

Deleterious effects of emamectin benzoate and triflumuron exposed to gamma radiation on *Pectinophora gossypiella* (Saund.)

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Abstract

Larval stage of *Earias insulana* (Boisd.) and *Pectinophora gossypiella* (Saund.) were exposed to gamma radiation doses (50&500 Gy). In addition, emamectin benzoate and triflumuron were exposed to the same doses for potentiating purpose. Lethal, biological and life table aspects were observed to evaluate gamma radiation effecting on *P. gossypiella* treated as newly hatched larvae with tested compounds alone or exposed to gamma doses. First and second instars of *E. insulana* was more susceptible to gamma radiation than 3rd and 4th larval instars as well as *P. gossypiella* newly hatched larvae was more susceptible instar to gamma doses than 4th instars larvae susceptibility. Dose of 500 Gy caused the higher potentiating lethal effect for emamectin benzoate against *P. gossypiella* treated as newly hatched larvae that reached to complete death in larval stage as well as dose of 50 Gy comparing with triflumuron lethal potentiating effect. Biological and life table aspects were affected by triflumuron +500 Gy that was the most potent compound effect on the most biological and life table aspects, followed by triflumuron + 50 Gy, emamectin benzoate and triflumuron when used singly.

Keywords: gamma radiation, *e. insulana*, *p. gossypiella*, emamectin benzoate, triflumuron.

1. Introduction

The Pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) and *Earias insulana* (Boisduval) (Lepidoptera: Noctuidae) were the most important pests of cotton plants. It is distributed throughout the world's cotton-growing areas. Damage to squares and flowers can be substantial if infestation occurs in the early and mid-growing season [1].

Gamma rays are formed with the self-disintegration of Cobalt-60 (Co⁶⁰) or Cesium-137 (Cs¹³⁷) sources that indicated for radiation processing. It is this process that results in irreparable damage to the life sustaining chemistry of living organisms and the initiation of cross linking chemistry or main chain scission in polymeric materials [2].

Life tables consider as a speculation tool about population of the pest. The life table program has speculated about the effecting of the tested compounds on the target pest to clarify the impact of tested factors on the developmental increase rate of the pest population [3, 4].

Overuse of conventional insecticides for *Helicoverpa* control has made *Helicoverpa* resistant to insecticides leading to more severe attacks on crops diverting interest of researchers to explore alternate control agents [5]. So, emamectin benzoate and triflumuron were target compounds with gamma doses. Emamectin benzoate was more effective on the most biological and life table aspects than pyridalyl in case of treating the newly hatched larvae by LC₅₀'s of the tested compounds [6]. Also, [7] nine compounds related to bio-agent groups were tested; among tested compounds was emamectin benzoate to control *Pectinophora gossypiella* (Saund.) and *Earias insulana* (Boisd.) population (77.8-81.1%) and infestation (80.8-83.8%) reduction percentages at 2018 & 2019 two cotton seasons.

Meanwhile [8] triflumuron when tested against the larvae of *Earias insulana* (Boisd.) in the laboratory experiments. The

compound was active only at 50 ppm. While, [9] the study for the effect of triflumuron (LC₄₀, LC₅₀, LC₆₀) on total and differential haemocyte in 3rd and 5th instar larvae of *Helicoverpa armigera*. The total haemocyte count increased just after the application of LC₅₀ for triflumuron in 3rd instar larvae. The percentage of prohaemocytes decreased from normal (42% to 26%), whereas the percentage of plasmatocytes, spherulocytes, cystocytes, and granulocytes increased from normal (18, 29, 2.75 and 8.25% to 29, 32, 4 and 10%, respectively) after the insecticide application. In addition, [10] *Spodoptera littoralis* (Boisd.) affected by chitin synthesis inhibitors (triflumuron) and is quite distinctive in its mode of action and potentially act on the target species. So, current work aims to assess the biological aspects of *P. gossypiella* and *E. insulana* larval stage as affected by exposing to gamma radiation doses (50 & 500 Gy). In addition to assess the lethal, biological and life table aspects of *P. gossypiella* treated as newly hatched larvae with emamectin benzoate and triflumuron that exposing to gamma doses mentioned.

Materials and Methods

A. Insect pests.

A laboratory strain of the pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) and spiny bollworm, *Earias insulana* (Boisd.) (Lepidoptera: Noctuidae) were reared at Bollworms Research Department, Plant Protection Research Institute, Agricultural Research Center, Giza, Egypt, on semi-artificial diet as described before [11]. Rearing conditions were adjusted at 27±1°C and 65-75% RH.

B. Tested compounds.

1. Emamectin benzoate 1.9% EC: (Pasha) A mixture of emamectin B1a (≥ 90%) and emamectin B1b (≤ 10%) as their benzoate salts. Application dose rate, 250cm³/

feddan. The product of Al-Helb Company for pesticides and Chemicals, Egypt.

2. **Triflumuron 48% SL:** (Alsystin) (Chitin synthesis inhibitors (CSI). A product of Bayer Crop Science, Germany; imported by Agricultural Material Company, Egypt.

C. Gamma radiation Treatments.

Newly hatched or 4th instars larvae of *Pectinophora gossypiella* (Saunders); also, *Earias insulana* (Boisd) 1-4 larval stage exposed to 50 & 500 Gy for mortality and biological assays. In addition, compounds of emamectin benzoate and triflumuron were exposed to the same two doses (50 & 500 Gy) to assess its lethal, biological and life table assays of *P. gossypiella* treated as newly hatched larvae. All irradiations were done by a Cesium¹³⁷ Indian GC Research, National Center for Radiation Research and Technology, delivered at a dose rate of 1.277 K.Gy/h.

D. Lethal assays.

Two gm of semi artificial diet/Petri-dish (7 cm diameter) were mixed with 1 cm of each emamectin benzoate or triflumuron prepared concentrations. Twenty five of newly hatched larvae of *P. gossypiella* to each four replicates/ concentrate/ tested compound were exposed to the compound alone or exposing to gamma doses of 50 & 500 Gy. The petri- dish used as untreated was prepared with 1 cm distilled water mixed with 2 gm artificial diet and kept at 27±1°C and 65-75% R.H. Then the larvae were investigated (alive and dead larvae) at 1-4 days post treatment. LC₄₀, LC₉₀ and slope values were assessed [12, 13] by using Ldp-line software (www.Ehabbakr software/Ldp line).

The comparing among treatments efficacy were according to following formula [14].

Toxicity index = $\frac{LC_{40} \text{ (LC}_{90}) \text{ of the compound A}}{LC_{40} \text{ (LC}_{90}) \text{ of the compound B}} \times 100$ Where A: The most effective compound and B: The other tested compound.

E. Biological aspects.

Newly hatched larvae of *P.gossypiella* treated with LC₄₀'s for different treatments of emamectin benzoate and triflumuron. Also, an untreated newly hatched larva was done. The following biological aspects were investigated as follows:

1. Larval stage.

- Larval duration (days).
- Larval mortality percentage.

% Larval mortality= No. dead larvae/ Total tested larvae X 100

% corrected mortality according to Abott's formula:

% corrected mortality = % tested mortality-% control mortality/100-% control mortality X 100

2. Pupal stage

- Pupal duration (days).
- % Pupation= No. produced pupae/Total tested larvae X100

3. Adult stage

- % Moths emergency = No. emerged moth/total tested larvae X100
- Pre-oviposition, oviposition and post-oviposition periods: determined by three replicates. Each one contained 5 pairs of emerged moths in clean glass chimneys (17 cm height and 7-12 cm in diameter) till female moth death.

- **Egg laying rate (total number of eggs per female):** counted from daily deposited eggs on a piece of paper in upper and lower of glass chimneys. Each treatment yielded through the daily egg production and on the differential survival of females.

- **Egg hatchability percentage:** calculated^[15] as follows:
- No. hatched eggs/ No. deposited eggs X 100

- **Control of hatchability percentage:** calculated^[15] as follows:
- No. hatched eggs in check – No. hatched eggs in treatment/ No. hatched eggs in check X 100

- **Fecundity percentage:** calculated^[16] as follows:
- No. eggs of treated female/ No. eggs of untreated female X 100

- **Sterility Percentages: Sterility observed percentage.** Calculated ^[15] as follows:

% Sterility observed = 100 – Egg hatchability percentage

- **Sterility corrected percentage.** Calculated ^[15] as follows: % Sterility corrected = % Sterility observed – Check/ 100- Check X 100

4. **Sex ratio:** no of adult female/Total no. of adult female and male X100

5. **Life cycle:** extended from egg deposition till adult emergence (days).

6. **Life span:** extended from egg deposition till adult moth death (days).

F. Life table assays.

Data of life table were analyzed by using life 48 basic computer program^[17]. The program has output data include information for each interval of adult female age: (egg laying rate) (M), number of females alive at age x (L), mean female age at each interval mid-point (X), female progeny per female produced (Mx), survival rate (Lx). In addition, generation time (T), net reproductive rate (Ro), intrinsic rate of natural increase (r_m), finite rate of increase (e^{rm}) and the number of times which the population multiplies in a unit time (doubling time, DT).

G. Statistical analysis

All data of biological and life table aspects of *P. gossypiella* and *E. insulana* were analyzed^[18] and Duncan's multiple range test^[19] at 5% probability level to compare the differences among time means.

Results

Lethal effects.

The newly hatched larvae of *Pectinophora gossypiella* (Saund.) treated with emamectin benzoate and triflumuron singly and exposing to gamma doses of 50 & 500 Gy to study the lethal effect as a result of treatments.

Table (1&2) obvious that emamectin benzoate+ 500 Gy was the most potent compound on *P. gossypiella* newly hatched larvae; LC₄₀ was 105.4 ppm after 1-day passed from treatment beginning and reached to 0.234 ppm at 4-day passed. Emamectin benzoate +50 Gy was followed the previous compound in its lethal effect on *P. gossypiella* newly hatched larvae; followed by emamectin benzoate

singly without exposing to gamma doses (Tables 1&2). Triflumuron had also potentiating lethal effect when exposed to gamma doses of 50 & 500 Gy; but it had the lower lethal effect than emamectin benzoate as shown in Table (1&2).

A. Biological assays.

According to pest behavior injures, the tested larval stage of the spiny bollworm, *Earias insulana* (Boisd.) was at 1st-4th instars larval stage; addition, pink bollworm, *Pectinophora gossypiella* (Saund.) newly hatched and 4th instars larvae were used for exposing to gamma doses of 50 & 500 Gy to study the deleterious changes in some biological assays as a result of larval stage exposing as described in Table (3).

1. Spiny bollworm, *Earias insulana* (Boisd.).

Gamma radiation doses of 50 & 500 Gy caused 100% larval mortality at 1st instar larvae of *E. insulana*. Also, 2nd instar larvae were dead when exposing to 500 Gy; but at 50 Gy, the larval mortality was 73.3% and the larvae spent 6 days only. On the other hand, pupation% was 26.7%; but the pupal mortality was 100% when *E. insulana* treated as 2nd instar larvae. *E. insulana* treated as 3rd instars larvae that exposed to gamma doses 50 & 500 Gy were 48&92% larval mortality for 50 & 500 Gy; while, pupation% were 52 & 8% and pupal mortality were 6.6&100% for two gamma doses of 50& 500 Gy, respectively.

Meanwhile, adult emergency was 45.6% for 50 Gy treatments and adult moth was dead after 9.5 days (Table 3). The same table showed that *E. insulana* 4th instar larvae when exposing to 50 &500 Gy; it's had larval mortality 26.7 & 80%; while, the pupal mortality were 20&10% and adult

emergency was 53.3 & 10% for 50&500 Gy, respectively; but, the adult emergency were dead at 13 & 3 days after emergency for 50 & 500 Gy.

Previous work mentioned that gamma doses of 50 Gy had a moderate efficacy against *E. insulana* egg than 500 Gy that caused 100 % egg mortality [4].

2. Pink bollworm, *Pectinophora gossypiella* (Saund.).

Newly hatched larvae of *P. gossypiella* exposed to 500 Gy had 100% larval mortality. But dose of 50 Gy caused 50% larval mortality after 21 days; while, pupal mortality was 10% as in Table (3). Adult emergency was 40% and oviposited 50 egg/female that had 50% hatching (Table 3). Dose of 500 Gy caused larval mortality 100% at 10-day passed at 4th instars larvae. While, dose of 50 Gy caused 12% larval mortality at 5-day passed; the pupal mortality was 28% and the adult emergency was 60% that laid 95egg/female and its egg hatchability was 60%.

Some biological aspects of *P. gossypiella* exposed as newly hatched larvae to gamma doses of 5-80 Gy were evaluated. Gamma doses caused a moderate delayed effect, especially with 40 & 80 Gy when compared with 5-20 Gy [20]. While, another work[21] showed that gamma-irradiation dose levels of 0.5, 1.0 and 1.5 KGy caused hundred percentage mortality in diapauses larval mortality of *P. gossypiella* at the fifth day of treatment by 1.5 KGy and the tenth day for exposing to 0.5 and 1.0 KGy. Dose of 0.5 KGy was the best dose in decreasing the total protein of *P. gossypiella* larvae. Meanwhile, the same dose (0.5 KGy) increased acetylcholine esterase activation and gave the highest enzyme activity as compared to other doses.

Table 1: Lethal effect of certain compounds on *P. gossypiella* newly hatched larvae at 1-2 days after treatments.

Treatments	LC ₄₀ ± confidence limit (ppm)	LC ₉₀ ± confidence limit (ppm)	Slope ± SE	Toxicity index	
				LC ₄₀	LC ₉₀
After 1- day					
Emamectin benzoate	216.7 (149.1±3162.2)	28488.5 (11190.3±55275.9)	0.636 ± 0.047	48.6	1.12
Emamectin benzoate + 50 Gy	120.2 (89.9±145.5)	2129.4 (1034.5 ± 6987.4)	0.724 ± 0.033	87.7	15.0
Emamectin benzoate+500 Gy	105.4 (92.6 ± 189.9)	319.5 (122.2 ± 718.4)	0.793 ± 0.053	100	100
Triflumuron	3985.9 (1468.2 ± 89852.1)	5994235.4 (1564125.1 ± 9986523.1)	0.323 ± 0.052	2.64	0.005
Triflumuron +50 Gy	2781.1 (0.8453 ± 56234.1)	2984322.3 (1239821.1 ± 7856921.1)	0.4230 ± 0.043	3.79	0.01
Triflumuron +500 Gy	1750.1 (0.4563.2 ± 3568.9)	1392582.03 (1010132.9 ± 3459684.5)	0.442 ± 0.043	6.02	0.02
After 2- day					
Emamectin benzoate	88.19 (22.45 ± 156.4)	1283.2 (1021.2 ± 5456.2)	0.584 ± 0.071	10.4	8.56
Emamectin benzoate+50 Gy	13.95 (0.465±67.88)	124.2 (48.82±250.6)	0.78 ± 0.052	66.0	88.4
Emamectin benzoate+500 Gy	9.21 (0.0234±28.89)	109.8 (26.9±220.2)	0.845 ± 0.063	100	100
Triflumuron	979.2 (245.9±1570.4)	601412.8 (235648.2±6254561.2)	0.39 ± 0.039	0.94	0.02
Triflumuron +50 Gy	768.4 (548.9±1470.2)	200359.1 (100012.2±56232.2)	0.53 ± 0.045	1.19	0.05
Triflumuron +500 Gy	475.6 (131.3±859.9)	57851.02 (23235.1±98652.1)	0.44 ± 0.069	1.94	0.19

Table 2: Lethal effect of certain compounds on *P. gossypiella* newly hatched larvae at 3-4 days after treatments.

Treatments	LC ₄₀ ± confidence limit (ppm)	LC ₉₀ ± confidence limit (ppm)	Slope ±SE	Toxicity index	
				LC ₄₀	LC ₉₀
After 3- day					
Emamectin benzoate	23.73 (2.167±55.79)	392.4 (177.5±1302.8)	0.634 ± 0.074	35.6	21.4
Emamectin benzoate+50 Gy	14.73 (0.231±32.69)	198.9 (66.45±369.2)	0.79 ± 0.062	57.4	42.1
Emamectin benzoate+500 Gy	8.451 (0.0289±18.44)	83.81 (12.12±143.3)	0.89 ± 0.085	100	100
Triflumuron	503.2 (340.4±698.9)	42252.3 (12561.1±123562.1)	0.412 ± 0.045	1.68	0.19
Triflumuron +50 Gy	102.83 (65.98±461.1)	16799.7 (14523.3±59638.6)	0.579 ± 0.058	8.22	0.49
Triflumuron +500 Gy	89.35 (32.32±348.7)	2329.4 (1123.3±86542.7)	0.56 ± 0.048	9.46	3.59
After 4- day					
Emamectin benzoate	12.09 (1.178±55.52)	144.1 (76.11±365.4)	0.69 ± 0.078	1.94	10.2
Emamectin benzoate+50 Gy	0.841 (0.0361±15.15)	76.84 (12.12±130.5)	0.93 ± 0.077	27.8	19.1
Emamectin benzoate+500 Gy	0.234 (0.0413±16.32)	14.66 (0.896±98.65)	1.56 ± 1.02	100	100
Triflumuron	409.2(22.34±785.9)	5235.2 (3121.1±9876.2)	0.58 ± 0.042	0.06	0.28

Triflumuron +50 Gy	98.42(12.54±258.8)	4252.1 (32561.1±89412.6)	0.66 ± 0.092	0.24	0.34
Triflumuron +500 Gy	10.75 (0.123±98.61)	2288.4 (1199.8±6784.4)	0.559 ± 0.047	2.18	0.64

Table 3: Gamma radiation efficiency on *E. insulana* and *P. gossypiella* biological aspects.

Biological aspects	<i>E. insulana</i> larval stage									L.S.D _{0.05}
	1 st instar		2 nd instar		3 rd instar		4 th instar		Untreated	
	50 Gy	500 Gy	50 Gy	500 Gy	50 Gy	500 Gy	50 Gy	500 Gy		
Larval duration (days)	-	-	6	-	6	7	3	7	16	
% larval mortality	100	100	73.3	100	48	92	26.7	80	5	
Pupal duration (days)	-	-	26.7	-	21	-	13.5	14	10	
% pupation	-	-	100	-	52	8	73.3	20	95	
% pupal mortality	-	-	100	-	6.6	100	20	10	0.7	
Adult duration (days)	-	-	-	-	9.5	-	13	3	18	
% Adult emergency	-	-	-	-	45.6	-	53.3	10	94.3	
	<i>P. gossypiella</i> larval stage									
Larval duration (days)	21	-	-	-	-	-	5	10	19	
% larval mortality	50	-	-	-	-	-	12	100	8	
Pupal duration (days)	11	-	-	-	-	-	12	-	12	
% pupation	50	-	-	-	-	-	88	-	92	
% pupal mortality	10	-	-	-	-	-	28	-	7	
Adult duration (days)	15	-	-	-	-	-	17	-	19	
% Adult emergency	40	-	-	-	-	-	60	-	85	
Pre-oviposition Period (days)	3	-	-	-	-	-	3	-	2	
Oviposition period (days)	5	-	-	-	-	-	7	-	14	
Post-oviposition period (days)	7	-	-	-	-	-	7	-	4	
No. egg/female	50	-	-	-	-	-	95	-	220	
% Egg hatchability	50	-	-	-	-	-	60	-	90	
% control of egg hatchability	48.9	-	-	-	-	-	38.8	-	-	
% Fecundity	20.2	-	-	-	-	-	32.3	-	100	
% sterility observed	50	-	-	-	-	-	40	-	10	
% corrected sterility	48.9	-	-	-	-	-	38.8	-	10	
Life cycle (days)	36	-	-	-	-	-	37	-	35	
Life span (days)	51	-	-	-	-	-	54	-	55	

Table 4: Some biological assays of *P. gossypiella* treated as newly hatched larvae by LC₄₀ of certain compounds.

Treatments	Larval duration (day)	Larval mortality %	Pupal duration (day)	Pupal mortality %	Pupation %	Adult Emergency %	Adult male longevity (day)
Emamectin benzoate	18 ^a	75 ^b	10 ^a	10 ^b	25 ^d	15 ^c	16 ^a
Emamectin benzoate+50 Gy	6 ^b	100 ^a	- ^b	- ^c	- ^e	- ^d	- ^b
Emamectin benzoate+500 Gy	5 ^b	100 ^a	- ^b	- ^c	- ^e	- ^d	- ^b
Triflumuron	19 ^a	50 ^c	12 ^a	10 ^b	50 ^b	40 ^b	15 ^a
Triflumuron +50 Gy	17 ^a	60 ^{bc}	15 ^a	25 ^a	40 ^{bc}	15 ^c	14 ^a
Triflumuron +500 Gy	17 ^a	70 ^b	16 ^a	25 ^a	30 ^{cd}	5 ^d	12 ^a
Untreated	19 ^a	8 ^d	12 ^a	7 ^b	92 ^a	85 ^a	15 ^a
L.S.D _{0.05}	9.73	16.6	7.75	5.42	10.6	6.65	5.69

Table 5: Some biological assays of *P. gossypiella* treated as newly hatched larvae by LC₄₀ of certain compounds.

Treatments	Pre-oviposition period (day)	oviposition period (day)	Post-oviposition period (day)	Adult female longevity (day)	No. egg/female	Egg hatchability %	Control of egg hatchability %	Fecundity %
Emamectin benzoate	2 ^a	8 ^b	4 ^a	14 ^a	120 ^b	60 ^{bc}	33.3 ^{bc}	54.5 ^b
Emamectin benzoate+50 Gy	-	-	-	-	-	-	-	-
Emamectin benzoate+500 Gy	-	-	-	-	-	-	-	-
Triflumuron	4 ^{ab}	10 ^b	6 ^a	20 ^a	130 ^b	70 ^b	22.2 ^c	59.1 ^b
Triflumuron +50 Gy	5 ^a	8 ^b	5 ^a	18 ^a	86 ^c	50 ^{cd}	44.4 ^{ab}	39.1 ^c
Triflumuron +500 Gy	5 ^a	8 ^b	5 ^a	18 ^a	70 ^c	40 ^d	55.6 ^a	31.8 ^c
Untreated	2 ^b	14 ^a	4 ^a	20 ^a	220 ^a	90 ^a	- ^d	100 ^a
L.S.D _{0.05}	1.99	3.45	2.15	9.69	21.5	16.3	16.2	11.99

Table 6: Some biological assays of *P. gossypiella* treated as newly hatched larvae with LC₄₀ by certain compounds.

Treatments	Sterility observed %	Sterility corrected %	Sex ratio %	Life cycle (day)	Life span (day)
Emamectin benzoate	40 ^{bc}	33.3 ^{bc}	55 ^a	32 ^a	46 ^a
Emamectin benzoate+50 Gy	-	-	-	-	-
Emamectin benzoate+500 Gy	-	-	-	-	-
Triflumuron	30 ^c	22.2 ^c	48 ^a	35 ^a	55 ^a
Triflumuron +50 Gy	50 ^{ab}	44.4 ^{ab}	46 ^a	36 ^a	54 ^a
Triflumuron +500 Gy	60 ^a	55.6 ^a	40 ^a	37 ^a	55 ^a
Untreated	10 ^d	10 ^d	55 ^a	35 ^a	55 ^a
L.S.D _{0.05}	14.7	11.9	14.6	14.2	16.3

Pink bollworm, *P. gossypiella* treated as newly hatched larvae with LC₄₀'s of emamectin benzoate, triflumuron, triflumuron +50 Gy and triflumuron + 500 Gy compared with untreated one with noted that emamectin benzoate +50 Gy and emamectin benzoate + 500 Gy had completely *P. gossypiella* dead during larval stage after 6 & 5 days from treatments. Untreated larval duration was 19 days as well as triflumuron treatment; but slightly decreased about 1-2 days in emamectin benzoate and triflumuron that exposed to 50&500 Gy. Emamectin benzoate was the best treatment increased from larval mortality and decreased the pupation, life cycle and life span. Meanwhile, triflumuron + 500 Gy had drastically decreased no. egg/female to reach 70 egg/female; also, percentages of egg hatchability, fecundity and sterility were decreased when *P. gossypiella* treated as newly hatched larvae as described in Table (4-6).

Life table assessments.

Newly hatched larvae of *P. gossypiella* treated with LC₄₀'s of emamectin benzoate, triflumuron, triflumuron + 50 Gy and triflumuron + 500 Gy; in addition to *P. gossypiella* newly hatched larvae and 4th instars larvae exposed to gamma dose of 50 Gy comparing with untreated one to study life table assays.

1. Female progeny/female (Mx) and survival rate (Lx).

Figure (1) described that untreated *P. gossypiella* had female daughter progeny/female ranged from 1.83 to 30.8 female daughter/female and its survival rate from 0.54 to 0.90; that value had highly decreased (0.4 – 1.8 female daughter/female) in *P. gossypiella* exposed as newly hatched larvae to gamma dose of 50 Gy; meanwhile, the same dose when *P. gossypiella* 4th instars larvae exposed to it; Mx values ranged; 0.51-24.1 female daughter/female and its survival rate were 0.1-0.62. On the other hand, Mx value increased (6.76- 50.8 female progeny/female) in emamectin benzoate treatment; but its survival rate had decreased to 0.36-0.6. Meanwhile, *P. gossypiella* newly hatched larvae treated with LC₄₀ of triflumuron; Mx (4.80-21.60 female daughter/ female) and its survival rate (0.42-0.7) were decreasing than untreated one. Moreover, triflumuron +50 Gy and triflumuron + 500 Gy had the highly Mx (5.98-15.64 & 2-14 female daughter/female) and Lx (0.30-0.50 & 0.2-0.4) values were decreased than other treatments and untreated one.

2. Developmental time.

That time extended from egg stage to female oviposition period as in Table (7). Normal developmental time was 51 days. That time affected by different treatment used to reach 42 days in emamectin benzoate treatment as well as *P. gossypiella* newly hatched larvae that was exposing to gamma dose of 50 Gy; also, developmental time was 49 days in triflumuron treatment as well as treatments of triflumuron +50 Gy or triflumuron + 500 Gy nearly that treated as newly hatched larvae.

3. Generation time (T).

Untreated *P. gossypiella* generation time (T) was 53.6 days. While, all the treatments used were decreased *P. gossypiella* generation time, especially when treated by emamectin benzoate (43.9 days) as shown in Table (7).

4. Net reproductive rate (Ro).

That period defined as number of females' progeny/female in one generation. Table (7) showed that triflumuron +500 Gy and triflumuron + 50 Gy had the most drastically decreased from net reproductive rate (10.4 & 15.6 females/female in one generation) comparing with normal net reproductive rate (104.5 females/female in one generation). Whereas, net reproductive rate (Ro) of newly hatched larvae exposed to dose of 50 Gy, emamectin benzoate, triflumuron and 4th instars larvae exposed to 50 Gy were 33.3, 34.3, 38.6 and 40.3 females/female in one generation.

5. Intrinsic rate of natural increase (r_m).

Ability of inheriting increase for pest is known as intrinsic rate of natural increase (r_m). Normal *P. gossypiella* r_m was 0.087 individual/ female/ day. That normal value was decreasing, especially in triflumuron + 500 Gy, followed by triflumuron + 50 Gy, triflumuron, emamectin benzoate, dose of 50 Gy that treated as newly hatched larvae and 4th instars larvae (Table 7).

6. Finite rate of increase (e^{rm}).

The same Table (7) obvious that all treatments gave the same trend in finite rate of increase (e^{rm}) that showed to daily population of *P. gossypiella* treated as newly hatched larvae was drastically decreased in triflumuron +500 Gy, followed by triflumuron + 50 Gy, triflumuron, emamectin benzoate and 50 Gy treatments that comparing with normal finite rate of increase (1.091 individual/day).

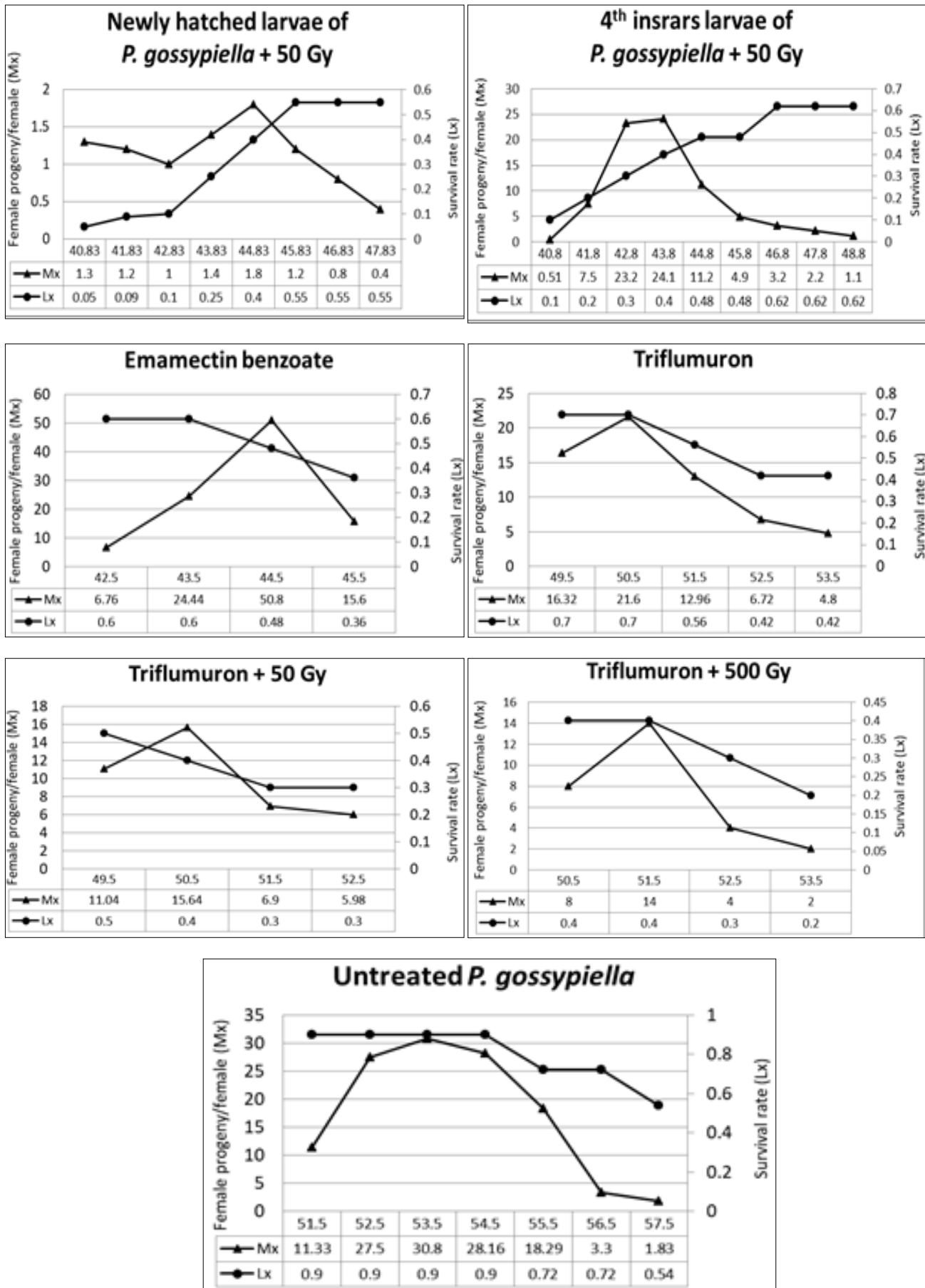


Fig 1: Female progeny/female (Mx) and survival rate (Lx) of *P. gossypiella* treated as newly hatched larvae with certain treatments.

Table 7: Life table assays of *P. gossypiella* affected by certain treatments.

Treatments	Developmental Time (days)	T (days)	(Ro)	Increase rate		DT (days)
				r_m	e^{rm}	
Emamectin benzoate	42	43.9	34.3	0.080	1.084	8.62
Emamectin benzoate+50 Gy	-	-	-	-	-	-
Emamectin benzoate+500 Gy	-	-	-	-	-	-
Triflumuron	49	50.7	38.6	0.072	1.075	9.61
Triflumuron +50 Gy	49	50.5	15.6	0.055	1.056	12.8
Triflumuron +500 Gy	50	51.4	10.4	0.046	1.047	15.2
Newly hatched +50 Gy	42	44.7	33.3	0.085	1.089	8.14
4 th instars larvae +50 Gy	40.3	43.4	40.3	0.086	1.091	8.05
Untreated	51	53.6	104.5	0.087	1.091	8.06
L.S.D. 0.05						

(T) = Generation time (Ro) = Net reproductive rate (r_m) = Intrinsic rate of natural increase (e^{rm}) = Finite rate of increase (DT) = Doubling time

7. Doubling time (DT).

Number of population to be twice known as doubling time (DT). Table (7) showed that triflumuron + 500 Gy had the longest time to duplicate (15.2 days) when *P. gossypiella* newly hatched larvae treated with it, followed by treatments of triflumuron + 50 Gy and triflumuron singly. Meanwhile, treatments of emamectin benzoate and dose of 50 Gy were as well as nearly untreated value. [22] The newly hatched larvae of *P. gossypiella* exposed to gamma doses of 5-80 Gy to study the life table parameters. All the treatments decreased from survival rate (Lx), intrinsic rate of natural increase (r_m), finite rate of increase (e^{rm}), net reproductive rate (Ro). While, generation and doubling times were increased as affected by exposing *P. gossypiella* newly hatched larvae to gamma doses. Also, [4] gamma ray dose of 500 Gy was the most efficacies on *E. insulana* egg compared with other treatments used. The aforementioned dose caused 19.3% egg hatchability and the larvae were completely dead at 1st or 2nd instar larvae of *E. insulana*. A dose of 50 Gy had a hatchability percentage (75%), but it caused the increasing larval mortality and completely pupal stage death.

Discussion

It could be concluded that when *E. insulana* treated as larval stage with gamma radiation doses (50 & 500 Gy), it drastically affected, especially in 1st and 2nd larval stage that increased the mortality; while, 3rd and 4th larval stage were completely dead on pupal stage (500 Gy) or adult stage (50 Gy). Meanwhile, *P. gossypiella* when exposed as newly hatched larvae or 4th instars larvae to gamma doses of 50 & 500 Gy, observed that 500 Gy had completely dead in the larval stage; while, dose of 50 Gy caused deleterious effects in the biological aspects.

On the other hand, the two compounds of emamectin benzoate and triflumuron that exposed to gamma doses of 50 & 500 Gy had potentiating lethal effect against *P. gossypiella* newly hatched larvae. Dose of 500 Gy increased from compounds potency to cause larval mortality as well as emamectin benzoate + 50 Gy. Other treatments of emamectin benzoate, triflumuron, triflumuron + 50 Gy, triflumuron + 500 Gy and dose of 50 Gy had deleterious effects on the most biological and life table assessments.

Many authors worked on emamectin benzoate efficacy on the bollworms [23] that assessed the reproductive inhibition and toxicity of emamectin benzoate on *Helicoverpa zea* (Boddie) when ingested by the adults if mixed as ppm active ingredient (wt:vol) with 2.5 M sucrose as a feeding stimulant. Because the mixture had to be ingested for its

function effect; also, effect of emamectin benzoate was evaluated at sub-lethal and lethal concentrations on proboscis extension and gustatory response of *H. zea* in the laboratory. Feral males captured in sex pheromone-baited traps in the field were used for toxicity evaluations because they were readily available and were more representative of the field populations than laboratory-reared adults. Laboratory-reared female moths were used for reproduction effects because it is very difficult to collect newly emerged feral females from the field. Emamectin benzoate was highly toxic to feral *H. zea* males with LC₅₀ values being 0.718, 0.525 and 0.182 ppm for 24, 48 and 72 h responses, respectively. Sub-lethal concentrations of emamectin benzoate did not significantly reduce proboscis extension response of feral males and gustatory response of female *H. zea*. Sublethal concentrations of emamectin benzoate had significantly reduced percent larval hatch of eggs and mating frequency of *H. zea* female. Larval survival to the pupal stage was also significantly reduced by ingestion of emamectin benzoate by *H. zea* female. These data suggest that emamectin benzoate is a useful toxicant in an attract-and-kill control strategy against *H. zea*. On the other hand, [6] emamectin benzoate caused an decrease in *P. gossypiella* larval, pupal & adult durations; pupation, adult emergency, oviposition period, egg laying rate, egg hatchability, fecundity, life cycle and life span. Meanwhile, the compound increased the mortality percentages of larval, pupal & adult post oviposition period, reductions in hatchability and sterility. Prediction aspects of *P. gossypiella* treated as newly hatched larvae by LC₅₀'s of emamectin benzoate was affected; All the aspects used; female progeny/female (Mx), survival rate (Lx), generation time (T), net reproductive rate (Ro), intrinsic rate of natural increase (r_m), finite rate of increase (e^{rm}) and doubling time (DT) were decreased in the pest as affected by tested compound treatments compared to untreated one. While, [24] lethal and sublethal effects of emamectin benzoate insecticide on the third instar larvae of *H. armigera* by residue contact methods at 26 ± 1°C, 70 ± 5% RH and a photoperiod of 16:8h (L:D) under laboratory conditions. LC₅₀ value, on the pest larval stage of emamectin benzoate was 1.75 µg a.i./ml. According to the findings, the larvae that were exposed to the LC₃₀ of emamectin benzoate exhibited lower pupal weight and increased larval & pupal developmental times compared with control. The longevity and fecundity of adults were significantly affected by the insecticide. Emamectin benzoate reduced the fecundity by 53.1% compared to control. The LC₃₀ value of emamectin benzoate reduced egg hatching by 62.06%. It is predicted

that these insecticide (emamectin benzoate) may induce significant effects on *H. armigera* population. Meanwhile,^[25] the newly hatched larvae of *P. gossypiella*, (Lab. Strain) with LC₂₀ values of six insecticides; among of them, emamectin benzoate (0.154 ppm) to study its effects on duration of larval, pupal, total immature stages, longevity, fecundity and fertility of resulted adults. Larval period was prolonged to 15.84 days compared to 14.63 days in control; while, pupal period estimated by 13.04 and 8.84 days in treatment and control, respectively. On the other hand, the adult stage resulted from treated larvae was highly affected by used compound. The respective fecundity was reduced to 85.74 eggs /female compared to 262.48 eggs/♀ in control. The percentage of hatchability was 56.29 compared with 96.45 % in control. Also,^[26] the field experiments during 2011 and 2012 cotton growing seasons to evaluate the efficacy commercial formulation of four insecticides; among of them, emamectin benzoate, against the pink bollworm, *P. gossypiella* and spiny bollworm, *E. insulana*. Emamectin benzoate was the most efficient compound during the two seasons. Average reductions of two seasons were 46.55 and 49.61% against pink and spiny bollworms. Also, the toxicity of these compounds was determined against 4th instar larvae of *E. insulana* using film residue assay method under laboratory conditions. The data revealed that emamectin benzoate was a superior potent compound with LC₅₀ value was 1.42 ppm. In addition,^[5] the cidal and antifeedant potential of emamectin benzoate and a semi-synthetic avermectin derived from the soil actinomycetes, *Streptomyces avermitilis*; against early IV instars of *H. armigera*. Larvae were fed on the castor leaf discs (3.5 cm diameter) dipped in different concentrations of emamectin benzoate; ranging from 0.05 -1.5 µg/ml. The leaf disc areas were measured pre-and post-larval feeding to estimate the antifeedant potential of compound. The effect of feeding was also assessed on the survival of larvae by scoring the larval mortality till 96 h. Our investigations showed significant larvicidal potential of emamectin benzoate against *H. armigera* revealing respective LC₅₀ values of 0.26, 0.095, 0.043 and 0.027 µg/ml after 24, 48, 72 and 96 h feeding. Furthermore, a remarkable decrease of 93.59% was observed in larval feeding potential indicating significant antifeedant efficacy of emamectin benzoate. A strong correlation between antifeedant index and the emamectin benzoate concentration resulted in 1.48-fold index reduction with a decrease in concentration. Also, an emamectin benzoate was considered as an effectual larvicidal and antifeedant agent against *H. armigera*. Employing selective insecticide can tackle issues of pest resistance and pest resurgence after ascertaining in the fields as *Helicoverpa* control agent and negating impact on non-target organisms. Also,^[27] the effect of emamectin benzoate (EB) on the survival, growth and nutrition efficiency of *H. armigera*. Dietary EB exhibited a significant systemic toxicity in *H. armigera* larvae resulting in LD₅₀ and LD₉₀ value of 0.092 and 0.156 µg/ml, respectively. Feeding with 0.05–0.2 µg/mL EB caused 10–100% larval mortality in a dose-dependent manner. Feeding the IV instars of *H. armigera* with 0.1–1.6 µg/mL EB-incorporated diet deterred feeding significantly. Substantial deterrent effects of EB with lower LD₅₀ values indicate the noteworthy systemic toxicity of EB on the *H. armigera* larvae. Both choice and no choice bioassay with dietary EB showed a distinct preference of larvae towards control diet. Larvae were

feeding with sub lethal doses of 0.05–0.01 µg/ml, EB impaired ingestion and digestion, induced considerable post-ingestive toxicity in larvae. Relative Consumption Rate (RCR) and the Relative Growth Rate (RGR) were recorded in the range of 1.653–3.985 and 0.385–0.978, respectively. The nutrition indices of larvae revealed reduction in Efficiency of Conversion of Ingested Food (ECI) by 10–24% and Efficiency of Conversion of Digested Food (ECD) by 2.0–52% and in Approximate Digestibility (AD) by 09–63%. The noticeable decrease in the food utilization, digestion and assimilation may have resulted in the observed reduced larval growth. The decreased metabolic efficiency in *H. armigera* larvae implicated that dietary EB probably weakened the biochemical machinery of larval gut and reduced physiological fitness. The results suggest that use of EB can be an effective tool in Integrated Pest Management program of *H. armigera*.

Triflumuron as a chitin synthesis inhibitor (CSI) was a target for many researches to control some pests as^[8] that tested triflumuron among Insect Growth Regulators for its efficacy against the larvae of the spiny bollworm, *Earias insulana* (Boisd.), in the laboratory experiments. The compound was incorporated at different concentrations in an artificial diet and 5-day old larvae were introduced and grown on the treated diets until pupation and adult emergence was active only at 50 ppm. When cotton bolls were dipped in triflumuron and offered to 6-day old larvae in the laboratory, only 4% and 10% of the larvae penetrated inside the bolls treated with 50 and 25 ppm a.i., respectively; whereas, 68% penetrated inside untreated bolls. While,^[9] the effect of triflumuron (LC₄₀, LC₅₀, LC₆₀) on total and differential haemocyte on 3rd and 5th instar larvae of *H. armigera*. The total haemocyte count just after the application of LC₅₀ of triflumuron at 3rd instar larvae increased (78900 cells/mm), while decreased (83800 cells/mm) after half an hour, and increased again (90200 cells/mm) after one hour of application from the normal count (68175 cells/mm). The percentage of prohaemocytes decreased from normal (42 to 26%); whereas, the percentage of plasmatocytes, spherulocytes, cystocytes, and granulocytes increased from normal (18, 29, 2.75 and 8.25% to 29, 32, 4 and 10%, respectively after the application of insecticide. Similar results were recorded with 5th instar larvae. In addition,^[10] chitin synthesis inhibitors (CSIs) are quite distinctive in its mode of action and potentially act on the target species. The susceptibility of laboratory 2nd & 4th instar larvae of cotton leaf worm, *Spodoptera littoralis* (Boisd.) to CSI (Triflumuron) was evaluated. The biochemical response of *S. littoralis* larvae was detected using the LC₅₀ of the compound, triflumuron (75.28) for the 2nd instar larvae; while, (1661.58 ppm) with 4th instar larvae. Second instar was more susceptible than the older ones. Triflumuron exhibited variations of activities for each enzyme. It increased the activity of AST (Aspartate Transaminase), on the contrary they decreased the activity of ALT (Alanine Transaminase). Triflumuron increased the activity of alpha esterases, acid phosphatase, chitinase and phenol oxidase; while, it decreased the activity of both beta esterase and alkaline phosphatase.

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