

TOXICITY OF TESTED COMPOUNDS AGAINST 4th INSTAR LARVAE OF COTTON LEAFWORM, *SPODOPTERA LITTORALIS* (BOISD)

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ABSTRACT

The toxicity of tested compounds against 4th instar larvae of cotton leafworm, *Spodoptera littoralis* (Boisd.) was studied and the obtained results revealed that Agerin had low residual effects, thus considered less harmful to predators, but failed to exhibit any mortality against *S. littoralis* larvae after the first day of feeding on treated leaves. On the other hand, although chlorpyrifos had high initial kill (96%) one day after feeding, but it had a moderate residual effect. With respect to Lufenuron, the data showed that, it had long residual effect against *Spodoptera littoralis* larvae for more than 27 days after spraying, but it was comparatively less harmful to predators. Concerning the effect of binary mixtures of tested compounds against the 4th instar of the cotton-leafworm, the data confirmed that, the average initial and residual activity of all tested mixtures increased and ranged between (100 and 24.8%), (100 and 87.4%) and (100 and 90%) for Agerin+chlorpyrifos, Agerin+Lufenuron and chlorpyrifos+Lufenuron, respectively. Accordingly lufenuron could be combined with conventional insecticides to get rapid initial kill, and subsequently could be included in the spray programmes. The effect of binary mixtures of tested compounds on some biometric measurements of *S. littoralis* was also discussed.

INTRODUCTION

Cotton leafworm, *S. littoralis* considered the most destructive pest attack all parts of cotton plants including green bolls. Chemical control is still adapted as one of the major techniques recommended to control such pest. The synthetic insecticides began to suffer from less potency for controlling this pest owing to the increased rate of developing resistance. IGR's considered new compounds, which kill the insect, thought their interference with the moulting process, a process that is vital to the well being of the insect (Moawad, 1974; Moawad, *et al.*, 1996a and b). In addition to their larvicidal activity, they were effective in producing abnormalities in larval, pupa and adult stages of insects. Moreover, the effect extended to include reduction in number of eggs and percent hatchability. Also, using infectious pathogens, which are compatible with most insecticides considered a new approach to control cotton-leafworm.

The present work aims to evaluate the toxicity and latent effects of *Bacillus thuringiensis* (Agerin), Chlorpyrifos (Dursban) and Lufenuron (Match) at their recommended rates, half-recommended rates and their binary mixtures against 4th instar larvae of the field strain of *S. littoralis*.

MATERIALS AND METHODS

I-Test organisms:

Cotton leafworm, *Spodoptera littoralis* (Boisd):

Egg-masses of the cotton leafworm, *S. littoralis* (Boisduval) were collected early in the season from cotton field in Kafr El-Sheikh Governorate before the beginning of any chemical control programme and reared in the laboratory as described by El-Defrawi *et al.*, (1964).

II. Chemical used:

1- Chlorpyrifis

(*O,O*-diethyl *O*-3,5,6-trichloro-2-pyridyl phosphorothioate). A formulated sample (48% EC) was supplied from Dow Agro Sciences

2- Lufenuron:

(*RS*)-1-[2,5-dichloro-4-(1,1,2,3,3,3-hexafluoropropoxy)phenyl]-3-(2,6-difluorobenzoyl)urea. A formulated sample (5%EC) was supplied from Sengenta Co.

3- Agerin:

A sample formulated as wettable powder [the active ingredient is *Bacillus thuringiensis* sub species kurstaki, 3200 International Units per milligram (6.4% a.i.)] was supplied by Abbott's laboratories, Chemical and Agricultural Products Division, North Chicago. 11, USA.

III Treatments:

1.Experimental design and seed treatment:

The cotton area was divided into plots, each plot 1/100 feddan in two successive seasons, 2003 and 2004. Complete randomized blocks design was used and each treatment was replicated four times together with the control plots. The tested compounds and their binary mixtures were sprayed using a knapsack sprayer at their half and recommended rates/200 liters per feddan. All treatments are shown in Table (1).

Samples of cotton leaves were collected at random from each treatment at intervals after spraying and the treated cotton leaves were offered to 4th instar larvae (50 larvae/treatment/ interval). Larvae were fed

on treated leaves during the first day of each interval and the survive larvae were fed for another four days on untreated leaves. Cumulative mortalities were calculated at the end of each interval and corrected according to **Abbott's formula (1925)**. The cumulative mortalities of the first intervals (samples collected after spraying directly) was considered as initial kill, while the total mean of the cumulative mortalities of the other intervals were considered as residual effects. Also, percent pupation, percent pupal malformation and percent of moths emergence were all estimated. Data were statistically analyzed by the analysis of variance and significance were determined at 5% level of significant by **Duncan Multiple range Test (Snedecor 1962)**.

Table (1): Tested treatments, their rates of application, their binary mixtures and intervals of collecting post-treatment samples

No.	Treatments	Rate/feddan	Intervals of treated cotton leaves collected post-treatment (days)
1	<i>B. thuringiensis</i> (Agerin)	500 g	0,1,2,3,4,5,6,9,12
2	<i>B. thuringiensis</i> (Agerin)	250 g	0,3,6,9,12
3	Chlorpyrifis 48% E.C	1000 ml	0,3,6,9,12
4	Chlorpyrifis 48% E.C	500 ml	0,3,6,9,12
5	Lufenuron 50% E.C	160 ml	0,3,6,9,12,15,18,21,24,27
6	Lufenuron 50% E.C	80 ml	0,3,6,9,12
7	Agerin + Chlorpyrifis	250g + 500ml	0,3,6,9,12
8	Agerin + Lufenuron	250g + 80ml	0,3,6,9,12
9	Chlorpyrifis + Lufenuron	500ml + 80ml	0,3,6,9,12
10	Control	-	0,1,2,3,4,5,6,9,12,15,18,21,24,27

RESULTS AND DISCUSSION

1. Toxicity of tested compounds applied alone at their recommended rates as well as their side effects on some biological aspects:

1.1 Toxicity of tested compounds applied alone at their recommended rates:

1.1. a. Effect of *Bacillus thurillgiensis* (Agerin) alone against 4th instar larvae of *S. littoralis* (Boisd.):

Concerning the larval mortality, data obtained in Table (2) showed that, although Agerin failed to exhibit any mortality even after the first day of feeding on treated leaves, but the actual larval mortality did not appear before 2 days of treatment then it increased to reach an average of 64.3% after 5 days post ingestion of treated cotton leaves at 0-time. The mortality percentage decreased with increasing the time elapsed after spraying. The

lowest average percentage (2.5%) has been recorded on 9 days post spraying and confirmed that Agerin had short residual effect.

With regard to the effect of treatments on percent pupation of *S. littoralis*, it is quite clear that, Agerin (at zero time) caused severe effect on pupal formation. The average percent of pupal formation is very low (7.2%) compared with 89.4% of untreated control. Moreover, there is a positive correlation between average percent pupation and time elapsed after spray. The total mean of residual effect on % pupation of Agerin was 37.5% as compared with 89.4% for control (Table 2).

With respect to the effect of tested compounds on some biological aspects, the data revealed that Agerin caused an average of 10.5% malformed pupae and 58.4% adult emergence compared with 0.8 and 89.1% as corresponding values of control.

The current results are documented with the findings of many investigators (El-Hamaky *et al.*, 1987; El-Ghar *et al.*, 1995; Moawad *et al.*, 1996 and Abdel-Latif, 2001). In addition, El-Halim (1993), Romeilah and Abdel-Meguid (2000) and Attala (2001) reported that, Dipil 2x (*B. thuringiensis*) have strong effect on 4th instar larvae of *S. littoralis* and reduced the percentages of pupation, adult emergence and the average weight of pupae. Moreover, this compound increased the percentage of deformed pupae.

1-1.b. Effect of Chlorpyrifos (O.P) alone against 4th instar larvae of *S. littoralis*.

Concerning the effect of chlorpyrifos on larval mortality, the data presented in Table (3) revealed that this compound has high initial kill (96%) one day after feeding. Moreover, the percent mortality increased steadily to reach 100% after 2 days. Then the percent mortality decreased gradually with increasing the time elapsed after spraying, where the lowest percentage (14.3%), has been recorded on day 12 after spraying. The total mean of residual activity was 41.8%, which reflect a moderate residual effect of chlorpyrifos.

Table (2) Effect of *B. thuringensis* at recommended rate on some biological aspect (percentage pupation, malformed pupae and adult emergence) of 4th instar larvae of *S. littoralis*.

Treatments	Effectiveness	A*	season	%larval mortality after days		%pupation	%malformed pupae	%adult emergence	
				1 days	C*				
				Agerin 500g/fed.	Initial activity				0 days
2004	0.0	60.1	6.3			8.3	11.1		
Average	0.0	64.3	7.2			9.7	5.6		
Residual activity	1 days	2003	2003		0.0	61.6	8.1	20.4	0.0
			2004		0.0	55.7	11.1	22.5	18.0
			Average		0.0	60.2	9.6	21.5	9.0
	2 days	2003	2003		0.0	50.1	12.5	18.3	36.3
			2004		0.0	47.9	11.1	20.4	30.3
			Average		0.0	49.0	11.8	19.4	33.3
	3 days	2003	2003		0.0	46.6	15.7	15.0	36.1
			2004		0.0	43.4	12.5	15.0	55.0
			Average		0.0	45.0	14.1	15.0	45.6
	4 days	2003	2003		0.0	40.8	19.0	12.5	50.3
			2004		0.0	40.0	24.0	11.3	55.3
			Average		0.0	40.4	21.5	11.9	52.8
	5 days	2003	2003		0.0	36.4	25.5	12.5	66.0
			2004		0.0	28.2	28.6	6.3	66.7
			Average		0.0	32.2	27.0	9.4	66.3
	6 days	2003	2003		0.0	22.2	57.3	9.1	70.4
			2004		0.0	18.6	50.3	2.6	73.2
			Average		0.0	20.4	53.8	5.9	41.8
	9 days	2003	2003		0.0	5.0	71.5	2.2	82.1
			2004		0.0	0.0	80.0	0.0	85.0
			Average		0.0	2.5	75.8	1.1	83.6
	12 days	2003	2003		0.0	0.0	82.0	0.0	88.0
			2004		0.0	0.0	87.6	0.0	84.2
			Average		0.0	0.0	84.8	0.0	86.1
Total mean of residual activity					0.0	31.2	37.5	10.5	58.4
General mean				0.0	34.88	34.1	10.4	52.5	
Control			2003	0.0	0.0	89.1	0.6	90.3	
			2004	0.0	0.0	89.6	0.9	88.9	
			Average	0.0	0.0	89.4	0.8	89.6	

Wehre: A*= Day of collecting samples after spraying, C*= Cumulative 5 days Initial activity: Effectiveness at zero time from spray. Residual activity: Effectiveness at 1, 2, 3, 4, 5, 6, 9 and 12 days from spray.

As for the effect of chlorpyrifos on pupal formation, the data presented in Table (3) revealed that chlorpyrifos had no direct hit on pupal formation since it induced zero % pupal mortality at zero time. Moreover, its residual effect on pupal formation is moderate with general percent mortality of 43.3% while the corresponding value of control is 90.3%. Chlorpyrifos had also moderate effect on both pupal malformation and adults' emergence. In term of figures it caused 8.8% malformed pupae and 44% adults-emergence compared with 1% and 91.7% as corresponding values of control.

Table (3) Effect of Chlorpyrifos at recommended rate on some biological aspect (percentage pupation, malformed pupae and adult emergence) of 4th instar larvae of *S. littoralis*.

Treatments	Effectiveness	A*	season	%larval mortality after days		%pupation	% malformed pupae	%adult emergence
				1 days	Cumulative 5 days			
Chlorpyrifos 1.0L/fed.	Initial activity	0 days	2003	96.0	100	-	-	-
			2004	96.0	100	-	-	-
			Average	96.0	100	-	-	-
	Residual activity	3 days	2003	17.2	75.7	23.0	15.0	27.4
			2004	16.0	65.3	0.0	0.0	15.0
			Average	16.6	70.5	11.5	7.5	21.2
		6 days	2003	9.6	50.3	50.0	12.5	50.0
			2004	7.8	42.6	33.3	15.0	53.5
			Average	8.7	46.5	41.7	13.8	51.8
		9 days	2003	3.0	39.8	66.7	8.3	66.7
			2004	0.0	31.8	40.0	9.1	75.8
			Average	1.5	35.2	53.4	8.7	71.3
		12 days	2003	0.0	15.0	73.3	8.3	68.5
			2004	0.0	13.6	60.0	0.0	83.1
			Average	0.0	14.3	66.7	4.15	75.8
Total mean of residual activity				6.8	41.8	43.3	11.0	55.0
General mean				24.64	53.44	34.64	8.8	44.0
Control			2003	0.0	7.7	90.6	1.0	91.2
			2004	0.0	7.7	90.0	1.0	92.3
			Average	0.0	7.7	90.3	1.0	91.7

Wehre: A*= Day of collecting samples after spraying

Initial activity: Effectiveness at zero time from spray.

Residual activity: Effectiveness at 3, 6, 9 and 12 days from spray.

These results agreed fully with the previous finding of Rizk *et al.*, (1990), Mourad *et al.*, (1991) and Abdel-Latief (2001) who reported that the

initial kill of chlorpyrifos against 4th instar larvae of *S. littoralis* ranged between 94-100%, but its residual activity ranged between 28.44-64% after 12 days from spraying.

1.1.c. Effect of Lufenuron (IGR) alone against 4th instar larvae of *S. littoralis* (Boisd.):

Table (4) represents the initial effect at zero time and residual effect after 9 intervals (i.e., 3, 6, 9, 12, 15, 18, 21, 24 and 27 days) from spraying lufenuron against 4th instar larvae of *S. littoralis* in both successive seasons, 2003 and 2004. Fourth instar larvae were fed on treated cotton leaves for 24 hours, then alive larvae were fed on untreated cotton leaves till pupation at each interval.

With regard to larval mortality, the data obtained in Table (4) showed that lufenuron gave low mortality (6.1 %) after first day of feeding on treated leaves, but thereafter the mortality increased within the first period to reach 100% as initial activity.

Concerning the residual activity, lufenuron was still highly persistent causing 90.1% after 15 days from spraying. A positive correlation was noticed between cumulative mortality and time elapsed after feeding. The lowest percentage (33.4%) has been recorded after 27 days post spraying, while the total average of residual activity was 75.6%, confirming that lufenuron was highly persistent to control such pest.

As for the effect of lufenuron on percent of pupal formation, the results showed that lufenuron induced 0.0% pupation up to 9 days from spraying. There was a positive correlation between percent pupation and time elapsed after spraying where 69.8% pupation was noticed after 27 days post treatment as compared to 90.3% for control, while the total average of % pupation as residual activity was 23.2% as compared to 90.3% for control. Regarding the effect of lufenuron on percentage of malformed pupae, the results (Table 4) showed that this compound caused 5.9% deformed pupae, compared with 1% for the control. Moreover, the data also indicated that lufenuron caused significant reduction of adult emergence. The general mean of adult emergence in case of lufenuron-treated group was 24.6% while the corresponding value is 91.7% for control. The current results are in line of those stated by (Javaid *et al.*, 1999; El-maghraby *et al.*, 1999; Abdel-Aziz, 2000 and Aioub *et al.*, 2002)

It was noticed that the average initial and residual activity of all tested mixtures ranged between (100 and 24.8%), (100 and 87.4%) and (100

Table (4) Effect of Lufenuron at recommended rate on some biological aspect of 4th instar larvae of *S. littoralis*.

Treatments	Effectiveness	A*	season	%larval mortality after days		%pupation	% malformed pupae	%adult emergence	
				1 days	C*				
				Lufenuron 160ml/fed.	Initial activity				0 days
2004	4.1	100	-			-	-		
Average	6.1	100	-			-	-		
Residual activity	3 days	2003	4.0		100	-	-	-	
		2004	3.6		96.6	-	-	-	
		Average	3.8		98.3	-	-	-	
	6 days	2003	3.2		95.3	-	-	-	
		2004	3.6		95.7	-	-	-	
		Average	3.4		95.5	-	-	-	
	9 days	2003	0.0		95.1	-	-	-	
		2004	0.0		95.1	-	-	-	
		Average	0.0		95.1	-	-	-	
	12 days	2003	0.0		94.0	11.1	-	8.3	
		2004	0.0		93.4	0.0	-	0.0	
		Average	0.0		93.7	5.6	-	4.2	
	15 days	2003	0.0		89.8	11.1	30.0	11.1	
		2004	0.0		90.34	11.1	20.3	8.3	
		Average	0.0		90.1	11.1	25.2	9.7	
	18 days	2003	0.0		80.1	18.5	26.0	18.5	
		2004	0.0		80.4	8.12	14.3	12.5	
		Average	0.0		80.3	13.3	20.2	15.5	
	21 days	2003	0.0		50.4	39.9	18.5	58.3	
		2004	0.0		52.9	45.9	11.1	59.2	
		Average	0.0		51.7	42.9	14.8	58.8	
	24 days	2003	0.0		45.6	67.0	8.5	69.0	
		2004	0.0		38.7	65.0	0.0	73.2	
		Average	0.0		42.2	66.0	4.3	71.1	
	27 days	2003	0.0		30.7	71.4	0.0	85.3	
		2004	0.0		36.1	68.2	0.0	88.2	
		Average	0.0		33.4	69.8	0.0	86.8	
	Total mean of residual activity				0.0	75.6	23.2	6.5	27.3
	General mean				0.0	78.04	20.9	5.9	24.6
	Control			2003	0.0		90.6	1.0	91.2
		2004	0.0		90.0	1.0	92.3		
		Average	0.0		90.3	1.0	91.7		

Wehre: A* = Day of collecting samples after spraying, C* = Cumulative 5 days. Initial activity: Effectiveness at zero time from spray. Residual activity: Effectiveness at 3, 6, 9, 12, 15, 18, 21, 24 and 27 days from spray.

2. Toxicity of the tested compounds applied alone and in binary mixtures against 4th instar *S. littoralis* larvae at their half recommended rates:

The purpose of this study was to evaluate the initial and residual effects of Agerin, chlorpyrifos and lufenuron applied alone and in binary mixtures at half recommended rates against 4th instar larvae of the field strain of cotton leafworm *S. littoralis*.

2.1. Effect of the tested compounds alone:

Data presented in Table (5) showed that Agerin and lufenuron exhibited no single case of mortality after the first day of feeding on treated leaves but extending feeding period for another 4 days on untreated cotton leaves giving cumulative mortality 39.9 and 94.8%, respectively at zero time, while chlorpyrifos was more effective with percentage mortality of 70.9% after one day from feeding, but its cumulative larval mortality was 96.6% after 5 days.

Regarding the residual time intervals, (i.e. 3 days after spray, considering the cumulative mortality after 5 days from feeding) the tested compounds could be arranged descending by as follows: Agerin (45%) Table 2, chlorpyrifos (70.5%) Table 3 and Lufenuron (98.3%) Table 4, their activities were positively influenced by extending the feeding period.

Concerning the third time interval (6 days post spraying), lufenuron was the most effective inducing 95.5% Table 4, followed by chlorpyrifos and Agerin as their average larval mortality 46.5 and 20.4%, (Table 3 and 2) respectively. This arrangement differs in the fourth and fifth time intervals (9 and 12 days after spraying).

Based on the general mean of residual activity of the tested compounds (Table 5), lufenuron was the superior compound (76.5%) while chlorpyrifos came in the second order recording 13.7%. On the other hand, Agerin (9.3%) considered the least effective one in this respect.

2.2. Effect of binary mixtures of the tested compounds against 4th instar larvae of cotton leafworm, *S. littoralis*:

With respect to the activity of the same three tested compounds each applied alone against 4th instar larvae of *S. littoralis* at their half recommended rates, the data presented in Table (5), revealed that the average of initial and residual activity for 2003 and 2004 cotton seasons exhibited (94.8 and 76.5%), (96.6 and 13.7%) and (39.9 and 9.3%) for lufenuron, chlorpyrifos and Agerin, respectively.

It was noticed that the average initial and residual activity of all tested mixtures ranged between (100 and 24.8%), (100 and 87.4%) and (100

and 90.6%) for Agerin + Chlorpyrifos, Agerin + Lufenuron and Chlorpyrifos + Lufenuron, respectively. In other words, the highest average of initial and residual activity was obtained when Lufenuron was mixed either with Chlorpyrifos or with Agerin, while the mixture of Agerin + Chlorpyrifos was the least in activity.

Reviewing the above mentioned results, it could be concluded that Lufenuron, when applied at its recommended rate have high toxic potential against cotton leafworm, *S. littoralis* and it had long residual effect, where its persistent in the field lasted over 27 days after spraying. Moreover, Lufenuron could be used in combination with conventional insecticides, such as chlorpyrifos, if there is a need to get a rapid initial kill. In addition, it could be included in the spray programmers for the management of cotton pests, rather than continuous application of conventional insecticides. The foregoing results are in agreement with the trend of results obtained by many investigators (Abdel-Megeed *et al.*, 1984; Kassem and Zeid, 1987; El-Hamaky *et al.*, 1990; Rizk *et al.*, 1990; Korkor, 1999 and Abdel-Latief, 2001)

2.3. Effect of the tested compounds and their binary mixtures on some biometric measurements of *S. littoralis* (Boisd.):

To evaluate the separate effects of *B. thuringiensis* (Agerin), chlorpyrifos and lufenuron as well as their binary mixtures on some biometric measurements (i.e. percent pupation, malformed pupae and adult emergence), each compound was applied at two rates; the first at its recommended rate and the other at its half recommended rate. Fourth instar of *S. littoralis*, larvae were fed on treated cotton leaves for the first day of each interval, after that the larvae were fed on untreated leaves till pupation.

2.3. a. Effect on pupation percentage:

Data in Table (6) showed that, lufenuron proved to be the most effective compound in reducing the percent pupation when it was used alone (causing 1.1 and 20.6% pupation) at its recommended rate and half recommended rate, respectively as compared with 90.3% for control. Agerin was the least effective ones (causing 47.1 and 60.1 pupation) at its recommended and half recommended rate, respectively. Regarding the obtained results, lufenuron proved to be more effective when being used alone or combined with Agerin or chlorpyrifos. The toxicity of Agerin was significantly increased when mixed with chlorpyrifos or lufenuron, where percentage pupation was reduced from 60.1% of Agerin alone (half rate) to 29.9 and 6.1% when binary mixed by chlorpyrifos or lufenuron, respectively.

Table (5): The initial and residual activity of half recommended dose of Agerin, Chlorpyrifos and Lufenuron and their binary mixtures against 4th instar larvae of cotton leafworm *S. littoralis* (Boisd)

Treatment	Rat/fed	Season	Corrected % mortality at indicated time intervals										Mean	% effectiveness	
			Initial time		3 day		6 day		9 day		12 day			Initial activity	Residual activity
			1 days	Cumulative 5 days	1 days	Cumulative 5 days	1 days	Cumulative 5 days	1 days	Cumulative 5 days	1 days	Cumulative 5 days			
Agerin	250g	2003	0.0	42.0	0.0	28.6	0.0	11.1	0.0	0.0	0.0	0.0	16.3	42.0	9.9
		2004	0.0	37.8	0.0	25.3	0.0	9.5	0.0	0.0	0.0	0.0	14.5e	37.8	8.7
		Average	0.0	39.9	0.0	27.1	0.0	10.3	0.0	0.0	0.0	0.0	15.4e	39.9c	9.3e
Chlorpyrifos	500ml	2003	72.0	96.1	8.2	24.9	5.0	17.3	0.0	9.5	0.0	0.0	29.6	96.1a	12.9
		2004	69.8	97.0	6.4	30.0	3.2	18.2	0.0	10.0	0.0	0.0	31.0	97.0	14.6
		Average	70.9	96.6	7.3	27.5	4.1	17.8	0.0	9.8	0.0	0.0	30.3c	96.1a	13.7e
Lufenuron	80ml	2003	0.0	94.0	0.0	88.7	0.0	80.0	0.0	71.3	0.0	67.6	80.4	94.0	77.0
		2004	0.0	95.6	0.0	89.4	0.0	82.3	0.0	69.1	0.0	63.1	79.9	95.6	76.1
		Average	0.0	94.8	0.0	89.1	0.0	81.2	0.0	70.2	0.0	65.5	80.2b	94.8a	76.5b
Agerin + Chlorpyrifos	250g + 80ml	2003	86.0	100	4.0	33.9	0.0	28.1	0.0	20.7	0.0	4.5	37.4	100	21.8
		2004	84.9	100	5.8	50.9	0.0	30.7	0.0	23.0	0.0	6.3	42.2	100	27.7
		Average	85.5	100	4.9	42.4	0.0	29.4	0.0	21.9	0.0	5.4	39.8cd	100a	24.8d
Agerin + Lufenuron	250g + 80ml	2003	4.0	100	4.0	100	2.0	94.6	0.0	85.0	0.0	68.4	89.6	100	87.0
		2004	4.0	100	3.0	95.3	4.0	93.4	0.0	90.5	0.0	78.8	90.2	100	87.8
		Average	4.0	100	3.5	97.7	3.0	94.0	0.0	87.7	0.0	73.6	89.9ab	100a	87.4ab
Chlorpyrifos + Lufenuron	500ml + 80ml	2003	72.0	100	4.8	96.6	0.0	95.2	0.0	87.7	0.0	80.8	89.2	100	90.1
		2004	77.3	100	6.0	96.4	4.0	91.6	0.0	91.3	0.0	84.9	92.8	100	91.1
		Average	74.7	100	5.4	96.5	2.0	93.4	0.0	89.5	0.0	82.9	92.5ab	100a	90.6a

Mean followed by the same letter in each column are not significantly at 5% level. Initial activity: Effectiveness at zero time from spray. Residual activity: Effectiveness at 3, 6, 9 and 12 days from spray:

2.3. b. Effect on percentage of malformed pupae:

Data presented in Table (6) showed that both Agerin alone and chlorpyrifos (alone) are equally effective on percentage of malformed pupae counting (6.9 and 2.2%) in case of high rate and half rate of Agerin, respectively, while the corresponding values of chlorpyrifos are 6.8 and 2.7%, respectively. However, no significant differences were observed between Agerin and chlorpyrifos. It is of interest to mention that lufenuron exhibited 9.2% malformed pupae at its half-recommended rate while no single case of malformed pupae was observed at the high rate. However, the logic interpretation for that might be due to the fact that malformation and teratogenicity required sublethal concentration of biologically active compound. Thus, the high concentration might be lethal and killed the pupae during metamorphosis.

Concerning the effect of binary mixtures of the tested compounds, lufenuron when mixed with Agerin or chlorpyrifos exhibited highly mortalities, although do not effect on % malformed pupae, while Agerin + chlorpyrifos was recording 8.9% as compared 1% for control.

2.3.c. Effect on percentage of adult emergence:

Data in Table (6) indicated that, the rate of adult emergence was drastically decreased by using lufenuron causing 0.8 and 23.0%, when used alone at the recommended rate and half the recommended rate as compared with 91.8% for control. However, Agerin was the lowest effective compound causing 58.5 and 80.1% at its recommended rate and half the recommended rate, respectively.

Regarding the effect of binary mixtures, chlorpyrifos + lufenuron was highly effective in reducing the adult emergence (3.1%), followed by Agerin + lufenuron (17.0%) and Agerin + chlorpyrifos recording 51.4% as compared with 91.8% for control.

These results are compatible with the finding of **El-Hamaky et al., (1987)** who revealed that among eight mixtures tested, chlorpyrifos and profenofos with chlorfluozuron were the most toxicants reducing the reproductive potential of cotton leafworm, also the percentage pupation, the pupa weight, adult emergence, number of deposited eggs per female and percentage of hatched eggs were reduced.

Table (6): Latent toxicities of Agerin, Chlorpyrifos and Lufenuron and their binary mixtures against 4th instar larvae of cotton leafworm *S. littoralis* (Boisd)

Treatment	Rat/fed	Season	% pupation indicated time intervals						% malformed pupae						%adult emergence						
			0 day	3day	6 day	9 day	12day	Mean	0 day	3day	6 day	9 day	12day	Mean	0 day	3day	6 day	9 day	12day	Mean	
Agerin	500ml	2003	14.0	34.5	74.2	80.9	90.2	58.8	6.2	4.0	0.0	0.0	0.0	2.06	58.0	71.3	90.2	87.2	82.8	77.9	
		2004	15.1	40.9	77.6	86.0	87.0	61.3	8.3	3.8	0.0	0.0	0.0	2.4	62.4	80.0	86.0	93.0	90.0	82.3	
		Average	14.6	37.7	75.9	83.5	80.6	60.1b	7.3	3.9	0.0	0.0	0.0	2.2bc	60.2	75.7	88.1	90.1	86.4	80.1ab	
	250g	2003	8.1	15.7	57.3	71.5	82.0	46.9	11.1	15.0	9.1	2.2	0.0	7.5	0.0	36.1	70.4	82.1	88.0	55.3	
		2004	6.3	12.5	50.3	80.0	87.6	47.3	8.3	15.0	8.6	0.0	0.0	6.4	11.1	55.0	73.2	85.0	84.2	61.7	
		Average	7.2	14.1	53.8	75.8	84.8	47.1c	9.7	15.0	8.6	1.1	0.0	6.9ab	5.6	45.6	71.8	83.6	86.1	58.5cd	
Chlorpyrifos	1000ml	2003	-	23.0	50.0	66.7	73.3	42.6	-	15.0	12.5	8.3	8.3	8.8	-	27.4	50.0	66.7	68.5	42.5	
		2004	-	0.0	33.3	40.0	60.0	26.7	-	0.0	15.0	9.1	0.0	4.8	-	15.0	53.5	75.8	83.1	45.5	
		Average	-	11.5	41.7	53.4	66.7	34.7d	-	7.5	13.8	8.7	4.2	6.8ab	-	21.2	51.8	71.3	75.1	44.1d	
	500ml	2003	-	65.0	75.2	81.5	83.4	61.0	-	8.3	3.3	0.0	0.0	2.3	-	70.6	81.0	92.8	87.4	66.2	
		2004	-	53.4	70.1	78.4	90.0	58.4	-	11.1	4.0	0.0	0.0	3.0	-	72.1	84.3	85.4	93.5	67.1	
		Average	-	59.2	72.7	80.1	86.7	59.7b	-	9.7	3.7	0.0	0.0	2.7bc	-	71.4	82.7	88.7	90.5	66.7bc	
lufenuron	160 ml	2003	-	-	-	-	11.1	2.2	-	-	-	-	-	-	-	-	-	-	8.3	1.7	
		2004	-	-	-	-	0.0	0.0	-	-	-	-	-	-	-	-	-	-	-	0.0	0.0
		Average	-	-	-	-	5.6	1.1f	-	-	-	-	-	-	-	-	-	-	-	4.2	0.8f
	80 ml	2003	-	11.1	18.5	36.0	50.0	23.1	-	23.2	19.0	10.2	0.0	10.5	-	8.3	12.5	40.0	56.0	23.4	
		2004	-	8.3	11.0	28.9	42.3	10.1	-	18.1	14.9	9.1	0.0	8.1	-	4.3	11.1	43.2	54.4	22.6	
		Average	-	9.7	14.8	32.5	46.7	20.6e	-	20.7	16.9	8.7	0.0	9.2a	-	6.3	11.8	41.6	55.2	23.0c	
Control	-	2003	90.0	90.0	94.0	90.0	89.0	90.6	0.0	0.0	2.6	0.0	2.4	1.0	82.0	92.0	94.0	100	88.0	91.2	
		2004	93.0	90.0	92.0	88.0	87.0	90.0	2.4	0.0	0.0	0.0	2.4	1.0	90.0	100	91.0	92.0	88.3	92.3	
		Average	91.5	90.0	93.0	89.0	88.0	90.3a	1.2	0.0	1.3	0.0	2.3	1.0	86.0	96.0	92.5	96.0	88.2	91.8a	

Mean followed by the same letter in each column are not significantly at 5% level

Table (6): Continued

Treatment	Rat/fed	Season	% pupation indicated time intervals						% malformed pupae						%adult emergence					
			0 day	3day	6 day	9 day	12day	Mean	0 day	3day	6 day	9 day	12day	Mean	0 day	3day	6 day	9 day	12day	Mean
Agerin + Chlorpyrifos	250g + 80ml	2003	-	21.4	23.6	47.3	57.9	31.0	-	25.0	16.3	6.7	0.0	9.6	-	55.0	58.9	70.1	79.3	52.7
		2004	-	12.5	33.3	40.0	60.3	28.7	-	20.0	8.3	8.3	3.7	8.1	-	40.0	60.3	68.5	81.2	50.0
		Average	-	17.1	28.5	12.5	20.0	29.9de	-	22.5	12.3	7.5	1.9	8.9a	-	47.5	59.6	69.3	80.3	51.4d
Agerin + lufenuron	250g + 80ml	2003	-	-	-	8.3	11.1	8.2	-	-	-	16.7	11.1	5.6	-	-	-	33.3	40.2	14.8
		2004	-	-	-	10.4	15.6	3.9	-	-	-	0.0	2.6	0.5	-	-	-	40.0	56.2	19.2
		Average	-	-	-	-	8.3	6.1f	-	-	-	8.4	6.9	3.1bc	-	-	-	36.7	48.2	17.0e
Chlorpyrifos + lufenuron	500ml + 80ml	2003	-	-	-	-	11.1	1.2	-	-	-	-	11.1	2.2	-	-	-	-	20.0	4.0
		2004	-	-	-	-	9.7	2.2	-	-	-	-	5.8	1.2	-	-	-	-	11.1	2.2
		Average	-	-	-	-	89.0	1.7f	-	-	-	-	8.5	1.7c	-	-	-	-	15.6	3.1f
Control	-	2003	90.0	90.0	94.0	90.0	89.0	90.6	0.0	0.0	2.6	0.0	2.4	1.0	82.0	92.0	94.0	100	88.0	91.2
		2004	93.0	90.0	92.0	88.0	87.0	90.0	2.4	0.0	0.0	0.0	2.4	1.0	90.0	100	91.0	92.0	88.3	92.3
		Average	91.5	90.0	93.0	89.0	88.0	90.3a	1.2	0.0	1.3	0.0	2.3	1.0	86.0	96.0	92.5	96.0	88.2	91.8a

Mean followed by the same letter in each column are not significantly at 5% level

Our results were also matched with the previous finding of **El-Halim (1993)** mentioned that both larval and pupal duration were markedly prolonged with increasing the dose of *B. thuringiensis*, while percentage pupation was reduced, marked latent adverse effects were detected on adult emergence, fecundity and egg viability, particularly with doses above 320 IU/ml. In addition, **Awad et al., (1995)** found that all tested insecticides reduced significantly percent pupation and moth emergence till 12 days post-treatment. Moreover, **Korkor et al., (1996)** confirmed that all tested compounds decreased pupation percentage and moth emergence at the tested intervals. **Zidan et al., (1996)** showed that (Dipel 2x) *B. thuringiensis*, increased larval duration, while decreased pupal weight and caused slight malformation in pupae and Moths resulting from treated larvae. In addition, **Aioub et al., (2002)** found that lufenuron and flufenoxtiron causing nullified adult emergence from treated larvae and no normal adult was emerged at any time after lufenuron application till the experimental end time during the two seasons.

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الملخص العربي

سمية بعض المبيدات المختبرة ضد الجيل الرابع دودة ورق القطن

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تم دراسة السمية للمركبات المختبرة ضدّ الطور اليرقى الرابع لحشرة دودة ورق القطن. ووضحت النتائج ان الاجرين كان له تأثيرات متبقية منخفضة، ولذلك اعتبر أقل ضرراً على المفترسات، ولكنه لم يحدث اى نسب موت بعد يوم واحد من تغذية اليرقات بالاوراق المعاملة به. ومن ناحية اخرى، بالرغم من أن الكلوربيروفوس كان له سمية مرتفعه (٩٦ %) بعد يوم واحد بعد التغذية ، لكنّه كان له تأثير متبقى معتدل. فيما يتعلق بمبيد اليفنيورون اظهرت النتائج انه كان له تأثير متبقى مرتفع ضد حشرة دودة ورق القطن لاكثر من ٢٧ يوم بعد الرش، لكنّه كان نسبياً أقل ضرراً بالمفترسات.

بالنسبة لتاثير الخلائط الثنائية للمركبات المختبرة ضدّ العمر اليرقى الرابع لدودورق القطن أكدت النتائج بأنّ تاثير الخليط والمتبقي لكلّ من الخلائط كان يتراوح بين (١٠٠ و ٢٤,٨ %)، (١٠٠ و ٨٧,٤ %) و (١٠٠ و ٩٠ %) لخلائط التالية اجرين + كلوربيروفوس ، اجرين + الايفرون ، الكلوربيروفوس + اليفنيورون على التوالي. وفقاً لذلك فان مبيد اليفنيورون يمكن أن يخلط مع المبيدات الحشرات التقليدية للحصول على اعلى معدل اباده كما يمكن ان تتضم الى برامج الرش. كذلك تم دراسة تأثير الخلائط الثنائية للمركبات المختبرة على بعض القياسات البيولوجية لدودة ورق القطن.