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EFFICACY OF SOME INSECT GROWTH REGULATORS AGAINST LARVAE OF THE COTTON LEAFWORM *Spodoptera littoralis* (BOISD)

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ABSTRACT

The efficacy of insect growth regulators; chromafenozide (Virtu) 80% WP, and 5% SC, methoxyfenozide (Runner) 24% SC and chlorfluazuron (Atabron) 5% EC against the cotton leafworm larvae was studied. The toxicity of the three tested insecticides against the 4th larval instar is arranged as follows according to LC_{50} values chlorfluazuron, chromafenozide and methoxyfenozide.

Evaluation of the tested IGRs in lab-field experiment had initial toxicity of 100% mortality for both the 2nd and the 4th instar in the 1st period. Their mean residual effect against the 2nd instar was 70, 67.7, 65.7 and 62.7% for methoxyfenozide, chromafenozide 5% SC, 80% WP and chlorfluazuron 5% EC, respectively. The same order was obtained against the 4th instar with 83.3, 81.7, 80 and 78%. Studying the efficacy of the tested insecticides under the field conditions showed that the number of larval instars was reduced in all treatments. The results confirm the high efficacy of the IGRs to high infestation with *S. littoralis* on cotton plants. The tested insecticides can be statistically classified descendingly as follows: chromafenozide 80% WP; methoxyfenozide 24% SC; chlorfluazuron 5% EC and chromafenozide 5% SC against the 4th larval instar. According to food consumption study the means of consumption index (C.I.) for the 5th larval instar significantly decreased below that of control check in all treatments and were arranged in descending order as follows: chromafenozide 80% WP, chlorfluazuron 5% EC, chromafenozide 5% SC and methoxyfenozide 24% SC. The same trend was found with the 6th larval instar of *S. littoralis*. Comparisons based on the

overall mean during the whole experimental periods indicate significant reduction in growth rate compared with the control.

Key words: *cotton leafworm,efficacy, food consumption, growth rate, insect growth regulators*

1. INTRODUCTION

Cotton leafworm is one of the most important economic pests on cotton and vegetable crops. The intensive use of conventional pesticides caused some side effects such as pest resistance, pest resurgence and outbreak of secondary pests. The needs for specific compounds against economic insects are becoming more and more important. In this respect, recent chemical groups with different mode of action such as insect growth regulators (IGRs) were introduced. IGRs are new tools for controlling of pest population since they act during the sensitive periods of insect development, causing morphological abnormalities and physiological disorders, as well as death of the treated insects.

The juvenoids belonging to phenylthiourea group (Benzoyl urea), juvenile hormone analogues (JHA) or mimics (JHM) are used as successful alternative compounds for pest control (Radwan and Rizk, 1975, Abo Elghar *et al.*, 1978) and are known to affect the metabolic processes of ingested food (Radwan *et al.*, 1986).

Wing *et al.*, (1988) and Wing and Aller (1989) proved that the insecticidal active members of diacylhydrazines (tebufenozide and methoxyfenozide) functioned as agonists or mimics of the insect molting hormone, 20-hydroxyecdysone (20E). Methoxyfenozide is the latest commercially developed compound in this class commercially and is the most potent analogue against lepidoptera larvae (Ishaaya *et al.*, 1995; Le *et al.*, 1996; Trisyono and Chippendale 1997 and Smagghe *et al.*, 1999).

Benzylphenyl urea act on insects of various orders by inhibiting chitin formation, thereby causing abnormal endocuticular deposition and abortive molting. Studies of the mode of action of chlorfluazuron (atabron) revealed that the compound alters cuticle composition especially that of chitin, thereby affecting the elasticity and firmness of the endocuticle. The reduced level of chitin in the cuticle seems to result from the inhibition of biochemical processes leading to chitin formation (Ishaaya 1990). Slansky and Scriber (1985) indicated that the amount of food consumed by a larvae influences its performance, growth rate, developmental time, final body weight and survival.

The purpose of this study was to evaluate 1- the efficacy of two members of the diacylhydrazines: methoxyfenozide (Runner 24% SC) and chromafenozide at two formulations (Virtu, 5% SC and 80% WP) in addition to chlorfluazuron (Atabron 5% EC) which is a member of the benzoyl urea against the second and the fourth larval instars of cotton leafworm (laboratory and field strains) in laboratory and field. 2- estimate the residual effect of the tested insecticides on food consumption and growth rate.

2. MATERIALS AND METHODS

Used IGRs

1-Chromafenozide (virtu 5% SC and 80% WP): 3, 4-dihydro-5-methyl-2*H*-1-benzopyran-6-carboxylic acid 2-(3,5-dimethylbenzoyl)-2-(1,1-dimethylethyl) hydrazide. Virtu 5% SC and virtu 80% WP were tested at recommended rate (400 ml and 25 g/fed.).

2- Methoxyfenozide (runner 24% SC at 150 ml/fed.): 3-methoxy-2-methylbenzoic acid 2-(3,5-dimethylbenzoyl)-2-(1,1-dimethylethyl) hydrazide.

3- Chlorfluazuron (atabron 5% EC at 400 ml/fed.): *N* [[[3, 5-dichloro-4- [[3-chlor-5- (trifluromethyl)-2-pyridinyl] oxy] phenyl] amino] carbonyl]-2,6-difluorobenzamide.

Leaf dipping technique

A laboratory strain of *S. littoralis* was reared under laboratory conditions at 25°C±2 and 75±5% RH for several generations as described by EL-Defrawi *et al*., (1964). Cotton leaves were dipped into the insecticide solution for 10 seconds, then left to dry. Five replicates with 10 larvae of the 4th instar per replicate. The larvae were allowed to feed on treated fresh leaves for 48 hours, then on untreated fresh leaves for the 72 hours. The percentage mortality was recorded in the fifth day and corrected by Abbott's formula (1925). The data were then subjected to probit analysis to calculate the regression equations, slope of regression lines and LC_{50} and LC_{90} of the tested IGRs.

Field –lab. test

The experiment was carried out in the farm of Faculty of Agriculture, Cairo University. The experimental area was divided according to the complete randomized block design including four replicates (6X7 cm^2) for each treatment. The tested insecticides; virtu 5% SC and 80% WP, runner 24% SC and atabron 5% EC were used

at their recommended rates; 400 ml, 25 gm, 150 ml and 200 ml/fed., respectively. A CP-3 knapsack sprayer was used in applying the insecticides as foliar treatment.

The tested field strain was collected as egg-masses from El-Fayum Governorate and reared for one generation under laboratory conditions. Two treated leaves were put in each jar with twenty 2nd or 4th larval instar. Five replicates were used for each treatment and each instar. The larvae were allowed to feed on the treated leaves for 2 days and then for 3 days on untreated leaves. The treated leaf samples were collected randomly at four intervals at 0- 1, 7- 8, 14-15 and 21-22 days after spraying, respectively. Alive and dead larvae of *S. littoralis* were recorded after 5 days in each period. An untreated check was included in the test by feeding designated larvae on untreated leaves.

Field test

This experiment was conducted at El-Fayum Governorate under field conditions to evaluate the tested insect growth regulator compounds; chromafenozide 5% SC and 80% WP, methoxyfenozide 24% SC and chlorfluazuron 5% EC against *S. littoralis* on cotton. They were applied at their recommended rates; 400 ml, 25 gm, 150 ml and 400 ml /fed., respectively.

The experimental area was divided according to the complete randomized block design including four replicates for each treatment. The area of each replicate was one kirate (175 m^2). A back motor sprayer was used in applying the insecticides as foliage treatment. The tested insecticides were sprayed at the beginning of August after attacking the second aggressive generation of *S. littoralis* cotton plants.

Cotton was kept under observation until the number of egg batch increased. All of egg batches were collected from experimental area and burned. Then, the new egg batches were left off on cotton plant leaves for about seven days to obtain newly hatched and young larvae of *S. littoralis*. Ten selected cotton plants for each replicate were marked and the young larval stage (1st, 2nd and 3rd instars) were counted early in the morning on such plants before spraying and throughout the experimental period at 3, 5, 7 and 9 days after spraying. New egg batches were collected and burned every day after spraying. Efficacy of the treatments was determined on the basis of the percentage reduction in the number of young larval stages of *S. littoralis* according to Henderson and Tilton formula (1955).

Estimation of biological activity

Three experiments were conducted in the laboratory to evaluate the effect of the tested insecticides on different biological aspects of the fourth, fifth and sixth larval instars of cotton leafworm. The previously mentioned method was also applied in this test by using newly ecdysed 4^{th}, 5^{th} and 6^{th} larvae after 3 h. of starvation. Every day, the larvae were weighed before and after feeding. Also, fresh leaves were weighed before and after feeding.

Feeding rate, which is the amount of food consumed during the feeding period of each instar, was expressed as day per larvae. These parameters were calculated according to the equations described by Waldbauer (1968).

Consumption index (CI) = C/ (T) X (A)

Growth rate (GR) = G/ (T) X (A)

Where:

C= Fresh weight of consumed leaves

T= Duration of feeding period

A= Mean fresh weight of the larva during the feeding period

G= Fresh weight gain of the larvae.

Data were subjected to analysis of variance (ANOVA) and means were separated by Duncan multiple range test (Duncan, 1955).

3. RESULTS AND DISCUSSION

3.1. Toxicity of the tested insecticides to the laboratory strain of *S. littoralis*

The results in Table (1) show the efficiency of the tested insecticides; chlorfluazuron, chromafenozide and methoxyfenozide against the fourth larval instar of *S. littoralis*. The candidate insecticides were arranged according to LC_{50} values in the following descending order; chlorfluazuron, chromafenozide and methoxyfenozide. Chlorfluazuron which, belongs to benzoylurea group was more effective than the other two tested compounds, which belong to diacylhydrazines (chromafenozide and methoxyfenozide). In contrary, according to LC_{90} value methoxyfenozide was the most effective insecticide followed by chlorfluazuron and then chromafenozide. Concerning the slope values of the toxicity lines, methoxyfenozide showed the steepest toxicity line with slope value 4.33 followed by chromafenozide (2.25) and chlorfluazuron (1.87).

Table (1): Comparative toxicity of the tested IGRs to the 4th larval instar of *S. littoralis*.

Insecticide	LC_{50} (ppm)	Lower limit	Upper limit	LC_{90} (ppm)	Slope	Toxicity Index	Folds
Chlorfluazuron	2.05	---	----	9.96	1.87	100.0	1.79
Chromafenozide	3.00	2.59	3.57	11.15	2.25	68.4	1.22
Methoxyfenozide	3.66	3.34	4.04	7.24	4.33	56.0	1.00

3.2. Efficacy of the tested insecticides against the cotton leafworm *S. littoralis* larvae .

Evaluation of the tested insecticides chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC was carried out in lab-field test. Results are set out in Table (2). Generally, the percentage mortality of the second and the fourth larval instars of *S. littoralis* was 100% in the first and second periods using all tested insecticides. The percentage mortalities of the second larval instar after five days in the third period were 81, 85, 84 and 68% by using chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC, respectively. The corresponding values for the fourth larval instar were 92, 88, 90 and 80%, respectively. The percentage mortalities of the second larval instar after 5 days in the fourth period were 20, 18, 26 and 26% by using chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC, respectively. The corresponding values for the fourth larval instar were 48, 57, 60 and 54%, respectively.

The means of residual effect of chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC on the second larval instar at the 2nd, 3rd and 4th intervals were 65.7, 67.7, 70.0 and 62.7%, respectively. The corresponding values on the fourth larval instar were 80.0, 81.7, 83.3 and 78.0%, respectively. It is evident from the data that there are no differences between the recommended insecticides; chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC and the new formulation of chromafenozide (80% WP) in their efficacy against the second and the fourth larval instars of *S. littoralis*. It may be due to the amount of active ingredients that reached cotton plant were the same (20 g) except for methoxyfenozide, which was 36g.

3.3. Efficacy of the tested insecticides against *S. littoralis*

Fie'd experiment was conducted to evaluate the tested IGRs compounds; chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24 % SC and chlorfluazuron 5% EC against cotton

Table (2): Initial and residual effect of the tested insect growth regulators on the second and fourth larval instars of *S. littoralis* at indicated post treatment intervals.

Insecticide	Rate/ fed.	Initial effect		Residual effect							
		1st period		2nd period		3rd period		4th period		Mean	
		2nd	4th	2nd	4th	2nd	4th	2nd	4th	2nd	4th
Chromafenozide 80% WP	25 g	100	100	96	100	81	92	20	48	65.7	80.0
Chromafenozide 5% SC	400 ml	100	100	100	100	85	88	18	57	67.7	81.7
Methoxyfenozide24% SC	150 ml	100	100	100	100	84	90	26	60	70.0	83.3
Chlorfluazuron 5% EC	400 ml	100	100	94	100	68	80	26	54	62.7	78.0

Table (3): Percent reduction in infestation of *S. littoralis* after spraying the cotton plants with IGRs during 2005 cotton season.

Insecticide	Rate/ fed.	% Reduction in infestation at indicated days				Residual effect	Total mean
		3 (Initial kill)	5	7	9		
Chromafenozide 80% WP	25 g	83.0	84.8	92.0	94.1	90.3	88.5
Chromafenozide 5% SC	400 ml	83.5	92.6	98.1	99.5	96.7	93.4
Methoxyfenozide 24% SC	150 ml	83.6	92.4	97.1	99.2	96.3	93.1
Chlorfluazuron 5% EC	400 ml	84.5	93.5	99.3	100.0	97.6	94.3

leafworm on cotton plants. The tested compounds did not show any phytotoxic symptoms on cotton plants when applied at the tested rates. The IGRs application started when the number of larval instars ranged between 25.2 and 30.4 larvae per plant. The efficacy of the tested insecticides against larval instars of *S. littoralis* was estimated after 3, 5, 7 and 9 days post application. Results indicated that there were differences between the control and the IGR treatments and also slight differences occurred between the tested insecticides. Evaluation data after three days of spraying (initial kill) showed that the number of alive larval instars was reduced in all treatments at different rates according to the insecticide used.

The efficacy of tested IGRs was expressed as a percentage reduction in alive larval instars of *S. littoralis* after 3, 5, 7 and 9 days of spraying, which were 83.0, 83.5, 83.6 and 84.5 using chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC, respectively. The corresponding values after 5 days of application were 84.8, 92.6, 92.4 and 93.50%, respectively. Also, they were 92.0, 98.10, 97.1 and 99.3%, respectively after 7 days of application. The residual and general effect values indicated that there were no differences in the efficacy of the tested compounds against the cotton leaf worm on cotton plants under field conditions. Also, there was no difference in the efficacy of the two formulations (WP and SC) of chromafenozide against cotton leaf worm. The results confirm that IGRs gave excellent control to the high infestation of *S. littoralis* larvae on cotton.

3.4. Effect of IGRs on food consumption

Consumption index (C.I.) is one of the feeding activity parameters. The results of food consumption of the three tested larval instars (4^{th}, 5^{th} and 6^{th}) of *S. littoralis* after feeding on leaves treated with the tested compounds are presented in Tables (4, 5 and 6). Comparing the results of the four compounds against the 4^{th} larval instar in Table (4) showed that there is a significant difference in C.I. between the untreated check and the treatments. In each of the four tested intervals there were also differences between the compounds. The results revealed that in the first interval significant difference between all of the tested compounds and the untreated check. Although chromafenozide 80% WP and chromafenozide 5% SC had the same active ingredient and also the amount of a.i but there were significant difference between the two different formulations in consumption index in the first period. On the contrary, there is no significant difference between them in the second period. Three tested

compounds had significant difference in between and differed also from the control in the second period.

In the third interval, the consumption indeces of chromafenozide 5% SC and chlorfluazuron 5% EC differed significantly and they were more than those in untreated check. Methoxyfenozide 24% SC treatment had no significant difference than check, while chromafenozide 80% WP differed significantly than all the treatments and also the check. The results of the last interval (fourth) indicated that there was no significant difference between the treatments of chromafenozide 5% SC and methoxyfenozide 24% SC in C.I. and both were more than the check. It is evident from the results of the fourth interval that there were slight differences between the treatments and the check in consumption index. The mean of C.I. for the tested IGRs through all periods indicated that the treatments were lower than those in the check. They can be statistically classified descendingly according to their exhibiting the consumption to chromafenozide 80% WP, methoxyfenozide 24% SC, chlorfluazuron 5% EC and then chromafenozide 5% SC.

All of the tested compounds differed than the untreated check in their effect on food consumption of the 5th larval instar of *S. littoralis* (Table 5). It was clearly found that the consumption index of 5th larval instar significantly decreased below that of the untreated check in all treatments. In the second period, the data revealed a similar trend of the effect of tested IGRs on the food consumed with high decrease in C.I. by using chromafenozide 80% WP. No significant difference in the food consumption could be detected between the untreated check and chlorfluazuron 5% EC in the third interval. It was also found that the mean values of C.I for the tested IGR through all periods indicated that the treatments were lower than those of check and could be arranged descendingly as chromafenozide 80% WP, chlorfluazuron 5% EC, chromafenozide 5% SC and methoxyfenozide 24% SC.

The same trend of efficacy of the tested insecticides on the food consumption of the fourth and fifth larval instars was also found in the sixth larval instar of *S. littoralis* (Table 6). All intervals showed that the C.I. means were 0.73, 0.65, 0.49 and 0.68 for chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24% Sc and chlorfluazuron 5% EC, respectively, compared to 1.09 in the check. Accordingly, the present data confirmed that feeding the different larval instars on leaves treated with IGR compounds resulted in the reduction in food consumption.

Table (4): Food consumption (C.I.) for the 4th instar larvae of *S. littoralis* after feeding for 48 hours on cotton leaves treated with the tested IGRs.

Insecticide	Rate/fed.	Mean C.I. values at the indicated testing intervals								Mean
		1st interval 0-1 day		2nd interval 7-8 day		3rd interval 14-15 day		4th interval 21-22 day		
		C.I.	Change %	C.I.	Change %	C.I.	Change %	C.I.	Change %	
Chromafenozide 80% WP	25 g	8.90^{d}	43.67	22.38^{b}	11.72	9.73^{d}	22.47	8.27^{bc}	1.54	12. 32^{c}
Chromafenozide 5% SC	400 ml	11.76^{bc}	25.57	23.50^{b}	7.30	15.95^{a}	-27.09	9.50^{a}	-13.10	15.18^{a}
Methoxyfenozide 24% SC	150 ml	13.56^{b}	14.18	16.22^{d}	36.02	11.85^{c}	5.58	9.88^{a}	-17.62	12.88^{bc}
Chlorfluazuron 5% EC	400 ml	12.62^{b}	20.13	19.58^{c}	22.76	14.38^{b}	-14.58	7.52^{d}	10.48	13. 53^{b}
Control	---	15.8^{a}	---	25.35^{a}	---	12.55^{c}	---	8.40^{b}	---	15.53^{a}
L.S.D.	---	1.95	---	1.58	---	1.02	---	0.72	---	0.75

Table (5): Food consumption (C.I.) for the 5th instar larvae of *S. littoralis* after feeding for 48 hours on cotton leaves treated with the tested IGRs.

Insecticide	Rate/fed	Mean C.I. values at the indicated testing intervals								Mean
		1st interval 0-1 day		2nd interval 7-8 day		3rd interval 14-15 day		4th interval 21-22 day		
		C.I.	Change %	C.I.	Change %	C.I.	Change %	C.I.	Change %	
Chromafenozide 80% WP	25 g	2.97^{b}	24.81	2.38^{e}	56.01	3.02^{d}	54.17	2.70^{ab}	11.77	2.77^{d}
Chromafenozide 5% SC	400 ml	1.46^{d}	63.04	5.20^{ab}	3.88	5.69^{b}	13.66	2.15^{b}	29.74	3.63^{c}
Methoxyfenozide 24% SC	150 ml	2.29^{bc}	42.03	4.63^{bc}	14.42	6.80^{c}	-3.19	2.17^{b}	29.09	3.97^{b}
Chlorfluazuron 5% EC	400 ml	1.03^{d}	73.92	4.5^{c}	16.82	5.27^{b}	20.03	2.83^{a}	7.52	3.41^{c}
Control	---	3.95^{a}	---	5.41^{a}	---	6.59^{a}	---	3.06^{a}	---	4.75^{a}
L.S.D.	---	0.72	---	0.60	---	0.69	---	0.59	---	0.29

3.5.Effect of IGRs on growth rate of *S. littoralis* larvae

The effect of the tested compounds on the growth rate (GR) of 4th, 5th, and 6th larval instars of *S. littoralis* after feeding on treated cotton leaves are set out in Tables 7, 8 and 9, respectively. Generally, it was found that the growth rates of the different larval instars increased gradually from the first interval up to the fourth interval. The percentage reduction in G.R. of the fourth larval instar in the treatments was high at the first interval and ranged between 75.96 and 100%. On the contrary, it was low in the fourth interval and ranged between12.3 and 29.62%. The mean of G.R. through the experimental intervals indicated that there were great differences between the treatments and the control. They were 0.192, 0.212, 0.006 and 0.057 in the treatments of virtu 80% WP, virtu 5% SC, runner 24% SC and atabron 5% EC compared to 0.493 in the check treatment.

Also, it was found that the tested IGRs were able to suppress the growth rate of the fifth and the sixth larval instars to different degrees in comparison to that of the untreated control. The suppression of G.R. greatly varied according to the time elapsed after spraying. The same results obtained by the fourth larval instar were obtained for the fifth and sixth larval instars. The mean of G.R. of the fifth larval instar during the whole experimental intervals were -0.04, 0.005,-0.095 and 0.088 for chromafenozide 80% WP, chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC compared to 0.253 in the check treatment (Table 8). The corresponding values for the sixth larval instars were 0.033, 0.050, 0.033 and 0.013, respectively, compared to 0.253 for the untreated control.

Parallel to the development of benzoylphenylureas chlorfluazuron (Atabron), several other IGRs of agricultural importance have been developed such as chromafenozide (Virtu) and methoxyfenozide (Runner), which represent diacylhydrazine (ecdysteroid agonist). During the last fifteen years a new class of (IGRs) emergd from the discovery that substituted dibenzoylhydrazines act as agonists of 20 – hydroxyecdysone (Wing 1988;Wing *et al.*, 1988). The sentinel member of this chemical class was discovered in 1983 (Hsu 1991). An analogue, tebufenozide, proved to be extremely potent against and selective toward the Lepidoptera larvae (Carlson *et al.*, 1994; Dhadialla *et al.*, 1998) and is now widely used against these pests on several crops throughout the world.

Methoxyfenozide is the latest compound in this class to be developed commercially and is the most potent analogue (Ishaaya *et al.*, 1995; Trisyono and Chippendale 1997; Smagghe *et al.*, 1998b,

Table (6): Food consumption (C.I.) for the 6th instar larvae of *S. littoralis* after feeding for 48 hours on cotton leaves treated with the tested IGRs.

Insecticide	Rate /fed	Mean C.I. values at the indicated testing intervals								Mean
		1st interval 0-1 day		2nd interval 7-8 day		3rd interval 14-15 day		4th interval 21-22 day		
		C.I.	Change %	C.I.	Change %	C.I.	Change %	C.I.	Change %	
Chromafenozide 80% WP	25 g	0.70^{b}	39.66	0.62^{b}	39.22	1.05^{b}	23.36	0.54^{bc}	32.50	0.73^{b}
Chromafenozide 5% SC	400ml	0.56^{c}	51.72	0.70^{b}	31.37	0.88^{b}	35.77	0.47^{c}	41.25	0.65^{c}
Methoxyfenozide 24% SC	150 ml	0.58^{bc}	50.0	0.37^{c}	63.73	0.50^{c}	63.50	0.50^{c}	37.50	0.49^{d}
Chlorfluazuron 5% EC	400 ml	0.58^{bc}	50.0	0.65^{b}	36.27	0.95^{b}	30.66	0.53^{bc}	33.75	0.68^{bc}
Control	---	1.16^{a}	---	1.02^{a}	---	1.37^{a}	---	0.80^{a}	---	1.09^{a}
L.S.D.	---	0.1286	---	0.1522	---	0.2636	---	0.0996	---	0.0735

Table (7): Growth rate (G.R.) of the fourth instar larvae of *S. littoralis* after feeding for 48 hours on cotton leaves treated with different IGRs.

Insecticide	Rate ml/fed	Mean G.R. values at the indicated testing intervals								Mean
		1st interval 0-1 day		2nd interval 7-8 day		3rd interval 14-15 day		4th interval 21-22 day		
		G.R.	Reduction %	G.R.	Reduction %	G.R.	Reduction %	G.R.	Reduction %	
Virtu 80% WP	25 g	0.10	90.38	0.22	42.11	0.15	18.03	0.299	18.75	0.192
Virtu 5% SC	400 ml	0.18	82.70	0.28	26.32	0.13	28.96	0.259	29.62	0.212
Runner 24% SC	150 ml	0.00	100.0	-0.3	178.95	0.00	100.0	0.323	12.23	0.006
Atabron 5% EC	400 ml	0.25	75.96	-0.4	205.26	0.07	61.75	0.308	16.30	0.057
Control	---	1.04	---	0.38	---	0.183	---	0.368	---	0.493

Table (8): Growth rate (G.R.) of the 5th instar larvae of *S. littoralis* after feeding for 48 hours on the treated leaves.

Insecticide	Rate /fed	Mean G.R. values at the indicated testing intervals								Mean
		1st interval 0-1 day		2nd interval 7-8 day		3rd interval 14-15 day		4th interval 21-22 day		
		G.R.	Reduction %	G.R.	Reduction %	G.R.	Reduction %	G.R.	Reduction %	
Virtu 80% WP	25 g	-0.15	200	-0.18	150	0.10	68.8	0.07	61.1	-0.04
Virtu 5% SC	400 ml	-0.05	133.3	-0.13	136.1	0.15	53.1	0.05	72.2	0.005
Runner 24% SC	150 ml	-0.25	266.7	-0.24	166. 7	0.05	84.4	0.06	66.7	-0.095
Atabron 5% EC	400 ml	-0.15	200	-0.06	116. 7	0.08	75.0	0.18	0.0	0.088
Control	---	0.15	---	0.36	---	0.32	---	0.18	---	0.253

Table (9): Growth rate (G.R.) of the 6th instar larvae of *S. podoptera littoralis* after feeding for 48 hours on the treated leaves.

Insecticide	Rate ml/fed	Mean G.R. values at the indicated testing intervals								Mean
		1st interval 0-1 day		2nd interval 7-8 day		3rd interval 14-15 day		4th interval 21-22 day		
		G.R.	Reduction %	G.R.	Reduction %	G.R.	Reduction %	G.R.	Reduction %	
Virtu 80% WP	25 g	-0.07	134.3	-0.05	113.4	0.06	66. 7	0.19	24.6	0.033
Virtu 5% SC	400 ml	-0.02	109.8	0.0	100	0.05	72.2	0.17	32.5	0.050
Runner 24% SC	400 ml	-0.01	104.9	-0.06	116.0	0.06	66.7	0.14	44.4	0.033
Atabron 5% EC	150 ml	-0.11	153.9	-0.16	142. 8	0.11	38.9	0.21	16.7	0.013
Control	---	0.20	---	0.37	---	0.18	---	0.25	---	0.253

1999). The first sales of methoxyfenozide occurred in 1999 and the first full registrations in the United States were granted for cotton and pome fruits in 2000.

The results presented here indicate that chlorfluazuron was more effective than the other IGRs, chromafenozide and methoxyfenozide according to LC_{50} values. The toxicity of some acylureas results from their high retention in the insect as a result of rapid transport from the gut into the larval tissues and / or of lower detoxification (Guyer and Neumann, 1988; Neumann and Guyer, 1983). The primary route of intoxication for these IGRs is ingestion. Acute doses induce a prompt cessation of feeding followed by eventual death through the induction of a premature larval molt (Wing *et al.*, 1988, Rohm and Haas Company 1989; Smagghe and Degheele 1994a and b). Chronic doses have a chemosterilizing effect by disrupting both oogenesis and spermatogenesis (Smagghe and Degheele 1994a,b). Signs of acute poisoning include, but are not limited to, double head capsule formation, cuticular blackening stunted growth , hindgut extrusion and hemolymph loss .

It is evident from the evaluation of the tested IGRs compounds in field laboratory test that there are no differences between the recommended IGRs; chromafenozide 5% SC, methoxyfenozide 24% SC and chlorfluazuron 5% EC and the new formulation of chromafenozide (80% WP) in their efficacy against the second and fourth larval instars of *S. littoralis*. It may be due to the quantity of active ingredient for each compound which reached cotton plants were the same (20 g/fed.) except in the case of methoxyfenozide it was 36g/fed. The same results were obtained in the field evaluation, which also had no differences between the efficacy of IGRs compounds against cotton leafworm. The results confirm that these compounds give excellent control to the high infestation of *S. littoralis* larvae on cotton. These finding agree with results obtained by El- Malla *et al.*, (2004) who reported that in field- lab. experiments the initial toxicity of methoxyfenozide (Runner 24% SC) was 93% when used at the recommended rates. Also in field- aged leaf residue bioassays larval mortality was 75%.

On the other hand, the effect of IGRs on the food consumptions of the fourth, fifth and sixth larval instars and their ability to utilize food for growth were measured through growth rate. It was clearly found that the consumption indices of the 4^{th}, 5^{th} and 6^{th} larval instars significantly decreased below that of check in all treatments. Accordingly, it was found that the tested IGR's were able to suppress the growth rate of the 4^{th}, 5^{th} and 6^{th} larval instars to different degrees in comparison to those of the untreated control and

this suppression of G.R. greatly varied according to the time elapsed after spraying (El-Malla *et al.*, 2004). The overall means of consumption index (C.I.) of *S. littoralis* for tebufenozide, methoxyfeozide, chlorpyrifos significantly decreased below that of the control in all treatments at all intervals. The methoxyfenozide data revealed slight increase in C.I. mean for larvae in the first interval but also high decrease at 2^{nd} and 3^{rd} intervals than the control, recording C.I value of + 0.88, -25.71 and -49.87 for the 3^{rd} intervals respectively.

Nauen and Bretschneider (2002) reported that moulting accelerating compounds (MAC's) are chemically described as substituted dibenzoyl hydrazines directly acting on ecdysone receptors. Compounds such as methoxfenozide and chromafenozide induce a precocious moult in Lepidopteran larvae, this leads first to the cessation of feeding and weight gain and then, at the end of the intoxication process, to premature head capsule slippage and death.

4. REFERENCES

Abbott W.S. (1925). A method for computing the effectiveness of an insecticide. J. Econ. Entomol., 18:265-267.

Abo- Elghar M.R., Radwan H.S.A. and Ammar I. (1978). Morphogenic activity of IGR disrupting chitin biosynthesis against pupae of the cotton leafworm *Spodoptera littoralis* (Boisd.). Z. ang. Ent. 86:308-311.

Carlson G.R., Dhadialla T.S., Thompson C., Ramsey R., Thirugananam M., James W. and Slaeeki R. (1994). Insect toxicity, metabolism and receptor binding characteristics of the non- steroide ecdysone agonist RH- 5992 proc. XIth Ecdysone Workshop 43.

Dhadialla T. S., Carlson G.R. and Le D.P. (1998). New insecticides with ecdysteroidal and juvenile hormone activity. Annual Rev. Entomol. 43: 545-69.

Duncan D.B. (1955). Multiple range and Multiple F- test. Biometrics 11,1:1-24.

El- Defrawai M.E., Toppozada A., Mansour N. and Zeid M. (1964). Toxicological studies on Egyption cotton leafworm *Prodenia litura* (F.).I: Susceptibility of different larval instar to insecticides. J. Econ. Entomol. 57 (4): 591-593.

El-Malla M. A., Hashem S. M. and Youssef A.G. M. (2004). Bioresidual toxicity of two diacylhydrazine compounds and their sublethal effects on nutritional indices of the cotton

leafworm *Spodoptera littoralis*. Bull. Ent. Soc. Egypt, Econ. Ser., 30: 58-71.

Guyer W and Neumann R. (1988). Activity and fate of chlorfluazuron and diflubenzuron in the larvae of *Spodoptera littoralis* and *Heliothis virescens*. Pestic. Biochem. Physiol.30:166-177.

Hendrson C. F., and Tilton E.W. (1955). Test with acaricides against the brown wheat mite. J. Econ. Entomol. 48:157-161.

Hsu A.G.T. (1991). 1.2 Diacyl-L-alkyl-hydrazines; novel class of insect growth regulators, pp. 478-490. In synthesis and chemistry of agrochemicals II, D.R. Baker, J.G. Feynes. W.K. Moberg (eds.),AGS Syinp.Ser.443.am,Chem, Soc. Washington. DC.

Ishaaya I.(1990).Benzoylphenyl ureas and other selective insect control agents –Mechanism and application. Pesticides and alternatives, Elsevier science publishers B.V. 365-376.

Ishaaya I., Yablonski S. and Horowitz A.R. (1995). Comparative toxicology of two Ecdysteroid agonists, RH -2485 and RH-5992. on susceptible and pyrethroid resistant strains of the Egyptian cotton Leafworm. *Spodoptera littoralis* .Phytoparasitica 23:139 145.

Le D.P., Thirugnanam M., Lidert Z., Carlson G.R. and Ryan J. B. (1996). A new selective insecticide for caterpillar control. Proc. Brighton Crop Prot. Conf. BCPC, Farnham, Surrey, UK 481-486.

Nauen R. and Bretschneider T. (2002). New modes of action of insecticides. Pesticide Outlook. Royal Society of Chemistry. 241-245.

Neumann R. and Guyer W. (1983). 10th Int. Conger plant Prot, Brighton, 445-451.C.F.Ishaaya,1990

Radwan H.S.A. and Rizk G.A.M. (1975). Initial and chronic effects of the insect growth regulator PH 6040 on the American bollworm, *Heliothis armigera*., Proc. 8th British Insecticides and Fungicides Conference.

Radwan H.S.A, Assal O.M., Abo- Elghar G.E., Riskalla M.R. and Ahmed M.T. (1986). Some aspects of the action of diflubenzuron and trifluron cn food consumption, growth rate and food utilization by *Spodoptera littoralis* larvae. J. Insect Physiol. 32 (2): 103- 107.

Rohm and Haas Company (1989). RH.5992 Insect Growth Regulator. Technical information Ballein AG-2255 regulator. Technical Information Ballelim AG2255.

Slansky F.J.R. and Scriber J. M. (1985). Food consumption and utilization: Comprehensive physiology, biochemistry and pharmacology. EDS. Kerkut, G.A., and Gilbert, I.I. 3:87-163.

Smagghe G. and Degheele D. (1994a). Action of the nonsteroidal ecdysteroid mimic BH-5849 on larval development and adult reproduction of insects of different orders Invert. Reprod. Develop .25:227-236.

Smagghe G. and Degheele D. (1994 b). Action of a novel nonsteroidal ecdysteroid mimic, tebufenozide (RH-5992) on insects of different orders. Pestic. Sci .42: 85- 92.

Smagghe G., Carton B., Wesemael W., Ishaaya I. and Tirry L. (1998 b). Ecdysone agonists- mechanism of action and application on *Spodoptera* species. Pestic. Sci.55:386-389.

Smagghe G., Nakagawa Y., Carton B., Mourad A. K., Fujita T. and Tirry L. (1999). Comparative ecdysteroid action of ring-substituted dibenzoylhydrazines in *Spodoptera exigua*. Arch. Insect Biochem. Physiol. 41:42- 53.

Trisyono A., and Chippendale G. M. (1997). Effect of the nonsteroidal ecdysone agonists, methoxyfenozide and tebufenozide, on the European corn borer (Lepidoptera: Pyralidae). J. Econ. Entomol. 90: 1486- 1492.

Waldbauer G.P. (1968). The consumption and utilization of food by insects. Adv. Insect Physiol. 5: 229-282.

Wing K.D. (1988). RH- 5849, a nonsteroidal ecdysone agonist: Effect on a *Drosophila* cell line. Science 241: 467 - 469.

Wing K.D., Slaweeki R. A. and Garlson G. R. (1988). RH - 5849. a nonsteroidal ecdysone agonist : Effect on larval Lepidoptera. Science 241: 470-472.

Wing K.D and Aller H. E. (1989). Ecdysteroid agonists as novel insect growth regulators, in pesticides and alternative. Innovative Chemical and Biological Approaches to pest control. Ed by Casida J. Elsevier Press, Amsterdam, Netherlands, 251-257.

كفاءة بعض منظمات النمو الحشرية ضد يرقات دودة ورق القطن

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ملخص

درست فاعلية منظمات النمو الحشرية chromafenozide 5% EC, and 80% WP, chlorfluazuron 5% EC, methoxyfenozide 24% SC ضد يرقات دودة ورق القطن. كان ترتيب المركبات وفقا لقيمة الجرعة السامة النصفية LC_{50} كالتالي: chlorfluazuron ثم chromafenozide ثم methoxyfenozide. في الاختبار المعملي الحقلي أعطت جميع المركبات المختبرة ١٠٠% موت ليرقات العمرين الثاني والرابع لدودة ورق القطن في الفترة الأولى. وكان متوسط تأثير متبقيات methoxyfenozide 24% SC ، Chromafenozide 80% WP ، chromafenozide 5% SC ، chlorfluazuron 5% EC هو ٧٠ ، ٦٧,٧ ، ٦٥,٧ ، ٦٢,٧ % موت ليرقات العمر الثاني. و وجد نفس الترتيب في حالة استخدام يرقات العمر الرابع حيث كانت نسب الموت ٨٣,٣ ، ٨١,٧ ، ٨٠ ، ٧٨% .

وجد في الدراسة الحقلية أن جميع يرقات دودة ورق القطن يحدث لها انخفاض في معدل استهلاك الغذاء نتيجة لاستخدام المبيدات موضع الدراسة. وقد أكدت النتائج أن مركبات منظمات النمو الحشرية تعطى مكافحة فعالة ضد الإصابة الشديدة بيرقات دودة ورق القطن في الحقل. ويمكن ترتيب المبيدات تنازليا طبقا لقيمة Consumption Index C.I. كما يلي: chromafenozide 80% WP ، methoxyfenozide 24% SC ، chlorfluazuron 5% EC and chromafenozide 5% SC بالنسبة ليرقات العمر الرابع لدودة ورق القطن.

كما يحدث انخفاضا معنويا في قيمة الـ C.I. بالنسبة ليرقات العمر الخامس في جميع المعاملات بالمقارنة بالكنترول ويمكن ترتيب المبيدات تنازليا كما يلي: chromafenozide 80% WP ، chlorfluazuron 5% EC ، chromafenozide 5% SC ، methoxyfenozide 24% SC. لوحظ نفس الترتيب بالنسبة ليرقات العمر السادس لدودة ورق القطن. كذلك أوضحت الدراسة أن هناك فروقا معنوية بالنسبة للخفض في معدل النمو بالمقارنة بالكنترول.

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