		LC_{90}(ppm) its limits at 95%		Slope	Toxicity Index (%)
Flufenoxuron	0.002		121.49		0.268	35.00	16.38		3058.11		0.528	100.00
	0.0001	0.017	5.78	111838.6	± 0.059		0.55	70.57	1724.98	924896.02	± 0.065	
Chlorfluazuron	0.0016		73.04		0.2743	43.75	60.41		30877.24		0.473	27.11
	0.0001	0.0183	6.37	835.92	± 0.086		22.21	164.31	11351.93	83986.11	± 0.069	
Lufenuron	0.0007		115.70		0.245	100.00	27.48		9191.14		0.508	59.61
	0.000003	0.012	3.83	331058.87	± 0.060		10.83	69.73	3621.41	23327.12	± 0.068	

Toxicity index = LC_{50} of the most effective compound / LC_{50} of the tested compound x 100