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Gamma radiation for potentiating azadirachtin and fertacho efficacy to control *Pectinophora gossypiella* (Saund.)

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Abstract
Azadirachtin and fertacho are two insecticide compounds were exposed to gamma radiation doses of 400 & 700 Gy for potentiating purposes against the pink bollworm, *Pectinophora gossypiella* (Saund.) treated as 1-4 day old eggs to study the lethal effect of compounds used. In addition to biological and life table parameters of *P. gossypiella* treated as 1-day old egg by two aforementioned compounds. A dose of 700 Gy can potentiate the efficacy of both tested compounds, followed by a dose of 400 Gy to become the efficacies of azadirachtin and fertacho was higher than the compounds when used singly without exposing to gamma doses. In addition, most of the biological aspects (larval, pupal & adult stages) and life table parameters of female daughter/female (Mx), survival rate (Lx), developmental time, generation time (T), net reproductive rate (Ro), intrinsic rate of natural increase (r_m), finite rate of increase (e^{rm}) and doubling time for *P. gossypiella* treated as a 1-day old egg were affected by gamma doses used.
So, gamma doses of 700 Gy, followed by 400 Gy can potentiate azadirachtin and fertacho efficacies against *P. gossypiella* than its efficacies when used singly without exposing to gamma doses.

Keywords: gamma radiation, azadirachtin, fertacho, *p. gossypiella*, lethal, biological, life table

Introduction
The Pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechiidae) is the most important pest distributed throughout the world's cotton-growing areas. If an infestation occurs in the early and mid-growing season, it causes damage to the square and flowers of cotton plants [1].
Conventional insecticides use to control the bollworms causes the resistance that evolved for pest towards the most insecticides used. So, towards eco-friendly compounds for control strategy that could be combined with gamma radiation for potentiating purposes as mentioned before [2, 3].
Gamma radiation is considered a genetic control method; it involves the release of genetically modified insects to control the same species [4]. In addition, [5] studied the effect of a safe chemical (azadirachtin) for the effective management of lepidopteran pest, *Spodoptera litura* (Fab.). Moreover, *S. litura* were exposed to radiation prior to insecticidal treatment. While, [6] they found the neem (*Azadirachta indica*) to be a potent anti-feedant and growth inhibitor to the cotton bollworm, *Helicoverpa armigera* (Hubner). Growth inhibition in topical treatment of *H. armigera* may be primarily attributed to decreased food intake. Meanwhile, [7] when used the pesticides at repetitive application have increased the input cost of the local farmer and similarly aroused the serious problem of pest resistance. Nevertheless, the indigenous botanical extracts have been used effectively against various sucking pests of cotton but only a few studies have been attempted to observe their action against bollworms. Three local extracts were tested; among them the neem (*Azadirachtin indica*) was used in the traditional method. The overall results showed that the sprays at different intervals indicated the highest pest population reduction at neem (14.58-15.33%) and a similar trend was also noted in the second year of the study. The bio-extracts were much effective until 48 hrs, which indicated that these bio-pesticides need to spray repeatedly. While, [8] it was showed that Azadirachtin-A (AzaA) (*Azadirachta indica*) has insecticidal properties; however, its molecular mechanism remains elusive. The "targeted and no targeted proteomic profiling", metabolomics, matrix-assisted laser desorption/ionization-time of flight (MALDI-TOF) imaging, gene expression, and in silico analysis were provided clues about its action on *Helicoverpa armigera* (Hub.). Fourth instar *H. armigera* larvae fed on AzaA-based diet (AzaD) were suffered from significant mortality, growth retardation, reduced larval mass, complications in molting, and prolonged development. Furthermore, the death of larvae fed on AzaD-was observed with various phenotypes like bursting, blackening and half-molting. Overall, data suggest that AzaA generally targets more than one protein in *H. armigera* and hence could be a potent bio-pesticide. Life tables consider as a prediction tool for pest populations. The life table program has predicted about effecting tested compounds on the pest to obvious the impact of the tested factors on the developmental increase rate of the pest population [9, 10]. Thus, current work aims to potentiate the two compounds of azadirachtin and fertacho by exposing them to gamma doses of 400 & 700 Gy to study the lethal, biological, and life table parameters of the pink bollworm, *Pectinophora gossypiella* (Saund.) treated as a 1-day old egg.

Materials and Methods
The Pest
A laboratory strain of the pink bollworm, *Pectinophora gossypiella* (Saunders) (Lepidoptera: Gelechidae) was 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±1ºC and 65-75% RH.

Compounds

1. **Achook (0.15% EC.): Azadirachtin, *Azadirachta indica* A. Juss;** 750 cm^3/ feddan; a product of Bahar agrochem & feeds Company, India; imported by Al-Masrya for agriculture development, Beheira Governorate, Egypt.
2. **Fertacho (40% W.P): Thiamethoxam 20% + chlorantranelebrol 20%;** 35 gm/ feddan; a product of Syngenta Agro Swetherland, Qalubeiah Governorate, Egypt.

Radiation Treatments

Egg stage at 1-day old of *Pectinophora gossypiella* (Saunders) was exposed to gamma radiation doses of 400 & 700 Gy. In addition, compounds of azadirachtin and fertacho were exposed to the same two doses (400 & 700 Gy). All irradiations were done by a Cesium [137] Indian GC Research, National Center for Radiation Research and Technology, delivered at a dose rate of 1.277 K.Gy/h.

Lethal Assays

One-four day old eggs were the stage used for lethal assays by using the compounds of azadirachtin and fertacho alone or exposing to gamma doses of 400 & 700 Gy. The dipping technique was used for treatments. Three replicate/ treatment/ concentration/ tested compound. 1-4 day old egg of *P. gossypiella* was dipped in distilled water for untreated comparison. The treatments kept at 27±1ºC and 65-75% R.H. Then, the egg treatments were investigated (alive, and dead egg).

LC_{50}, LC_{90}, and slope values were assessed [12, 13] by using Ldp-line software (www.Ehabbakr software/Ldp line).

The comparing among treatments efficacy was according [14] as follows:

Toxicity index = LC_{50} (LC_{90}) of the compound A/ LC_{50} (LC_{90}) of the compound B X 100

Where A: The most effective compound and B: The other tested compound.

Biological Parameters

One old egg of *P.gossypiella* treated with LC_{50}'s of azidrachtin and fertacho. Also, an untreated 1-day old egg was done. The following biological parameters were investigated as follows:

Larval stage

- **Larval duration** (days) was observed from the hatchability of treated egg till pupation.
- **Larval mortality percentage.**

% Larval mortality= No. dead larvae/ Total treated larvae X 100 % corrected mortality according [12] to following formula:

% corrected mortality=% treatment mortality-% check mortality/100-% check mortality X 100

Pupal stage

- **Pupal duration** was observed from pupation beginning till adult emergency (days).
- **% Pupation**= No. produced pupae/Total treated larvae X100

Dult stage

- **% Moths emergency** = No. emerged moth/total treated larvae X100
- **Pre-oviposition, oviposition, and post-oviposition periods** were determined by three replicates. Each one contained 5 pairs of emerged moths in a clean glass chimney (17 cm height and 7-12 cm in diameter) till female moth death.
- **Egg laying rate (total number of egg/ female):** deposited eggs were daily counted on a piece of paper on glass chimneys. Each treatment data 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** was 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
- **Corrected sterility percentage:** calculated [15] as follows:
- % Corrected sterility = % Sterility observed – Check/ 100- Check X 100

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

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

Life span: extended from egg deposition to adult moth death (days).

Life Table Parameters

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

Statistical analysis

All biological aspects and life table parameters of *P. gossypiella* were analyzed by using [18] Duncan's multiple range tests [19] at 5% probability level to compare the differences among time means.

Results

Lethal Effects

Pink bollworm, *Pectinophora gossypiella* (Saund.) egg stage was treated with two compounds (azadirachtin and

fertacho), each of them exposed to gamma doses of 400 and 700 Gy for potentiating purpose.Table (1) showed *P. gossypiella* egg stage at 1-day old was the most susceptible to the compounds used than the 2-day old egg. Gamma radiation can potentiate tested compounds efficacy than the same compounds when used singly without exposure to gamma doses. Also, azadirachtin + 700 Gy was the best treatment efficacy on a 1-day old egg, followed by azadirachtin + 400 Gy, azadirachtin singly, fertacho + 700 Gy, fertacho +400 Gy and then fertacho singly. Two-day old eggs of *P. gossypiella* treatments were at the same trend of the result in one-day old egg treatment but persistence towards compounds than 1-day old eggs of *P. gossypiella* (Table 1). Also, Table (2) found that 3-day old eggs are susceptible is comparing with 4-day old eggs treatments.

Biological Aspects

P. gossypiella treated as a 1-day old egg with LC_{50}'s by tested compounds to observe some biological aspects of *P. Gossypiella* as affected by the treatments.

Larval Stage

Gamma radiation doses of 400 &700 Gy caused 100% larval mortality after 9& zero-days from gamma radiation exposing beginning as a 1-day old egg (Table 3). [20] It was showed that 1-day old egg is more sensitive to gamma irradiation. Then the other ages of 2, 3- day old egg had moderate susceptible to irradiation. While, 4- day old egg stage was the least harmful than other treatments used.

On the other hand, larval duration decreased about 2-3 days in fertacho treatments and increased 1- day in azadirachtin treatment; also, it was as well as untreated in azadirachtin treatment. Fertacho +700 Gy was the most effective compound increased the larval mortality of *P. gossypiella* treated as 1-day old egg to 78%, followed by fertacho +400 Gy as well as azadirachtin + 700 Gy (70%); also, fertacho as well as azadirachtin +400 Gy caused 60% larval mortality when *P. gossypiella* treated as a 1-day old egg.

Table 1: Lethal effect of certain compounds on *P. gossypiella* 1-2 day old egg stage.

Treatments	LC_{50} ± confidence limit (ppm)	LC_{90}± confidence limit (ppm)	Slope ± SE	Toxicity index	
				LC_{50}	LC_{90}
	1- day old egg				
Azadirachtin	12.38 8.178±18.56	1488.4 668.7±4518.8	0.616± 0.0565	4.543	1.802
Azadirachtin +400 Gy	5.064 3.009±8.153	1030.3 348.8±5901.7	0.5552± 0.0707	11.11	2.603
Azadirachtin +700 Gy	0.563 0.358±0.8231	26.82 14.652±62.941	0.7636± 0.0776	100	100
Fertacho	253.3 165.6±362.9	8299.4 4291.1±23117.8	0.8457± 0.1039	0.222	0.323
Fertacho + 400 Gy	73.81 43.79±112.95	6188.7 2984.9±18246.5	0.6663± 0.0746	0.762	0.433
Fertacho + 700 Gy	12.55 5.105±23.98	10149.4 3515.7±53678.7	0.4407± 0.0552	4.481	0.264
	2- day old egg				
Azadirachtin	240.2 151.8±380.2	19984.5 6865.9±131350.4	0.668± 0.0989	0.99	2.691
Azadirachtin, +400 Gy	135.2 81.72±206.1	9013.7 3687.2±41347.4	0.7027±m 0.1002	1.76	5.965
Azadirachtin +700 Gy	2.383 1.462±3.993	537.7 159.3±3926.4	0.545±0.0704	100	100
Fertacho	21743.315012.1±32082.2	1206770.4 552869.3±3732714.2	0.7347±0.0745	0.011	0.044
Fertacho + 400 Gy	11923.1 8231.3±16998.7	542701.2 279087.8±1388315.5	0.773± 0.0754	0.019	0.099
Fertacho + 700 Gy	9234.1 6522.3±12769.6	284110.7 163274.7±605149.6	0.8612± 0.0785	0.026	0.189

Table 2: Lethal effect of certain compounds on *P. gossypiella* 3-4 day old egg stage.

Treatments	LC_{50} ± confidence limit (ppm)	LC_{90}± confidence limit (ppm)	Slope ±SE	Toxicity index	
				LC_{50}	LC_{90}
	After 3- day				
Azadirachtin	294.9 174.7±471.9	56284.4 19716.7±301799.8	0.5619± 0.0709	3.272	1.002
Azadirachtin +400 Gy	199.02 111.75±321.2	38793.214258.8±192765.4	0.5597± 0.0713	4.848	1.453
Azadirachtin +700 Gy	9.649 6.631±14.264	563.7 256.2±1771.1	0.726± 0.0742	100	100
Fertacho	31945.6 21037.4±51338.2	3124790.11143741.5±14507288.4	0.644±0.0728	0.0302	0.018
Fertacho + 400 Gy	18846.7 12663.2±28377.5	1420300.7 606077.1±5017141.8	0.6827± 0.0731	0.0512	0.040
Fertacho + 700 Gy	11647.37821.5±16997.1	710361.01 339703.9±2066929.5	0.7179± 0.0741	0.083	0.079
	After 4- day				
Azadirachtin	654.9 453.9±962.7	34737.7 16112.9±105100.4	0.7431± 0.0747	9.379	15.25
Azadirachtin +400 Gy	928.3 626.6±1440.9	67266.7 27211.03±258689.6	0.6890±0.074	6.617	7.876
Azadirachtin +700 Gy	61.42 38.73±97.77	5297.9 1787.9±36288.1	0.6621±0.099	100	100
Fertacho	62299.9 42785.5±93219.6	5050123.5 2299148.4±14811737.8	0.6174± 0.0583	0.099	0.105
Fertacho + 400 Gy	31709.5 21303.9±49602.2	2422552.4 960693.6±9661247.9	0.6806± 0.0737	0.194	0.219
Fertacho + 700 Gy	17493.412032.9±25569.4	974053.5 457056.4±2901599.6	0.7341±0.0743	0.351	0.544

Pupal Stage

The normal pupal duration was 12 days and mortality 7% (Table 3). That untreated mortality increased to 30% at azadirachtin treatment. Meanwhile, pupation % ranged from 22-50% in all the treatments as eggs compared to normal pupation (92%). Also, adult emergency % ranged (15-30%) compared to 85% emergency in untreated one as illustrated in Table (3).

Table 3: Some biological aspects of *P. gossypiella* treated as egg by LC_{50}'s of certain compounds.

Treatments	Larval duration (days)	Larval mortality %	Pupal duration (days)	Pupal mortality %	Pupation %	Adult Emergency %	Adult male longevity (days)
400 Gy	9 b	100 a	- d	- e	- e	- d	- d
700 Gy	- c	100 a	- d	- e	- e	- d	- d
Azadirachtin	20 a	50 c	11 ab	30 a	50 b	20 c	15 bc
Azadirachtin +400 Gy	17 a	60 bc	7 c	22 b	40 bc	18 c	20 ab
Azadirachtin +700 Gy	19 a	70 b	7 c	15 bc	30 cd	15 c	22 a
Fertacho	16 ab	60 bc	12 a	10 cd	40 bc	30 b	12 c
Fertacho + 400 Gy	16 ab	70 b	9 bc	15 bc	30 cd	15 c	12 c
Fertacho + 700 Gy	17 ab	78 b	7 c	12 cd	22 d	15 c	11 c
Untreated	19 a	8 d	12 a	7 de	92 a	85 a	15 bc
L.S.D$_{0.05}$	6.81	16.5	2.62	6.79	11.6	8.17	5.24

Table 4: Some biological aspects of *P. gossypiella* treated as egg by LC_{50}'s of certain compounds.

Treatments	Pre-ovipositio period (days)	Oviposition period (days)	Post-oviposition period (days)	Adult female longevity (days)	No. egg/female	Egg hatchability %	Control of egg hatchability %	Fecundity %
Azadirachtin	4 bc	12 ab	2 b	18 bc	160 bc	70 bc	22.2 c	72.7 bc
Azadirachtin +400 Gy	7 a	10 ab	7 a	24 ab	140 cde	60 cd	33.3 b	63.6 de
Azadirachtin+700 Gy	5 ab	12 ab	8 a	25 a	125 e	50 d	44.4 a	56.8 e
Fertacho	4 bc	8 b	4 b	16 c	169 b	80 ab	11.11 d	76.8 b
Fertacho + 400 Gy	4 bc	8 b	4 b	16 c	150 bcd	70 bc	22.2 c	68.2 cd
Fertacho + 700 Gy	5 ab	9 ab	2 b	16 c	130 de	60 cd	33.3 b	59.1 e
Untreated	2 a	14 a	4 b	20 abc	220 a	90 a	- e	100 a
L.S.D$_{0.05}$	2.19	4.86	2.19	5.73	22.2	14.04	7.34	7.09

Adult Stage

Adult male longevity that treated as 1-day old egg was ranged from 11 to 22 days compared with untreated *P. gossypiella* (15 days) as shown in Table (3).

P. gossypiella treated as a 1-day old egg with tested compounds had increased in the pre-oviposition period, especially with azadirachtin +400 Gy (7-days) compared with untreated one (2-days) as in Table (4).

Fertacho treatments had the lower oviposition period (8-9 days) than azadirachtin treatments (10-12 days) that treated as 1- day old egg of *P. gossypiella* comparing with untreated (14 days) as in Table (4).

Fertacho and fertacho + 400 Gy were as well as the untreated value of *P. gossypiella* post-oviposition period that was 4 days. That period decreased to half in azadirachtin and fertacho + 700 Gy treatments as a 1-day old egg of *P. gossypiella* (Table 4).

All the treatments used caused adult female longevity was decreasing comparing with normal *P. gossypiella* (20 days) except for azadirachtin + 400 Gy and azadirachtin +700 Gy treatments that caused elongation about 4-5 days than untreated one (Table 4). Azadirachtin and fertacho treatments, especially with gamma doses had decreased no. of egg/female of *P. gossypiella* treated as a 1-day old egg than normal no. egg/female (220egg/♀) as described in Table (4). Also, egg hatchability of egg by females treated as 1-day old egg by tested compounds was decreasing comparing with untreated *P. gossypiella* egg hatchability (90%) as shown in Table (4).

Tested compounds of azadirachtin and fertacho, when used singly or exposed to gamma doses for *P. gossypiella*, treated as a 1-day old egg had control of egg hatchability ranged from 11.11 to 44.4% decreasing than normal egg hatchability (Table 4).

Meanwhile, the fecundity of *P. gossypiella* treated as 1- day old eggs by treatments used ranged from 56.8 to 76.8%; while, untreated fecundity was 100% (Table 4).

Table (5) illustrated that normal *P. gossypiella* sterility observed was 10%. Treating *P. gossypiella* as a 1- day old egg by compounds used caused sterility observed mentioned ranged from 20-50% (Table 5). The same trend was observed in sterility corrected (Table 5).

Untreated sex ratio was 55% (female/ total female and male). That ratio was decreased from 54 to 48% of *P. gossypiella* treated as a 1-day old egg as affected by compounds used (Table 5).

Different treatments caused decreasing in life cycle time (30-34 days) except for azadirachtin treatment that was increased about 2-days than normal life cycle time (35 days). On the other hand, life span time (extended from egg stage to adult moth death) of untreated *P. gossypiella* was 55 days as well as azadirachtin treatment with *P. gossypiella* treated as a 1-day old egg; whereas, other treatments had decreased life span time, except azadirachtin + 700 Gy treatment that had increased about 2-days than normal life span time (Table 5).

Table 5: Some biological aspects of *P. gossypiella* treated as egg with LC_{50}' s by Certain compounds.

Treatments	Sterility observed %	Sterility corrected %	Sex ratio %	Life cycle (day)	Life span (day)
Azadirachtin	30 bc	22.2 c	48 c	37 a	55 a
Azadirachtin +400 Gy	40 ab	33.3 b	49 c	30 a	54 a
Azadirachtin +700 Gy	50 a	44.4 a	51 abc	32 a	57 a
Fertacho	20 cd	11.11 d	52 abc	34 a	50 a
Fertacho + 400 Gy	30 bc	22.2 c	50 bc	31 a	47 a
Fertacho + 700 Gy	40 ab	33.3 b	54 ab	30 a	46 a
Untreated	10 d	10 d	55 a	35 a	55 a
L.S.D$_{0.05}$	17.8	7.43	4.39	10.04	12.2

[20] It was showed that irradiating the biocide, Dipel-2x with doses 5 up to 80 Gy of gamma irradiation activities its insecticidal efficiency against two harmful stages of the *Pectinophora gossypiella* (Saund.) newly hatched larvae and eggs of 1-4 day old.

Life Table Parameters

P. gossypiella treated as 1- day old egg with LC_{50}'s of different six treatments comparing with untreated *P. gossypiella* values was described in figure (1,2) and Table (6) to discuss the life table parameters of *P. gossypiella.*

Female Progeny/female (Mx) and Survival Rate (Lx)

Fertacho +700 Gy had the highly Mx decreasing (5.94-21.6 female daughter progeny/female) and its survival rate (0.36-0.6) comparing with fertacho +400 Gy and fertacho used singly when *P. gossypiella* treated as a 1- day old egg with treatments mentioned compared with normal female daughter progeny/female (Mx) that ranged from 1.83 to 30.8 female progeny/female and the normal survival rate ranged; 0.54-0.9 as illustrated in Figure (1).

Figure (2) illustrated that azadirachtin treatment with *P. gossypiella* treated as 1-day old egg had the least Mx value (4.8-19.2 female daughter progeny/female) comparing with azadirachtin +400 Gy or azadirachtin +700 Gy; but, the end one had drastically survival rate (Lx) decreased (0.4-0.5) comparing with untreated one of *P. gossypiella.*

Developmental Time

Time extended from egg stage to adult female oviposition period known as developmental time. That time was 51 days in normal *P. gossypiella*. Treatments used had decreased developmental time (43-49 days), when *P. gossypiella* treated as 1-day old egg, except for azadirachtin treatment that increased the time about 2-days than untreated one (Table 6).

Generation Time (T)

The trend found in the previous parameter of developmental time was appeared in generation time (T) as shown in Table (6).

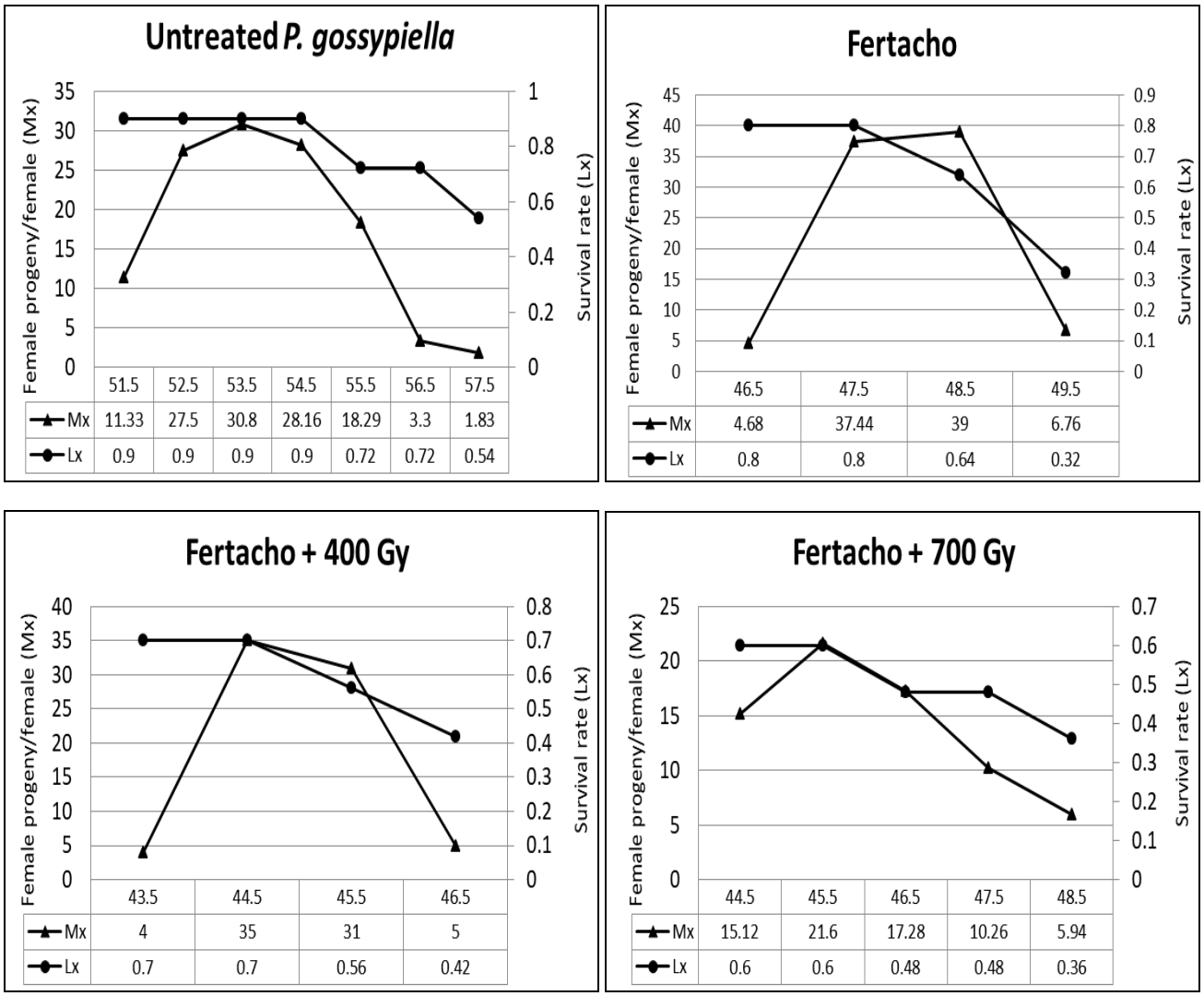

Fig 1: Female progeny/female (Mx) and survival rate (Lx) of *P. gossypiella* Treated as 1-day old egg with fertacho.

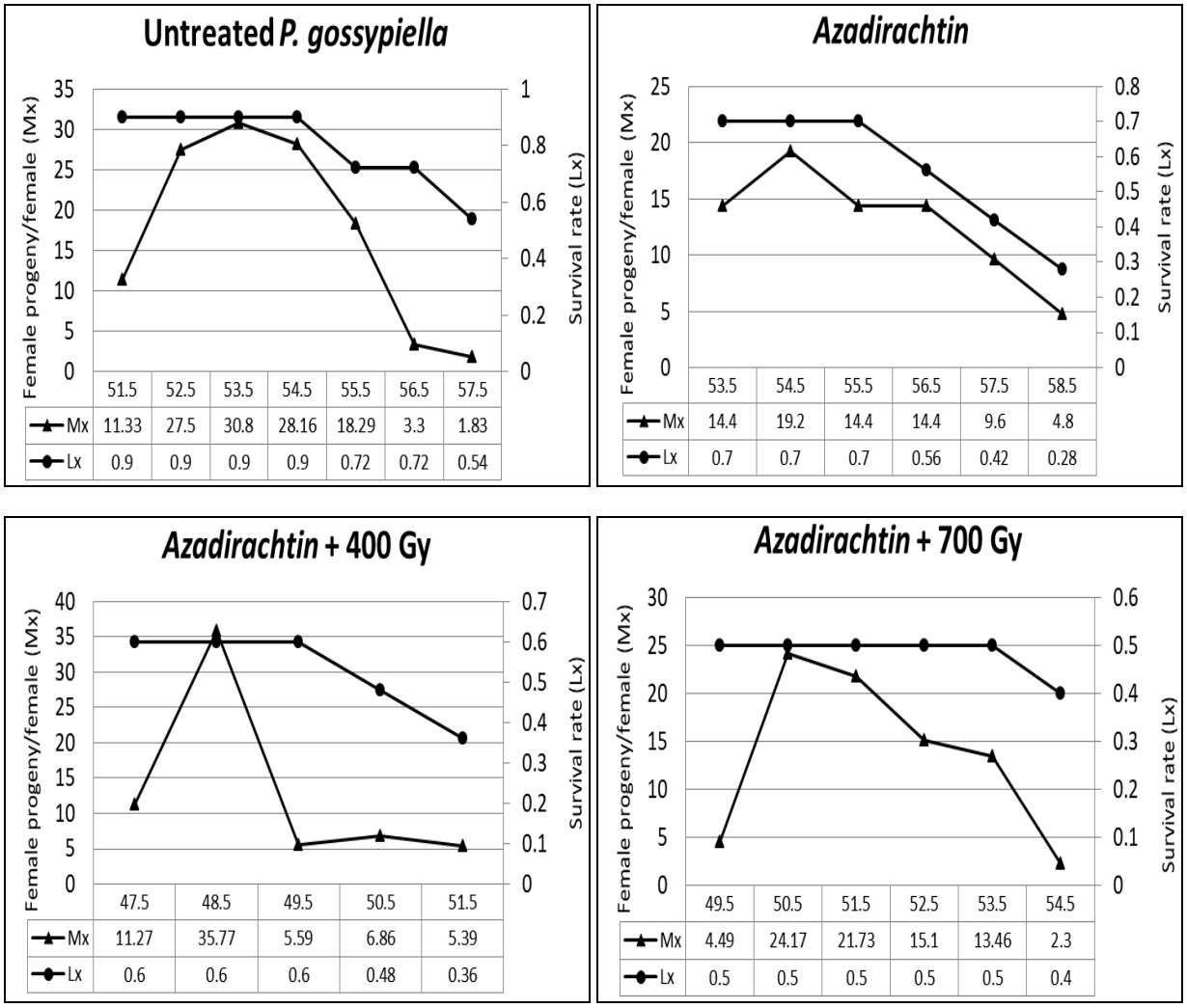

Fig 2: Female progeny/female (Mx) and survival rate (Lx) of *P. gossypiella* treated as 1-day old egg with Azadirachtin.

Net Reproductive Rate (Ro)

When *P. gossypiella* treated as a 1-day old egg with azadirachtin and fertacho different treatments, it had net reproductive rate (36.8 to 60.8 female daughter progeny/female in one generation) comparing with normal *P. gossypiella* net reproductive rate (Ro) that was 104.5 female daughter progeny/female in one generation (Table 6).

The intrinsic rate of Natural Increase (r_m)

Ability to inherit increase that means intrinsic rate of natural increase (r_m) of *P. gossypiella* was 0.086 individual/female/day as well as the value of fertacho and fertacho + 400 Gy treatments with *P. gossypiella* treated as a 1-day old egg.

Other treatments used had decreased the daily intrinsic rate Of natural increase (Table 6).

Finite Rate of Increase (e^{rm})

Table (6) showed that the normal daily population of *P. gossypiella* was 1.091 individual/day. The normal value of e^{rm} decreased to 1.082-1.089 individual/day in different fertacho treatments and 1.072-1.077 individual/day in different azadirachtin treatments with *P. gossypiella* treated as a 1-day old egg.

Doubling Time (DT)

Normal time that the generation can be twice (Doubling time, DT) was 8.06 days as well as values of feratacho and fertacho + 400 Gy treatments. On the other hand, azadirachtin treatments had increased that time than untreated ones as described in Table (6).

Table 6: Life table parameters of *P. gossypiella* affected by certain compounds.

Treatments	Developmantal time	T (days)	(Ro)	Increase rate		DT (days)
				r_m	e^{rm}	
Azadirachtin	53 [a]	55.2 [a]	47.04 [c]	0.069 [a]	1.072 [b]	10.05 [a]
Azadirachtin +400 Gy	47 [ab]	48.7 [a]	36.8 [c]	0.074 [a]	1.077 [ab]	9.37 [ab]
Azadirachtin +700 Gy	49 [ab]	51.6 [a]	40.4 [c]	0.072 [a]	1.074 [ab]	9.63 [ab]
Fertacho	46 [ab]	47.9 [a]	60.8 [b]	0.086 [a]	1.089 [ab]	8.06 [b]
Fertacho + 400 Gy	43 [b]	44.9 [a]	46.8 [c]	0.086 [a]	1.089 [ab]	8.06 [b]
Fertacho + 700 Gy	44 [b]	45.9 [a]	37.4 [c]	0.079 [a]	1.082 [ab]	8.77 [ab]
Untreated	51 [ab]	53.6 [a]	104.5 [a]	0.086 [a]	1.091 [a]	8.06 [b]
L.S.D. $_{0.05}$	7.37	10.23	12.7	0.019	0.016	1.48

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

Discussion

Authors work on exposing some compounds to gamma radiation doses for potentiating purposes of its efficacy against some pests [9] that exposed the newly hatched larvae of *P. gossypiella* to gamma doses of 5 up to 80 Gy to study the life table parameters of the pest. All the treatments had 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 increase as affected by exposing of *P. gossypiella* newly hatched larvae to gamma doses. Also, [10] authors described that gamma rays 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 from larval mortality and completely pupal stage death.

At current study, it could be concluded that gamma radiation dose of 700 Gy, followed by 400 Gy had a potentiating effect on azadirachtin and fertacho compound to become its efficacy was more effective compared with the same compounds when it is used singly without exposing to gamma doses that inverted on the lethal, biological and life table parameters of *Pectinophora gossypiella* (Saund.) when treated as a 1-day old egg.

A work [21] studied the comparing effect of neem (*Azadirachta indica* A. Juss) oil at 1%, 1.5% & 2% and neem seed water extract at 1%, 2% & 3% concentrations with that of synthetic insecticide (Polytrin) against *Bemisia tabaci, Amrasca devastans, Thrips tabaci, Earias insulana, Pectinophora gossypiella,* and *Helicoverpa armigera.* The treatments were administered four times during the cotton growing season and observations were recorded before one day and after 24, 72, 144, 216 & 288 days of treatment application. Neem derivatives at all concentrations had the badly affected for attacking the spotted bollworm; whereas, only at higher concentrations, it had adversely affected on an attack of pink bollworm up to 12 days after spray. Plots treated with 1.5 & 2% neem oil and 3% neem seed water extract had significantly higher yield as compared to control. Polytrin in all cases was highly toxic to the test insects as compared to any other treatments. While, another work [22] evaluated the various preparations of neem callus (*Azadirachta indica* A. Juss) (NCE1) and cells suspension extracts (NCE2) against three cotton insects including pink bollworm (*Pectinophora gossypiella* Saund.), African bollworm (*Helicoverpa armigera* Hub.) and leafworm (*Spodoptera litura* Fab.). The cotton leaves and medium-size excised bolls were sprayed with different dilutions of NCE1 & NCE2 and 3rd instar larvae were incubated. The dilutions T1 (1:10 v/v Extract: D.H2O) and T2 (1:100 v/v Extract: D.H2O) of both NCE1 and NCE2 showed highly significant results as almost 100% mortality was recorded after 2-3 days of larvae incubation. The larvae showed a repellent behavior, a decrease in weight, and negligible leaf area damage. The preparation T3 (1:1000 v/v Extract: D.H2O) showed 76 to 84% mortality, T4 (1:10000 v/v Extract: D.H2O) 28-72%, and T5 (1:10000 v/v Extract: D.H2O) 12-40% mortality after the 5th day of incubation. The larvae also showed repellent to non-repellent behavior, slow to moderate feeding activity the gradual increase of leaf area damage as extract preparations were diluted from T1-T3. The control showed 96 to 100% survival of all the three insect species with active feeding, an increase in insect weight and more than 50% leaf area damage after 2nd day of incubation. In conclusion, the extracts of callus and cell suspensions of neem have insecticidal potential that showed a significant mortality response against three bioassay insects. Whereas, [23] various concentration levels of neem oil (Nimbecidine 0.03% Aza) and water extracts of neem seed and leaf on the growth and development of African bollworm, *Helicoverpa armigera* under laboratory condition was studied. The square dip and larval immersion experiments were conducted in a Completely Randomized Design. In square dip experiment, all tested concentration levels (2.5, 5 & 10%) of neem seed and leaf extracts at 3, 6 & 9 days after treatment application resulted in significantly lower larval weight. In the larval immersion experiment, only 10% neem seed extract and 10% neem leaf extract resulted in significantly lower larval weight at 3 days after treatment. In the same experiment, all tested concentration levels (2.5, 5 & 10%) of neem seed extracts significantly reduced the weight of larvae at 6 days after treatment application. However, at 9 days after treatment application, only 5 and 10% neem seed extracts were found effective in reducing larval weight. Only the two higher concentration levels (5 & 10%) neem seed extract had significantly reduced the weight of pupae. On the other hand, [24] field efficacy of neem-based bio-pesticides like neem seed kernel extract (NSKE) and neem seed oil (NSO) as an alternative for the management of insect pests of cotton in northern Ghana were assessed. The treatments were 2% NSO, 5% NSO, 5% NSKE, 10% NSKE, chlorpyrifos alternated with lamda cyhalothrin, and untreated control. The results showed that 10% NSKE significantly reduced the abundance of bollworms to 0.75; while, for untreated, it was as high as 3.07. Seed cotton yield was between 52.20 & 90.82% that higher in the neem treated plots than untreated; while, yield loss was 64.79% lower on 10% NSKE treated plots than untreated plots.

[25] Lethal and sublethal effects of azadirachtin and *Bacillus thuringiensis* Berliner sub sp. kurstaki (Bacillales: Bacillaceae) were evaluated on the third instar of *H. armigera* under laboratory conditions. The LC_{50} value of azadirachtin was 12.95 µg a.i./mL. Total mortality of 56.7% was caused on third instar larvae when LC_{20} values of the insecticides were applied in combination with each other. The LT_{50} value of azadirachtin was 4.8 days. A sub-lethal study showed that the application of LC_{30} value of azadirachtin reduced larval and pupal weight and increased larval and pupal duration of *H. armigera*. The longevity and fecundity of female adults were significantly affected by insecticides. Female fecundity was reduced by the treatment. The lowest adult emergence ratio and pupation ratio were observed in the azadirachtin treatment.

[2] A field experiment was carried out during 2018 &2019 two cotton seasons. Thirteen compounds related to different groups were used; among of them azadirachtin, azadirachtin+400 Gy, azadirachtin+700 Gy, fertacho, fertacho+400 Gy, and fertacho+700 Gy. The treatments aforementioned were evaluated against three pests of cotton bolls that were pink bollworm, *Pectinophora gossypiella* (Saund); spiny bollworm, *Earias insulana* (Boisd.), and Cottonseed bug, *Oxycarenus hyalinipennis* (Costa) population and infestation reduction percentages. Fertacho+ 700 Gy was the best treatment, followed by azadirachtin +700 Gy, fertacho + 400 Gy, azadirachtin + 400 Gy,

fertacho and azadirachtin. In addition, the compounds used to enhance the most cotton crop parameters acts in seed numbers, lint and seed weights during the two cotton seasons. So, gamma radiation can potentiate the two compounds of azadirachtin and fertacho to become the most effective compounds on the aforementioned three pests and cotton crop parameters compared with the same compounds without exposure to gamma radiation. Another trend [8] used the liquid chromatography-mass spectrometry (LC−MS) data for showing the limited catabolic processing of ingested AzaA and dramatic alternations of primary metabolism in *H. armigera*. Results were indicated the presence of AzaA in the midgut of *H. armigera*. In the gut, out of 79 proteins identified, 34 were upregulated that were related to digestion, immunity, energy production, and apoptosis mechanism. On the other hand, 45 proteins were downregulated, including those from carbohydrate metabolism, lipid metabolism, and energy transfer. In the hemolymph, 21 upregulated proteins were reported to be involved in immunity, RNA processing, and mRNA-directed protein synthesis, while 7 downregulated proteins were implicated in energy transfer, hydrolysis, lipid metabolism, defense mechanisms, and amino acid storage-related functions. Subsequently, six target proteins were identified using labeled AzaA that interacted with whole insect proteins. In silico analysis suggests that AzaA could be efficiently accommodated in the hydrophobic pocket of juvenile hormone esterase and showed strong interaction with active site residues, indicating plausible targets of AzaA in *H. armigera*. Quantitative polymerase chain reaction analysis suggested differential gene expression patterns and partly corroborated the proteomic results.

Recentry,[3] nine compounds related to bio-agent groups were used; among of them azadirachtin and azadirachtin + orange oil. The treatments aforementioned were evaluated against three pests of cotton bolls that were pink bollworm, *Pectinophora gossypiella* (Saund); spiny bollworm, *Earias insulana* (Boisd.) and Cottonseed bug, *Oxycarenus hyalinipennis* (Costa) population and infestation reduction percentages. In addition, the compounds used were enhanced the most cotton crop parameters acts in seed numbers, lint and seed weights during the two cotton seasons 2018 & 2019.

Conclusion

Gamma radiation doses of 700 Gy, followed by 400 Gy can potentiate azadirachtin and fertacho efficacies against *P. gossypiella* than its efficacies when used singly without exposing to gamma doses. Also, most of the biological aspects in the larval, pupal & adult stages and life table parameters of female daughter/female (Mx), survival rate (Lx), developmental time, generation time (T), net reproductive rate (Ro), intrinsic rate of natural increase (r_m), finite rate of increase (e^{rm}) and doubling time for *P. gossypiella* treated as a 1-day old egg were affected with gamma radiation doses.

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