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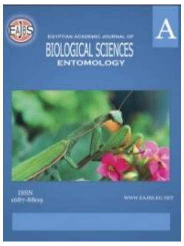

Co-Operation Impact Between Gamma Radiation and Spraying Droplets Distribution for Bioinsecticides Controlling Boll Pests on Cotton Plants in Egypt

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ABSTRACT

Field experiments were carried out of about 8 karats planted with (Giza 86) cotton variety during seasons 2018 and 2019 on 21st July and 5th, 20th August in a field located at Qaha Research Station, Plant Protection Research Institute, Qalyoubia governorate. The selected area was split into 7 plots and the control plot. Two spraying machines were used Pneumatic motor sprayer (Cifarilli) (20 L./Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) for application enhancement. Seven compounds related to different insecticide groups were used; one of them (*B. thuringiensis*) was exposed to gamma radiation doses of 160, 320 & 640 Gy (gray) =for potentiating purpose. The treatments were *Bacillus thuringiensis* (Kurstaki), *B. thuringiensis* +160 Gy, *B. thuringiensis* +320 Gy, *B. thuringiensis* +640 Gy, azadirachtin, *B. thuringiensis* +azadirachtin and diflubenzuron. The treatments mentioned 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. *B. thuringiensis* +640 Gy and diflubenzuron were considered the best treatments that caused reduction percentages in population and infestations against three pests used, followed by *B. thuringiensis* +320 Gy, *B. thuringiensis* +160 Gy and *B. thuringiensis* + azadirachtin, azadirachtin and then *B. thuringiensis*. 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 2018 & 2019. So, gamma radiation (160, 320 & 640 Gy) could potentiate *B. thuringiensis* to become the most effective compound on mentioned three pests and cotton crop parameters compared with the same compounds without exposing to gamma radiation; also, knapsack motor sprayer contribute to success the pest control comparing with Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) that was the least efficient according to homogeneity of droplet spectrum. It could be recommended to use these Bio-Insecticides with Low Volume spraying equipment with not less than (20 L/Fed.). A satisfactory coverage was obtained on cotton plants. The spectrum of droplets ranging between 122-185 μm (VMD). With a sufficient number ranging from 33-253 N/cm². The rate of performance of Pneumatic motor sprayer (Cifarilli) (20 L./Fed.) was 12 Fed./day. It was the best equipment, but the lowest rate of performance was Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) since it could spray only 3.45 Fed./day. Data showed that bio-insecticides may be recommended in integrated pest management because of their safety on animals, man and environment. Also, Low Volume spraying reducing the time lost in the process filling the machines with the spray solution and saving the lost spray on the ground.

INTRODUCTION

Cotton (*Gossypium* barbadense, L.) infested by many economic pests. From these pests were three cotton bolls destructive of pink bollworm, *Pectinophora gossypiella* (Saund); spiny bollworm, *Earias insulana* (Boisd.) and Cottonseed bug, *Oxycarenus hyalinipennis* (Costa) were the most destructive insect pests that cause terrible damage to cotton bolls. *P. gossypiella* is the destructive pest infesting cotton bolls; the newly hatched penetrates flower buds, flowers, and bolls shortly after hatching and then penetrates the lint and seeds of fully mature bolls (Noble, 1969). While *E. insulana* is a serious insect pest, it causes a damage to cotton bolls, the larvae mainly feed on fruiting parts of many crops and vegetables causes top boring for the soft and growing tissues especially the terminal buds and later it attack the flower buds and bolls that ultimately shed (Khan, *et al.* 2007). *O. hyalinipennis* (adult and nymphs) penetrate the cotton crop (squares and flowers) at an early season, but most economic losses were caused in the late stage (open bolls). Besides damaging the seeds and the reproductive parts, it causes the lint quality resulting in poor ginning of cotton fibers (Ananthakrishan *et al.*, 1982; Sweet, 2000 and Srinivas & Patil, 2004). Indiscriminate use of synthetic insecticides has not only caused the resistance problem in these pests but it has also polluted the environment. For thus the use of bioagent compounds for controlling the cotton bollworms to try being a successful step in removing chemical pesticides from the environment. Gamma irradiation as a genetic control method was considered among biological methods; it involves the release of genetically modified insects to control the same species (Soon, 1986). Inherited effects of gamma irradiation doses were studied by many authors as Sallam and Ibrahim (1993), Amer (2006), Amer, *et al.* (2012 and 2018) for controlling *P. gossypiella* by using *B. thuringiensis* exposed to different gamma doses that caused potentiating effect against the pest compared to *B. thuringiensis* when used singly without radiation. Rafique *et al.* (2012) and Abedi, *et al* (2014) evaluated *Azadirachta indica* against *P. gossypilla and H. armigera* and stated that the compound has insecticidal potential showed significant mortality response.

The first aim of the current field trial is to raise the spraying efficiency by using two spraying machines of Pneumatic motor sprayer (Cifarilli) (20 L./Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L./fed.). Also, the second purpose of this work was to potentiate the compound of B. *thuringiensis* by exposing to gamma radiation doses of 160, 320 & 640 Gy compared to a bioagent without exposure to gamma doses. In addition, additive compound (*B. thuringiensis +azadirachtin*) and IGR compound of diflubenzuron were applied. Seven treatments used to control the three insect pests of *P. gossypiella*, *E. insulana* and *O. hyalinipennis* on cotton bolls at 2018 and 2019 cotton seasons. A comparative study on the efficiency of different ground sprayers was carried out by (Hindy, 1992 and 1997), who detected a significant variation in the spray deposit due to the arrangement of the nozzles, spray volume, spraying type and rate of application. The world global attention was directed to the minimization of spraying volumes and the control costs which might be happened by using a cheap and effective insecticide or using a developmental ground spraying technique with low application costs per feddan (Magdoline *et al.* ,1992) and(Mathews,1992). Maintaining sprayers for pesticide application in a good state of repairing and proper working in order to reduce their harmful effects on human health and environment Dokic *et al.* (2018).

MATERIALS AND METHODS

Field experiments were carried out of about 8 karats planted with (Giza 86 variety, 2017 strain) cotton variety, planted at 15th Mars during seasons 2018 and 2019, in the field

located at Qaha Research Station, Plant Protection Research Institute, Qaluobeia governorate. The selected area was split into 7 plots and the control plot. We aimed to evaluate the efficacy of seven treatments to control *P. gossypiella*, *E. insulana,* and *O. hyalinipennis* that infesting cotton bolls during growing cotton seasons 2018 & 2019. The trial area was divided according to the complete randomized block design including four replicates for each treatment; each treatment was done on one karat each replicate was (1/4 Kirrat). Three rows of cotton plants between treatments left without spraying as barrier zone to avoid drift spray. The experiments were done at 4 pm. under local meteorological conditions of 35°C average temperature, 60 % average RH and 2 m/sec. average wind velocity during the experiment.
The tested compounds were applied three times at 15 days intervals. The first spray was applied when the percent infestation of green bolls reached about 3% at 21th July, the second spray 5 th August and the third spray 20 th August at 2018 and 2019 cotton seasons, respectively. Boll samples were collected at random before applying the compounds and then weekly after application. One hundred bolls (25 bolls x 4 replicates) were collected from each treatment and examined.

Insects.

Three pests were investigated on green cotton bolls which mentioned in Table (1).

Table (1). Insects infested the cotton bolls.

English name	**Bionomial name**	**Family**	**Order**
Pink Bollworm	*Pectinophora gossypiella* (Saunders)	Gelechiidae	Lepidoptera
Spiny Bollworm	*Earias insulana* (Boisduval)	Noctuidae	Lepidoptera
Cotton Seed Bug	*Oxycarenus hyalinipennis* (Costa)	Lygaeidae	Hemiptera

Compounds.

Seven treatments belong to three compounds as in Table (2).

Table (2). Compounds used common name and application rate.

Trade name	**Common name**	**Application rate**	**Product Co.**
Biotect 9.4% W. P	*Bacillus thuringiensis* (Kurstaki)	300g/ feddan	Organic for biotechnology co. Beheira Governorate, Egypt.
Achook 0.15% EC.	Azadirachtin, *Azadirachta indica*	750 cm^3/ feddan	Bahar agrochem & feeds, India
Kllefuron 5% EC.	Diflubenzuron	100 cm^3/ feddan	El-Wataneyah Co. For Agriculture Chemicals (Agrochem) Alexandria, Egypt.

Spraying Equipment Tested on Cotton plants: -

Two ground application equipment was selected to perform the scope of this work as follows:

1. Hand-held Hydraulic sprayer (Matabi) Spraying volume (56 L./fed.), Espine made.
2. Pneumatic motor sprayer (Cifarilli), Spraying volume (20 L./fed.) , Italy made.

- Categorization mentioned in table (3).

Table 3: Techno-Operational data, calibration and rate of performance of certain ground sprayers applied on Cotton field during season (2018).

Equipment	Pneumatic motor sprayer (Cifarilli)	Hydraulic sprayer (Matabi)
Type of atomization	Mechanical Pneumatic	Manual Hydraulic
Nozzle type	Air shear nozzle	Hollow cone nozzle 80º
Pump type	Centrifugal fan	Hydraulic pump
Number of nozzles	1	1
Pressure (bar)	-	5
Spray tank (L.)	20	20
Rate of application (L/fed.)	20	56
Working speed (Km/h.)	2.4	2.4
Swath width (m.)	5	1.5
Flow rate (L/min.)	1	0.8
Spray height (m.)	0.5	0.5
Type of Spraying	Target in all sprayers	
Productivity * (fed./h.)	2.85	0.86
Rate of performance* (fed./day)	12	3.4

* Number of spraying hours = 8 hours daily. *Number of workers =2.
* Calculations of productivity and rate of performance after Hindy (1992).

Gamma Radiation:

B. thuringiensis was exposed to gamma radiation doses of 160, 320 and 640 Gy =gray (unit of radiation) at a dose rate of 1.084 KGy/h by a Cesium^{137} Hendy Gamma Cell Research at National Center for Radiation Researches & Technology.

Seven Treatments Were Used As Follows:

1. *B. thuringiensis,* **2.** *B. thuringiensis* + 160 Gy **3.** *B. thuringiensis* + 320 Gy, **4.** *B. thuringiensis* + 640 Gy, **5.** Azadirachtin, **6.** *B. thuringiensis* +Azadirachtin, **7.** Diflubenzuron.

The percent reduction in population and infestation were calculated according to Handerson and Telton formula (1955).

Cotton Crop Parameters:

The number of seeds and weights of lint and seeds (g) cotton crop were assessed as compared to the control. The samples were collected per 100 open cotton bolls.

Calibration and Performance Adjustment of The Tested Equipment:

1-Collection of Spray Deposit:

Before spraying each Cotton treatment, a sampling line constructed of five-wire holder fixed in diagonal line inside each treatment to collect the lost spray between plants; each wire holder top had a fixed water-sensitive paper (Novartis Cards®) on it, also, the water-sensitive paper cards put on five plants; to collect the spray coverage on Cotton leaves at both upper, middle and lower levels of Cotton plant the Cotton plants were about one-meter length, were designed according to Hindy (1989). Cards were collected and transferred carefully inside the paper. Involved data to the laboratory for measuring and calculating the number of droplets/cm² and its volume mean diameter (VMD) µm in all treatments was done.

2-Determination of Spray Deposit:

Number and size of blue spots (deposited droplets) on the water-sensitive papers (Novartis cards®) measured with scaled monocular lens (Strüben) ® (15X) Japanese lens. volume mean diameter (VMD) µm and number of droplets in one square centimeter (N/cm²) were estimated according to Hindy (1992).

Phytotoxic Effect:

It was determined by recording any color change, leaf curling or flaming up to 15 days after each spraying, according to Badr *et al*. (1995).

Statistical Analysis:

All investigated data were analyzed by using Costat statistical program software, 1990 and Duncan multiple range tests (Duncan, 1955) at 5% probability level to compare the differences among time means.

RESULTS AND DISCUSSION

A field trial was done at Plant Protection Research Institute Station, Qaha district, Qalubeiah governorate during two cotton seasons (2018 & 2019). The purpose of the trial was potentiating one compound efficacy (*B. thuringiensis*) by exposing to gamma radiation doses (160, 320 & 640 Gy); also, compared its efficacy with the same compounds without radiation; in addition to compare with additive biocides (*B. thuringiensis* + azedirachtin) and IGR compound (diflubenzuron).

The controlling target pests were pink bollworm, *P. gossypiella*; spiny bollworm, *E. insulana*, and cottonseed bug, *O. hyalinipennis*; also, investigate the reduction percentages of larval population and infestation for three pests mentioned. Moreover, determined the cotton crop acts in seed number, lint & seed weight/100 opened cotton boll during two cotton seasons trials (2018 & 2019).

Penumatic motor sprayer (Cifarilli) (20 L./Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) were used as two spraying machines for obtaining homogenous spray coverage to the compounds applied on cotton plants.

Pink and Spiny Bollworms:

a. Larval Population Reductions:

Seven compounds were applied on cotton green bolls when larval population and infestation was 3% of *P. gossypiella* or *E. insulana* or both of them.

The pink and spiny larval population reductions had slightly increased at 2019 than 2018 cotton seasons as shown in Tables (3&4). The IGR compound (diflubenzuron) was the best treatment caused bollworms larval population reduction during two cotton seasons (70.6 &81.1% and 59.8 & 72.3% for Pneumatic motor sprayer (Cifarilli) (20 L./Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) during 2018 & 2019 cotton seasons, respectively). *B. thuringiensis* + 640 Gy had population reduction 70.2 & 79.9% and 59.1 & 70.2% for Pneumatic motor sprayer (Cifarilli) (20 L./Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) during 2018 & 2019 cotton seasons; followed by *B. thuringiensis* + 320 Gy and *B. thuringiensis* + 160 Gy as in Tables (4&5). Moreover, *B. thuringiensis* + azadirachtin had a potentiating effect in efficacy on larval reduction comparing with each of them when using singly.

b-Infestation Reduction:

The same trend in larval population reduction was also obvious in bollworms infestation reduction (Tables 6 &7); but the treatments used had infestation reduction highly than population reduction.

Also, Pneumatic motor sprayer (Cifarilli) (20 L./Fed.) had a high efficacy during compound application comparing with Hand-held Hydraulic sprayer (Matabi) (56 L./fed.).

Table 4: Percent reduction in larval populations of the pink and spiny bollworms during application by using two spraying machines with some compounds during cotton season 2018.

Compounds	% Larval population reductions during application									Seasonal Averages
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	9.33^{c}	10.7^{c}	**10.02**^{c}	12.6^{c}	11.1^{c}	**11.9**^{c}	14.3^{d}	15.2^{c}	**14.8**^{c}	**12.2**^{c}
***B. thuringiensis* +160 Gy**	50^{ab}	58^{ab}	**54**^{b}	58.8^{b}	66.6^{b}	**62.7**^{b}	70^{abc}	70^{ab}	**70**^{ab}	**62.2**^{b}
***B. thuringiensis* + 320 Gy**	53.3^{ab}	60^{ab}	**56.7**^{ab}	62.2^{ab}	66.6^{b}	**64.4**^{b}	73^{abc}	70^{ab}	**71.5**^{ab}	**64.2**^{ab}
***B. thuringiensis* + 640 Gy**	58^{a}	64.4^{a}	**61.2**^{a}	69.9^{a}	77^{a}	**73.5**^{a}	78^{ab}	74^{ab}	**76**^{a}	**70.2**^{a}
Azadirachtin	48.8^{b}	54.7^{b}	**51.8**^{b}	57^{b}	59.9^{b}	**58.5**^{b}	67.1^{c}	62.2^{a}	**64.7**^{b}	**58.3**^{b}
***B. thuringiensis* +Azadirachtin**	48.8^{b}	56.6^{ab}	**52.7**^{b}	58.8^{b}	63.3^{b}	**61.1**^{b}	69^{bc}	67.1^{b}	**68.1**^{ab}	**60.6**^{b}
Diflubenzuron	58^{a}	64.4^{a}	**61.2**^{a}	70^{a}	77^{a}	**73.5**^{a}	79^{a}	75^{ab}	**77**^{a}	**70.6**^{a}
L.S.D$_{0.05}$	8.21	7.31	6.32	8.95	8.74	6.19	8.74	7.54	8.65	7.54
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	8.88^{c}	9.9^{d}	**9.39**^{c}	10.8^{c}	9.5^{c}	**10.2**^{c}	11.1^{c}	12.6^{c}	**11.9**^{c}	**10.5**^{c}
***B. thuringiensis* +160 Gy**	40^{b}	48.8^{bc}	**44.4**^{b}	55^{a}	61.1^{a}	**58.1**^{a}	60^{ab}	60^{a}	**60**^{a}	**54.2**^{ab}
***B. thuringiensis* + 320 Gy**	44.4^{ab}	50^{bc}	**47.2**^{ab}	57^{a}	60^{a}	**61.8**^{a}	60^{ab}	58^{a}	**59**^{a}	**56**^{a}
***B. thuringiensis* + 640 Gy**	48.8^{a}	55^{ab}	**51.9**^{a}	60^{a}	66.6^{a}	**63.3**^{a}	64.4^{a}	60^{a}	**62.2**^{a}	**59.1**^{a}
Azadirachtin	38^{b}	44.4^{c}	**41.2**^{b}	45.5^{b}	47^{b}	**46.3**^{b}	55^{b}	50^{b}	**52.5**^{b}	**46.7**^{b}
***B. thuringiensis* +Azadirachtin**	38^{b}	45^{c}	**41.5**^{b}	55^{a}	59^{a}	**57**^{a}	61.1^{ab}	62.2^{a}	**61.7**^{a}	**53.4**^{ab}
Diflubenzuron	48.8^{a}	59^{a}	**53.9**^{a}	60^{a}	66.6^{a}	**63.3**^{a}	64.4^{a}	60^{a}	**62.2**^{a}	**59.8**^{a}
L.S.D$_{0.05}$	8.08	6.11	6.402	6.14	8.62	8.74	6.402	7.54	6.37	8.26

Table 5: Percent reduction in larval populations of the pink and spiny bollworms during application by using two spraying machines with some compounds during the cotton season 2019.

Compounds	% Larval population reductions during application									Seasonal Averages
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	12.6^{d}	12^{d}	**12.3**^{d}	14.2^{d}	16.9^{d}	**15.6**^{e}	20.7^{d}	20.7^{d}	**20.7**^{d}	**16.2**^{d}
***B. thuringiensis* +160 Gy**	60^{abc}	68.8^{ab}	**64.4**^{ab}	75.5^{ab}	78^{b}	**76.8**^{bc}	81^{abc}	80^{b}	**80.5**^{b}	**73.9**^{ab}
***B. thuringiensis* + 320 Gy**	64.4^{ab}	68.8^{ab}	**66.6**^{ab}	79.9^{a}	81^{ab}	**80.5**^{ab}	86^{ab}	80^{b}	**83**^{ab}	**76.7**^{ab}
***B. thuringiensis* + 640 Gy**	66.6^{a}	72^{a}	**69.3**^{a}	83^{a}	85^{a}	**84**^{a}	89^{a}	84^{ab}	**86.5**^{ab}	**79.9**^{a}
Azadirachtin	52.2^{c}	54.4^{c}	**53.3**^{c}	62.2^{c}	68.9^{c}	**65.6**^{d}	72.2^{c}	68.9^{c}	**70.6**^{c}	**63.2**^{c}
***B. thuringiensis* +Azadirachtin**	56.6^{bc}	60.6^{bc}	**58.6**^{bc}	70.7^{b}	75.5^{b}	**73.1**^{c}	79^{bc}	78.2^{b}	**78.6**^{b}	**70.1**^{bc}
Diflubenzuron	66.6^{a}	74^{a}	**70.3**^{a}	83^{a}	86^{a}	**84.5**^{a}	90^{a}	87^{a}	**88.5**^{a}	**81.1**^{a}
L.S.D$_{0.05}$	7.54	8.68	8.43	7.39	6.402	6.11	8.62	6.11	7.39	8.26
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	12^{c}	11^{d}	**11.5**^{c}	13^{c}	15^{e}	**14**^{c}	17^{d}	15^{e}	**16**^{d}	**13.8**^{d}
***B. thuringiensis* +160 Gy**	54^{ab}	59.9^{abc}	**56.95**^{ab}	68.8^{a}	70^{bcd}	**69.4**^{ab}	75^{b}	70^{b}	**72.5**^{b}	**66.3**^{abc}
***B. thuringiensis* + 320 Gy**	56^{ab}	59.9^{abc}	**57.95**^{ab}	70^{a}	74^{abc}	**72**^{a}	80^{a}	70^{b}	**75**^{ab}	**68.3**^{ab}
***B. thuringiensis* + 640 Gy**	60^{a}	62.2^{ab}	**61.1**^{a}	72^{a}	77^{ab}	**74.5**^{a}	80^{a}	70^{b}	**75**^{ab}	**70.2**^{ab}
Azadirachtin	50^{b}	52.2^{c}	**51.1**^{b}	59^{b}	64.4^{d}	**61.7**^{b}	68.8^{c}	59^{d}	**63.9**^{c}	**58.9**^{c}
***B. thuringiensis* +Azadirachtin**	53^{b}	55^{bc}	**54**^{ab}	65^{ab}	69^{cd}	**67**^{ab}	74^{b}	65^{c}	**69.5**^{bc}	**63.5**^{bc}
Diflubenzuron	60^{a}	65^{a}	**62.5**^{a}	72^{a}	78^{a}	**75**^{a}	82^{a}	77^{a}	**79.5**^{a}	**72.3**^{a}
L.S.D$_{0.05}$	6.15	7.89	8.003	7.59	7.29	7.53	4.03	4.34	6.24	7.47

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Table 6: Infestation percent reductions of the pink and spiny bollworms during application by using two spraying machines with some compounds during cotton season 2018.

Compounds	% Infestation reductions during application									Seasonal Averages
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	7.32^{d}	8.08^{e}	**7.7^{e}**	13.6^{d}	17.1^{d}	**15.4^{d}**	20.2^{d}	20.2^{d}	**20.2^{d}**	**14.4^{d}**
***B. thuringiensis* +160 Gy**	60^{b}	66.6^{bc}	**63.3^{bc}**	67^{b}	69.9^{ab}	**68.5^{ab}**	72.2^{b}	66.6^{bc}	**69.4^{b}**	**67.1^{b}**
***B. thuringiensis* + 320 Gy**	66.6^{ab}	69.9^{ab}	**68.3^{ab}**	72.2^{ab}	72.2^{ab}	**72.2^{ab}**	76^{ab}	70^{b}	**73^{ab}**	**71.2^{ab}**
***B. thuringiensis* + 640 Gy**	72.2^{a}	72.2^{ab}	**72.2^{a}**	76^{a}	77^{a}	**76.5^{a}**	82^{a}	80^{a}	**81^{a}**	**76.6^{a}**
Azadirachtin	50^{c}	52.2^{d}	**51.1^{d}**	54^{c}	56^{c}	**55^{c}**	60^{c}	58.8^{c}	**59.4^{c}**	**55.2^{c}**
***B. thuringiensis* +Azadirachtin**	60^{b}	58.8^{cd}	**59.4^{c}**	64.4^{b}	66.6^{b}	**65.5^{b}**	69.9^{b}	58.8^{c}	**64.4^{bc}**	**63.1^{bc}**
Diflubenzuron	69.6^{a}	78^{a}	**73.8^{a}**	77^{a}	78^{a}	**77.5^{a}**	84^{a}	80^{a}	**82^{a}**	**77.8^{a}**
L.S.D$_{0.05}$	7.54	8.68	7.87	8.43	8.95	8.39	7.72	8.003	8.74	8.62
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	7^{d}	7.2^{d}	**7.1^{c}**	11.1^{e}	15.5^{d}	**13.3^{e}**	17.7^{c}	17^{d}	**17.4^{d}**	**12.6^{e}**
***B. thuringiensis* +160 Gy**	50^{bc}	55^{abc}	**52.5^{ab}**	56^{cd}	58.8^{b}	**57.4^{cd}**	60^{b}	55^{bc}	**57.5^{c}**	**55.8^{cd}**
***B. thuringiensis* + 320 Gy**	53^{ab}	55^{abc}	**54^{ab}**	60^{bc}	62.2^{b}	**61.1^{bc}**	70^{a}	60^{b}	**65^{b}**	**60.03^{bc}**
***B. thuringiensis* + 640 Gy**	55^{ab}	58.8^{ab}	**56.9^{ab}**	66.6^{ab}	70^{a}	**68.3^{ab}**	72.2^{a}	70^{a}	**71.1^{ab}**	**65.4^{ab}**
Azadirachtin	46^{c}	50^{c}	**48^{b}**	50^{d}	48^{c}	**49^{d}**	53.3^{b}	50^{c}	**51.7^{c}**	**49.6^{d}**
***B. thuringiensis* +Azadirachtin**	50^{bc}	52^{bc}	**51^{b}**	52^{cd}	55^{bc}	**53.5^{cd}**	56.6^{b}	50^{c}	**53.3^{c}**	**52.6^{cd}**
Diflubenzuron	58.8^{a}	62.2^{a}	**60.5^{a}**	70^{a}	73^{a}	**71.5^{a}**	75^{a}	70^{a}	**72.5^{a}**	**68.2^{a}**
L.S.D$_{0.05}$	6.402	7.26	8.43	7.74	7.72	8.88	7.59	6.14	6.47	7.26

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Table 7: Infestation percent reductions of the pink and spiny bollworms during application by using two spraying machines with some compounds during the cotton season 2019.

Compounds	% Infestation reductions during application									Seasonal Average
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	10^{d}	12^{e}	**11^{e}**	20.2^{f}	23.9^{e}	**22.1^{e}**	33.3^{d}	24.4^{d}	**28.9^{d}**	**20.7^{d}**
***B. thuringiensis* +160 Gy**	60^{b}	70^{bc}	**65^{bc}**	70^{cd}	82.2^{bc}	**76.1^{c}**	86^{ab}	80^{b}	**83^{b}**	**74.7^{b}**
***B. thuringiensis* + 320 Gy**	66.6^{ab}	75^{ab}	**70.8^{ab}**	78^{bc}	85^{abc}	**81.5^{bc}**	89^{ab}	83^{ab}	**86^{ab}**	**79.4^{ab}**
***B. thuringiensis* + 640 Gy**	70^{a}	80^{a}	**75^{a}**	84^{ab}	90^{ab}	**87^{ab}**	90^{ab}	85^{ab}	**87.5^{ab}**	**83.2^{a}**
Azadirachtin	52.2^{c}	56^{d}	**54.1^{d}**	60^{e}	60^{d}	**60^{d}**	64^{c}	62.8^{c}	**63.4^{c}**	**59.2^{c}**
***B. thuringiensis* +Azadirachtin**	60^{b}	65.5^{c}	**62.8^{c}**	69.5^{d}	78^{c}	**73.8^{c}**	82.2^{b}	78.8^{b}	**80.5^{b}**	**72.4^{b}**
Diflubenzuron	70^{a}	80^{a}	**75^{a}**	88^{a}	92^{a}	**90^{a}**	93^{a}	90^{a}	**91.5^{a}**	**85.5^{a}**
L.S.D$_{0.05}$	6.32	7.39	6.22	8.08	8.39	7.78	7.54	7.59	7.47	7.58
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	9^{c}	10^{d}	**9.5^{c}**	16^{e}	17^{e}	**16.5^{e}**	28^{e}	18^{d}	**23^{d}**	**16.3^{d}**
***B. thuringiensis* +160 Gy**	55^{ab}	60^{b}	**57.5^{ab}**	62.2^{c}	66.6^{c}	**64.4^{c}**	75^{bc}	70^{b}	**72.5^{b}**	**64.8^{b}**
***B. thuringiensis* + 320 Gy**	58.8^{a}	65^{ab}	**61.9^{a}**	66.6^{bc}	70^{bc}	**68.3^{bc}**	80^{ab}	75^{ab}	**77.5^{ab}**	**69.2^{ab}**
***B. thuringiensis* + 640 Gy**	60^{a}	70^{a}	**65^{a}**	72^{ab}	75^{ab}	**73.5^{ab}**	82^{ab}	80^{a}	**81^{a}**	**73.2^{a}**
Azadirachtin	50^{b}	50^{c}	**50^{b}**	50^{d}	55^{d}	**52.5^{d}**	60^{d}	59^{c}	**59.5^{c}**	**54^{c}**
***B. thuringiensis* +Azadirachtin**	55^{ab}	58.8^{b}	**56.9^{ab}**	60^{c}	64^{c}	**62^{c}**	70^{c}	70^{b}	**70^{b}**	**62.9^{b}**
Diflubenzuron	60^{a}	70^{a}	**65^{a}**	75^{a}	78^{a}	**76.5^{a}**	84^{a}	80^{a}	**82^{a}**	**74.5^{a}**
L.S.D$_{0.05}$	6.14	6.66	7.74	7.98	6.11	6.08	7.54	8.003	7.89	6.05

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Cotton Seed Bug:

a. Population:

Tables (8&9) showed that diflubenzuron as well as *B. thuringiensis* + 640 Gy nearly was considered the best treatments caused reduction in seed bug population, followed by *B. thuringiensis* + 320 Gy and *B. thuringiensis* + 160 Gy had potentiating efficacy on cottonseed bug population than its reduction on cottonseed bug without exposing to gamma doses. Moreover, *B. thuringiensis* + azadirachtin had the best efficacy compared to use each of them singly.

b. Infestation.

The previous trend has also appeared in cottonseed bug infestation reduction as described in Tables (10&11).

Shah, *et al.* (2016) assess the efficacy of 12 insecticides against dusky cotton bug (*Oxycarenus laetus*) in field conditions, the insecticides were belonging to five different groups viz. organophosphate, pyrethroid, neo-nicotinoid, naturalize and insect growth regulator (IGRs). All tested insecticides were significantly different in relation to pest mortality than the untreated check. Among the insecticides, organophosphates proved the most effective, followed by pyrethroids and neonicotinoids while naturalize proved least effective, followed by insect growth regulator (IGRs).

Table 8: Percent reduction in cottonseed bug populations during application by using two spraying machines with some compounds during the cotton season 2018

Compounds	% Reduction of cotton seed bug populations during application									Seasonal Average
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	20^{c}	25^{c}	**22.5^{d}**	25^{d}	35^{d}	**30^{d}**	11.8^{d}	10^{d}	**10.9^{d}**	**21.1^{d}**
***B. thuringiensis* +160 Gy**	38^{a}	46.6^{b}	**42.3^{abc}**	58.8^{c}	69.9^{bc}	**64.4^{bc}**	55^{b}	52.5^{bc}	**53.8^{b}**	**53.5^{bc}**
***B. thuringiensis* + 320 Gy**	40^{a}	49^{ab}	**44.5^{ab}**	66.6^{b}	75^{ab}	**70.8^{ab}**	69.9^{a}	60^{ab}	**64.95^{a}**	**60.1^{ab}**
***B. thuringiensis* + 640 Gy**	44^{a}	55^{a}	**49.5^{a}**	72.2^{ab}	79^{a}	**75.6^{a}**	75^{a}	65^{a}	**70^{a}**	**65.03^{a}**
Azadirachtin	25^{bc}	45^{b}	**35^{c}**	52.5^{c}	62.5^{c}	**57.5^{c}**	47.1^{c}	47.5^{c}	**47.3^{c}**	**46.6^{c}**
***B. thuringiensis* +Azadirachtin**	28^{b}	46.6^{b}	**37.3^{bc}**	55^{c}	66.6^{bc}	**60.8^{c}**	50^{bc}	50^{c}	**50^{bc}**	**49.4^{c}**
Diflubenzuron	44^{a}	55^{a}	**49.5^{a}**	75^{a}	79^{a}	**77^{a}**	76^{a}	65^{a}	**70.5^{a}**	**65.7^{a}**
$L.S.D_{0.05}$	6.11	7.39	7.54	6.19	8.39	8.08	7.26	7.54	6.11	8.21
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	18^{e}	22^{c}	**20^{d}**	21^{c}	29^{c}	**25^{d}**	7.7^{f}	7.7^{d}	**7.7^{d}**	**17.6^{e}**
***B. thuringiensis* +160 Gy**	30^{cd}	40^{b}	**35^{bc}**	53^{b}	66.6^{ab}	**59.8^{abc}**	50^{cd}	48.8^{a}	**49.4^{ab}**	**48.1^{bc}**
***B. thuringiensis* + 320 Gy**	35^{bc}	44^{ab}	**39.5^{ab}**	55^{b}	69.9^{a}	**62.5^{abc}**	55^{bc}	50^{a}	**52.5^{a}**	**51.5^{b}**
***B. thuringiensis* + 640 Gy**	40^{ab}	49^{a}	**44.5^{a}**	62.2^{a}	70^{a}	**66.1^{ab}**	60^{ab}	50^{a}	**55^{a}**	**55.2^{a}**
Azadirachtin	24^{de}	38^{b}	**31^{c}**	49^{b}	59^{b}	**54^{c}**	42^{e}	40^{c}	**41^{c}**	**42^{d}**
***B. thuringiensis* +Azadirachtin**	25^{d}	40^{b}	**32.5^{c}**	52^{b}	62.5^{ab}	**57.3^{bc}**	45^{de}	44.4^{b}	**44.7^{bc}**	**44.8^{cd}**
Diflubenzuron	42^{a}	49^{a}	**45.5^{a}**	65^{a}	70^{a}	**67.5^{a}**	62.2^{a}	50^{a}	**56.1^{a}**	**56.4^{a}**
$L.S.D_{0.05}$	6.11	7.29	6.37	6.19	8.39	8.43	6.28	7.03	6.37	3.47

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Table 9: Percent reduction in cottonseed bug populations during application by using two spraying machines with some compounds during the cotton season 2019.

Compounds	% Reduction of cotton seed bug populations during application									Seasonal Average
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	25^{c}	30^{d}	**27.5**^{e}	35^{e}	40^{d}	**37.5**^{d}	14^{e}	12^{d}	**13**^{e}	**26**^{d}
***B. thuringiensis* +160 Gy**	42.2^{b}	52.2^{bc}	**47.2**^{cd}	65^{bc}	66.6^{bc}	**65.8**^{b}	72.2^{bc}	70^{b}	**71.1**^{b}	**61.4**^{b}
***B. thuringiensis* + 320 Gy**	50^{a}	56^{b}	**53**^{bc}	69.9^{ab}	72.2^{ab}	**71.1**^{ab}	76^{ab}	70^{b}	**73**^{b}	**65.7**^{ab}
***B. thuringiensis* + 640 Gy**	55^{a}	66.6^{a}	**60.8**^{ab}	73.3^{a}	79^{a}	**76.2**^{a}	83^{a}	80^{a}	**81.5**^{a}	**72.8**^{a}
Azadirachtin	35^{b}	45^{c}	**40**^{d}	55^{d}	58^{c}	**56.5**^{c}	62.2^{d}	45^{c}	**53.6**^{d}	**50.03**^{c}
***B. thuringiensis* +Azadirachtin**	38^{b}	49^{bc}	**43.5**^{d}	62.2^{c}	65^{bc}	**63.6**^{bc}	66.6^{cd}	64.4^{b}	**65.5**^{c}	**57.5**^{bc}
Diflubenzuron	55^{a}	70^{a}	**62.5**^{a}	73.3^{a}	79^{a}	**76.2**^{a}	84^{a}	80^{a}	**82**^{a}	**73.6**^{a}
$L.S.D_{0.05}$	7.54	8.39	8.53	6.24	8.95	7.78	7.72	7.26	3.32	7.89
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	24^{d}	27^{e}	**25.5**^{e}	29^{d}	33^{d}	**31**^{d}	10^{e}	7.7^{e}	**8.85**^{e}	**21.8**^{e}
***B. thuringiensis* +160 Gy**	38^{b}	48.8^{bc}	**43.4**^{bc}	55^{b}	58.8^{ab}	**56.9**^{ab}	62.2^{bc}	60^{b}	**61.1**^{bc}	**53.8**^{bc}
***B. thuringiensis* + 320 Gy**	40^{ab}	52.2^{ab}	**46.1**^{abc}	58^{ab}	62.2^{ab}	**60.1**^{ab}	69.9^{ab}	62.2^{ab}	**66.1**^{ab}	**57.4**^{ab}
***B. thuringiensis* + 640 Gy**	45^{a}	56^{ab}	**50.5**^{ab}	62.2^{a}	65^{a}	**63.6**^{a}	72.2^{a}	70^{a}	**71.1**^{a}	**61.7**^{ab}
Azadirachtin	30^{cd}	39^{d}	**34.5**^{d}	44^{c}	49^{c}	**46.5**^{c}	53^{d}	40^{d}	**46.5**^{d}	**42.5**^{d}
***B. thuringiensis* +Azadirachtin**	35^{bc}	42.2^{cd}	**38.6**^{cd}	52.2^{b}	55^{bc}	**53.6**^{bc}	58.8^{cd}	50^{c}	**54.4**^{cd}	**48.9**^{cd}
Diflubenzuron	45^{a}	60^{a}	**52.5**^{a}	62.2^{a}	65^{a}	**63.6**^{a}	73^{a}	70^{a}	**71.5**^{a}	**62.4**^{a}
$L.S.D_{0.05}$	6.16	8.68	8.26	6.22	7.54	7.47	7.72	7.54	8.003	7.87

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Table 10: Percent reduction in cottonseed bug infestations during application by using two spraying machines with some compounds during cotton season 2018.

Compounds	% Reduction of cotton seed bug infestations during application									Seasonal Average
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	25^{d}	40^{d}	**32.5**^{e}	50^{b}	25^{c}	**37.5**^{d}	20^{e}	7.7^{d}	**13.9**^{e}	**27.9**^{e}
***B. thuringiensis* +160 Gy**	38^{bc}	58.8^{ab}	**48.4**^{bc}	65^{a}	66.6^{b}	**65.8**^{b}	75^{c}	71^{b}	**73**^{c}	**62.4**^{bc}
***B. thuringiensis* + 320 Gy**	42.2^{ab}	62.2^{a}	**52.2**^{ab}	69.9^{a}	79^{a}	**74.5**^{a}	82^{b}	75^{b}	**78.5**^{bc}	**68.4**^{ab}
***B. thuringiensis* + 640 Gy**	50^{a}	65^{a}	**57.5**^{a}	72.2^{a}	82.2^{a}	**77.2**^{a}	89^{a}	85^{a}	**87**^{ab}	**73.9**^{a}
Azadirachtin	25^{d}	50^{c}	**37.5**^{de}	50^{b}	61.3^{b}	**55.7**^{c}	65.4^{d}	50^{c}	**57.7**^{d}	**50.3**^{d}
***B. thuringiensis* +Azadirachtin**	32^{cd}	54^{bc}	**43**^{cd}	55^{b}	66.6^{b}	**60.8**^{bc}	72^{c}	70^{b}	**71**^{c}	**58.3**^{cd}
Diflubenzuron	50^{a}	66.6^{a}	**58.3**^{a}	73^{a}	85^{a}	**79**^{a}	90^{a}	86^{a}	**88**^{a}	**75.1**^{a}
$L.S.D_{0.05}$	7.72	7.54	8.53	7.54	8.88	7.29	6.32	8.62	8.74	8.53
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	22^{d}	38^{d}	**30**^{c}	40^{cd}	19^{e}	**29.5**^{d}	15^{d}	7.7^{d}	**11.4**^{d}	**23.6**^{e}
***B. thuringiensis* +160 Gy**	30^{c}	45^{abcd}	**37.5**^{bc}	55^{b}	59.9^{bc}	**57.5**^{b}	65^{bc}	62.2^{b}	**63.6**^{b}	**52.9**^{bc}
***B. thuringiensis* + 320 Gy**	38^{b}	48^{abc}	**43**^{ab}	59^{ab}	66.6^{ab}	**62.8**^{ab}	69.9^{ab}	65^{ab}	**67.5**^{ab}	**57.8**^{ab}
***B. thuringiensis* + 640 Gy**	45^{a}	50^{ab}	**47.5**^{a}	62.2^{ab}	70^{a}	**66.1**^{ab}	75^{a}	72^{a}	**73.5**^{a}	**62.4**^{a}
Azadirachtin	23^{d}	40^{cd}	**31.5**^{c}	37^{d}	50^{d}	**43.5**^{c}	59^{c}	40^{c}	**49.5**^{c}	**41.5**^{d}
***B. thuringiensis* +Azadirachtin**	25^{cd}	42.2^{bcd}	**33.6**^{c}	45^{c}	52.2^{cd}	**48.6**^{c}	62.2^{bc}	60^{b}	**61.1**^{b}	**47.8**^{cd}
Diflubenzuron	45^{a}	52.2^{a}	**48.6**^{a}	65^{a}	70^{a}	**67.5**^{a}	77^{a}	72^{a}	**74.5**^{a}	**63.5**^{a}
$L.S.D_{0.05}$	6.16	7.54	7.78	7.54	8.95	8.53	7.54	7.72	7.78	7.95

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Table 11: Percent reduction in cottonseed bug infestations during application by using two spraying equipment with some compounds during the cotton season 2019.

Compounds	% Reduction of cotton seed bug infestations during application									Seasonal Average
	1st spray			2nd spray			3rd spray			
	7	14	Aver.	7	14	Aver.	7	14	Aver.	
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)										
B. thuringiensis	25^{c}	30^{d}	**27.5**^{d}	40^{e}	45^{e}	**42.5**^{d}	40^{d}	30^{c}	**35**^{d}	**35**^{d}
***B. thuringiensis* +160 Gy**	52^{b}	62.2^{b}	**57.1**^{bc}	72.2^{bcd}	75^{c}	**73.6**^{b}	72^{ab}	69^{b}	**70.5**^{b}	**67.1**^{b}
***B. thuringiensis* + 320 Gy**	62.2^{a}	65^{b}	**63.6**^{ab}	77^{abc}	79^{bc}	**78**^{ab}	77^{ab}	70^{b}	**73.5**^{ab}	**71.7**^{ab}
***B. thuringiensis* + 640 Gy**	67^{a}	75^{a}	**71**^{a}	80^{ab}	85^{ab}	**82.5**^{a}	80^{a}	82^{a}	**81**^{a}	**78.2**^{a}
Azadirachtin	45^{b}	55^{c}	**50**^{c}	65^{d}	60^{d}	**62.5**^{c}	55^{c}	35^{c}	**45**^{c}	**52.5**^{c}
***B. thuringiensis* +Azadirachtin**	49^{b}	59^{bc}	**54**^{c}	69^{cd}	72.2^{c}	**70.6**^{b}	70^{b}	65^{b}	**67.5**^{b}	**64.03**^{b}
Diflubenzuron	67^{a}	75^{a}	**71**^{a}	82^{a}	88^{a}	**85**^{a}	80^{a}	80^{a}	**80**^{a}	**78.7**^{a}
L.S.D$_{0.05}$	7.72	6.28	8.21	8.39	8.003	7.72	8.39	8.88	7.78	8.88
Hydraulic Matabi sprayer (56L.\Fed.)										
B. thuringiensis	22^{b}	28^{d}	**25**^{d}	35^{c}	39^{e}	**37**^{e}	30^{d}	19^{e}	**24.5**^{d}	**28.8**^{e}
***B. thuringiensis* +160 Gy**	46^{a}	54^{bc}	**50**^{abc}	65^{ab}	66.6^{bc}	**65.8**^{bc}	65^{ab}	58^{bc}	**61.5**^{ab}	**59.1**^{bc}
***B. thuringiensis* + 320 Gy**	50^{a}	58^{abc}	**54**^{abc}	69^{ab}	72.2^{abc}	**70.6**^{abc}	70^{ab}	65^{ab}	**67.5**^{ab}	**64.03**^{abc}
***B. thuringiensis* + 640 Gy**	52^{a}	62.2^{ab}	**57.1**^{ab}	72^{a}	75^{ab}	**73.5**^{ab}	72.2^{a}	70^{a}	**71.1**^{a}	**67.2**^{ab}
Azadirachtin	44^{a}	50^{c}	**47**^{c}	61^{b}	50^{d}	**55.5**^{d}	46.6^{c}	30^{d}	**38.3**^{c}	**46.9**^{d}
***B. thuringiensis* +Azadirachtin**	45^{a}	52^{c}	**48.5**^{bc}	62.2^{b}	64.4^{c}	**63.3**^{c}	62.2^{b}	55^{c}	**58.6**^{b}	**56.8**^{c}
Diflubenzuron	52^{a}	65^{a}	**58.5**^{a}	73^{a}	79^{a}	**76**^{a}	72.2^{a}	70^{a}	**71.1**^{a}	**68.5**^{a}
L.S.D$_{0.05}$	8.43	8.07	8.58	7.89	8.39	7.39	8.39	8.003	9.06	8.58

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Cotton Crop Parameters:

The parameters of cotton crop (seed numbers, lint and seed weights) for each 100 opened cotton bolls was an important step to clear the effective of seven treatments used on the quality of cotton crop as illustrated in Tables (12 & 13) that mentioned the role of gamma radiation treatments for potentiating *B. thuringiensis* used to purpose of crop quality enhancement. Also, utilizing pneumatic motor sprayer (Cifarilli) (20 L./Fed.) enhanced the application comparing with the economy Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) uses.

a. Seed Numbers:

B. thuringiensis + 640 Gy treatment caused increasing in cottonseed numbers to 1345 & 1255 and 1275 & 1098 seeds/ opened 100 bolls during application by Pneumatic motor sprayer (Cifarilli) (20 L./Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) in 2018 & 2019 cotton seasons compared to untreated 989 & 954.5 seeds/ 100 opened boll at 2018 & 2019 cotton seasons, respectively. Also, *B. thuringiensis* + 320 Gy had increased the cotton seed compared to untreated, followed by *B. thuringiensis* + 160 Gy that exposed to gamma radiation doses. Also, *B. thuringiensis* + azadirachtin treatment caused seed number increasing compared to *B. thuringiensis* or azadirachtin when applied singly.

b. Lint Weight (g):

B. thuringiensis + 640 Gy had the highest lint weight/100 opened boll, it was 99 & 98 and 91 & 89 g/100 opened boll for Penumatic motor sprayer (Cifarilli) (20 L./Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L./fed.) during cotton seasons 2018 & 2019, respectively compared with untreated (50.2 & 46.4 g) for cotton seasons 2018 & 2019. While *B. thuringiensis* without exposure to gamma doses had the least value comparing with other treatments used.

c.Seed Weight (g):

B. thuringiensis + 640 Gy had the highest cotton seed weights with two spraying machine used comparing with 86.6 &755 g for untreated cotton seeds at cotton seasons 2018 and 2019 (Tables 12 & 13), Followed by *B. thuringiensis* + 320 Gy, *B. thuringiensis* + 160 Gy, *B. thuringiensis* + azadirachtin, diflubenzuron, azadirachtin and *B. thuringiensis* ,respectively .

It could be classified the seven treatments used efficacies against three cotton boll pests (*P. gossypiella*, *E. insulana* and *O. hyalinipennis*) on the field application to four categories as follows:

1.The first category that had a high efficacy on tested pests than other treatments. It's were diflubenzuron and *B. thuringiensis* + 640 Gy.

2.The second category that had a high efficacy on tested pests but slightly decreased compared with the first category. It's were *B. thuringiensis* + 320 Gy and *B. thuringiensis* + 160 Gy.

3.The third category that had intermediate efficacy on tested pests. It's were *B. thuringiensis* + azadirachtin and azadirachtin singly.

4.The fourth category had lower efficacy on tested pests. It's was *B. thuringiensis* when used singly.

In general, the Pneumatic motor sprayer (Cifarilli) (20 L./fed.) gave the best application for treatments than Hydraulic Matabi sprayer (56L.\Fed.) of two cotton seasons because the degree of homogeneity of droplets spectrum in the case of Pneumatic motor sprayer (Cifarilli) is higher than handheld Hydrulic (Matabi) sprayer.

Table 12: Cotton crop parameters as affected by some compound's applications using two ground equipment during the cotton season 2018

Compounds	Average weights (gm/100boll)					
	Seed numbers	Comparison With untreated	Lint weights	Comparison With untreated	Seed weights	Comparison With untreated
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)						
Untreated	989 c	- d	50.2 e	- f	86.6 e	- f
B. thuringiensis	1100 bc	+111 c	65 d	+14.8 e	95 e	+8.4 e
***B. thuringiensis* +160 Gy**	1310 a	+321 ab	89 ab	+38.8 abc	118 abc	+31.4 b
***B. thuringiensis* + 320 Gy**	1320 a	+331 a	92 ab	+41.8 ab	122 ab	+35.4 b
***B. thuringiensis* + 640 Gy**	1345 a	+356 a	99 a	+48.8 a	130 a	+43.4 a
Azadirachtin	1220 ab	+231 b	70 cd	+19.8 de	97 de	+10.4 e
***B. thuringiensis* +Azadirachtin**	1304 a	+315 ab	84 b	+33.8 bc	112 bcd	+25.4 c
Diflubenzuron	1290 a	+301 ab	79 bc	+28.8 cd	102 cde	+15.4 d
$L.S.D_{0.05}$	137.5	87.5	12.7	11.05	15.3	4.93
Hydraulic Matabi sprayer (56L.\Fed.)						
Untreated	989 b	- d	50.2 d	- d	86.6 b	- e
B. thuringiensis	1000 b	+11 d	54 d	+3. 8 d	87 b	+0.4 e
***B. thuringiensis* +160 Gy**	1220 a	+231 ab	80 ab	+29.8 bc	102 ab	+15.4 c
***B. thuringiensis* + 320 Gy**	1260 a	+271 ab	85 ab	+34.8 ab	112 a	+25.4 b
***B. thuringiensis* + 640 Gy**	1275 a	+286 a	91 a	+40.8 a	118 a	+31.4 a
Azadirachtin	1080 b	+91 c	60 cd	+9.8 d	89 b	+2.4 e
***B. thuringiensis* +Azadirachtin**	1210 a	+221 ab	78 ab	+27.8 bc	95 b	+8.4 d
Diflubenzuron	1200 a	+211 b	72 bc	+21.8 c	90 b	+3.4 e
$L.S.D_{0.05}$	107.2	62.1	12.9	9.554	15.3	4.58

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Table 13: Cotton crop parameters as affected by some compounds applications using two ground sprayer machines during the cotton season 2019.

Compounds	Average weights (gm/100boll)					
	Seed numbers	Comparison With untreated	Lint weights	Comparison With untreated	Seed weights	Comparison With untreated
Pneumatic motor sprayer (Cifarilli) (20 L./fed.)						
Untreated	954.5 c	- e	46.4 d	- g	75.5 e	- e
B. thuringiensis	990 c	+35.5 d	51 d	+4.6 f	82 de	+6.5 de
***B. thuringiensis* +160 Gy**	1240 a	+285.5 a	80bc	+33.6 c	103bc	+27.5bc
***B. thuringiensis* + 320 Gy**	1245 a	+290.5 a	89 ab	+42.6 b	112 ab	+36.5 ab
***B. thuringiensis* + 640 Gy**	1255 a	+300.5 a	98 a	+51.6 a	120 a	+44.5 a
Azadirachtin	1030bc	+75.5 c	55 d	+8.6 e	84 de	+8.5 de
***B. thuringiensis* +Azadirachtin**	1200 ab	+245.5 b	71 c	+24.6 d	93 cd	+17.5 cd
Diflubenzuron	1190 ab	+235.5 b	68 c	+21.6 d	90cde	+14.5 d
L.S.D$_{0.05}$	174.5	33.2	11.5	3.82	15.5	11.3
Hydraulic Matabi sprayer (56L.\Fed.)						
Untreated	954.5 c	- f	46.4 d	- e	75.5 d	- e
B. thuringiensis	985 c	+30.5 e	49 d	+2.6 e	78 d	+2.5 e
***B. thuringiensis* +160 Gy**	1086 a	+131.5 b	77 b	+30.6 b	95bc	+19.5bc
***B. thuringiensis* + 320 Gy**	1090 a	+135.5 ab	82 ab	+35.6 b	104 ab	+28.5 ab
***B. thuringiensis* + 640 Gy**	1098 a	+143.5 a	89 ab	+42.6 a	111 a	+35.5 a
Azadirachtin	1000bc	+45.5 d	52 d	+5.6 e	80 d	+4.5 de
***B. thuringiensis* +Azadirachtin**	1080 a	+125.5 b	69 c	+22.6 c	90bcd	+14.5 cd
Diflubenzuron	1065 ab	+110.5 c	63 c	+16.6 d	85 cd	+9.5cde
L.S.D$_{0.05}$	69.6	10.8	7.93	5.61	13.5	9.62

Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Spray Coverage on Cotton Leaves of Insecticides Used:

Data in Table (14) showed that, *B. thuringiensis*, *B. thuringiensis* + 160 Gy, *B. thuringiensis* + 320 Gy, *B. thuringiensis* + 640 Gy, Azadirachtin, *B. thuringiensis* +Azadirachtin, and Diflubenzuron using two ground spraying equipment and varied spraying volumes depending on the sprayer used. Data indicated that in general a satisfactory coverage was obtained on cotton plants. The spectrum of droplets ranging between 122-185 µm (VMD) i.e. more than 50 droplets/ cm^2, with sufficient number ranging from 33-253 N/cm^2.

a-Penumatic Motor Sprayer (Cifarilli) (20 L/Fed.):

Data in Table (15) showed that the lost spray percentages which were 10.2 ,9 ,8.9,8.7, 9.9 ,9.3& 8.5 % from the total spray volume in the case of recommended dose of *B. thuringiensis*, *B. thuringiensis* + 160 Gy, *B. thuringiensis* + 320 Gy, *B. thuringiensis* + 640 Gy, Azadirachtin, *B. thuringiensis* +Azadirachtin, and Diflubenzuron , respectively.

b-Hydraulic Matabi Sprayer (56L/fed.):

Data in Table (15) showed that the lost spray percentages which were 16.5,15,14.8`,14.4,16, 15.4 and 14 % from the total spray volume in the case of recommended dose of *B. thuringiensis*, *B. thuringiensis* + 160 Gy, *B. thuringiensis* + 320 Gy, *B. thuringiensis* + 640 Gy, Azadirachtin, *B. thuringiensis* +Azadirachtin, and Diflubenzuron, respectively.

Table 14: Spraying coverage on cotton plants and the ground produced by certain ground spraying equipment during seasons 2018 and 2019 at Qalubiya Governorate.

Compounds	Pneumatic motor sprayer (Cifarilli) (20 L/Fed.)					
	Upper level		Middle level		Lower level	
	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD
B. thuringiensis	118^e	159^a	113^b	160^a	109^f	162^a
***B. thuringiensis*+160 Gy**	150^d	138^c	148^b	150^b	140^d	150^c
***B. thuringiensis*+ 320 Gy**	170^c	135^c	165^{ab}	138^c	155^c	140^d
***B. thuringiensis*+ 640 Gy**	197^b	131^d	185^a	135^c	175^b	138^d
Azadirachtin	120^e	153^b	115^b	150^b	110^f	155^b
***B. thuringiensis* +Azadirachtin**	122^e	130de	120^b	135^c	115^e	152^{bc}
Diflubenzuron	253^a	127^e	220^{ab}	130^d	200^a	128^e
L.S.D$_{0.05}$	**3.76**	**3.384**	**116.5**	**3.317**	**3.621**	**3.225**
	Hydraulic Matabi sprayer (56L.\Fed.)					
B. thuringiensis	109^f	185^a	120^g	180^a	105^f	170^a
***B. thuringiensis*+160 Gy**	153^d	153^b	160^d	155^c	140^d	157^{bc}
***B. thuringiensis*+ 320 Gy**	160^c	150^b	173^c	152^d	148^c	155^c
***B. thuringiensis*+ 640 Gy**	170^b	135^c	180^b	138^e	160^b	138^d
Azadirachtin	110^f	155^b	125^f	159^b	108^f	160^b
***B. thuringiensis* +Azadirachtin**	136^e	154^b	150^e	156^c	130^e	159^b
Diflubenzuron	186^a	122^d	195^a	125^f	170^a	128^e
L.S.D$_{0.05}$	**3.154**	**5.294**	**3.154**	**1.779**	**3.154**	**2.866**

L.S.D. at (0.5 %) between treatments. Numbers followed by the same letter at the same column are not significantly different.

Table 15: Spray lost between cotton plants produced by certain ground spraying equipment during seasons 2018 and 2019 at Qalubiya Governorate.

Equipment	**Pneumatic motor sprayer (Cifarilli) (20 L./fed.)**													
Treatments	*B. thuringiensis*		***B. thuringiensis*** +160 Gy		***B. thuringiensis*** + 320 Gy		***B. thuringiensis* + 640 Gy**		**Azadirachtin**		***B. thuringiensis*** **+Azadirachtin**		**Diflubenzuron**	
	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD
Mean On plants	113	160	146	146	163	137	186	134	115	153	119	139	224	128
Ground	35	170	39	132	44	164	48	135	34	160	33	157	57	130
% N/Cm^2 on ground (spray lost	10.2	-	9	-	8.9	-	8.7	-	9.9	-	9.3	_	8.5	-
Equipment	**Hydraulic Matabi sprayer (56L.\Fed.)**													
Treatments	*B. thuringiensis*		***B. thuringiensis*** +160 Gy		***B. thuringiensis*** + 320 Gy		***B. thuringiensis* + 640 Gy**		**Azadirachtin**		***B. thuringiensis*** **+Azadirachtin**		**Diflubenzuron**	
	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD	N/cm^2	VMD
Mean On plants	111	178	151	155	160	152	170	137	114	158	139	156	184	125
ON ground	55	185	68	141	71	146	73	148	55	175	64	170	77	150
% N/Cm^2 on ground (spray lost	16.5	-	15	-	14.8	-	14.4	-	16	-	15.4	_	14	-

Relations Between Spray Quality and The General Reduction Percentages of Two Seasons by Using Certain Bioinsecticides Applied on Cotton Plants:

Data in Table (16) showed that homogeneity of spray coverage was high and in the case of Pneumatic motor sprayer (Cifarilli) (20 L./fed.) followed by Hydraulic Matabi sprayer (56L/fed.).The difference in the mortality percentages was due to the different modes of action of the bio-insecticides, degree of gamma radiation, the different spray volume used.

and the degree of homogeneity of the droplets spectrum in the case of Knapsack motor sprayer (Cifarilli) is higher than the handheld Hydrulic (Matabi) sprayer.

Also, there was no Phytotoxic effect on Cotton leaves after application treatments with pesticides in all treatments there was no change in the leaves color, and no leaf curling or flaming up phenomena has happened in case of all treatments.

The rate of performance of Pneumatic motor sprayer (Cifarilli) (20 L./fed.), the sprayer was 12 Fed./day. It was the best equipment, but the lowest rate of performance was Hydraulic Matabi sprayer (56L/fed.) since it could spray only 3.45 Fed./day.

Table 16: Relationship between field spray quality of Bio-insecticides by Penumatic motor sprayer (Cifarilli) (20 L/Fed.) and Hydraulic Matabi sprayer (56L.\Fed.) during seasons 2018 and 2019 at Qalubiya Governorate.

Treatments	Spray quality= VMD/N/cm²= degree of homogeneity					
	Pneumatic motor sprayer (Cifarilli) (20 L./fed.)			Hydraulic Matabi sprayer (56L.\Fed.)		
	Upper level	Middle level	Lower level	Upper level	Middle level	Lower level
B. thuringiensis	1.3 a	1.4 a	1.49 a	1.7 a	1.51 a	1.61 a
B. thuringiensis +160 Gy	0.92 a	1.01 a	1.07 a	1 ab	0.97 a	1.12 a
B. thuringiensis + 320 Gy	0.79 a	0.84 a	0.9 a	0.94 ab	0.88 a	1.05 a
B. thuringiensis + 640 Gy	0.66 a	0.73 a	0.79 a	0.79 ab	0.77 a	0.86 a
Azadirachtin	1.28 a	1.3 a	1.4 a	1.4 ab	1.27 a	1.48 a
B. thuringiensis +Azadirachtin	1.07 a	1.1 a	1.3 a	1.1 ab	1.04 a	1.2 a
Diflubenzuron	0.5 a	0.59 a	0.64 a	0.66 b	0.64 a	0.75 a
$L.S.D_{0.05}$	**0.818**	**0.853**	**0.846**	**0.833**	**0.834**	**0.939**

S.Q. = spray quality. = VMD/N/cm^2= Spray quality (degree of homogeneity).
The spray height is constant ~ 0.5 meter in all treatments
VMD= Volume mean diameter, N/cm^2= Number of droplets/cm^2
Numbers followed by the same letter at the same column are not significantly different at P= 0.05.

Gamma radiation doses contribute to enhancement from efficacies of *B. thuringiensis* when exposed to gamma radiation doses of 160, 320 & 640 Gy against three cotton boll pests of *P. gossypiella*, *E. insulana*, and *O.hyalinipennis*. Previous works agreed with the current study as Amer (2006) showed that the combination of gamma irradiation with Dipel 2x activated the spores of the biocide compound and caused a potentiation effect. Also, Amer (2006) carried out the field experiments during the two cotton seasons 2004 and 2005. The results showed that the efficiency of Dipel-2x increased gradually with gamma irradiation from 5 to 80 Gy. Also, the treatments increased lint and seed weights (gm/100bolls). Amer, *et al* (2012) mentioned that LC_{50}'s on subjected insects (*P. gossypiella*, *S. littoralis*, and *A.* craccivora) treated with *B. thuringiensis* and exposed to gamma doses (150, 250 & 350 Gy) were lower than unexposing *B. thuringiensis* to gamma doses. Amer, *et al.* (2015a) exposed *B. thuringiensis*, *M. anisopliae* and biopolymer compound (chitosan) to gamma doses of 15, 30 & 60 Gy, respectively for potentiating effect. It showed potentiated effect especially with a dose of 60 Gy was more effective than other doses used against *S. littoralis* treated as 4th instar larvae at different efficiencies tests. Amer, *et al.* (2015b) mentioned that *B. thuringiensis* + 60 Gy lead to swelling of the outer cuticle fibrous layer of *S. littoralis* larvae integument. Furthermore, hypodermis layer had distention and damage in *S. littoralis* larvae. Also, it occurrence of split and destruction of muscles into small portions and remarkable suffered on the fat body cells as vacuolization and destroyed the fat body membranous sheath; in addition to alterations influences in the midgut of *S. littoralis* as destroyed of columnar or hyperphesia cells padding midgut, damage of brush border with excess of goblet cells. Furthermore, Amer, *et al.* (2018) reported that a heavily % DNA of *S. littoralis* had destruction rang: 40-92% caused by Chitosan + 60 Gy that had the highly % DNA destruction (8.399%), followed by chitosan + 30Gy (7.829%), *M. anisopliae* + 15 Gy (5.681%), chitosan (3.991%), *B. thuringiensis* + 30 Gy (3.902%), *M. anisopliae*+ 60 Gy (2.604 %) and chitosan + 15 Gy (1.868%). Amer, *et al.* (2019) stated that gamma-ray doses (50&500 Gy) treatments were the most efficacy against *E. insulana* egg stage than magnetic flux treatments (20& 180 mlt).

Diflubenzuron compound as Insect Development Inhibitor makes a disturbance of formation of lamellate deposition of the procuticle. After fixation and staing, the globular material could be found instead. The new instar was either not able to ecdyse due to lack of rigidity of its exoskeleton or dies shortly after ecdysis. The ovicidal activity caused either by contact activity on egg or adult female treatment. The larvae in the egg had fully developed but unable to leave the egg (Wright and Retanakaran, 1987). In addition, Srinivasan and Uthanasamy (2001) conducted the experiment was conducted to evaluate the efficacy of diflubenzuron alone and in combination with profenofos and α –cypermethrin against the American bollworm, *H. armigera.* The combinations were found to reduce the incidence of *H. armigera*. Moreover, Mahmoud, *et al.* (2014) evaluated the toxicity of lufenuron and diflubenzuron against the newly hatched larvae of *P. gossypiella* under laboratory conditions. There is prolongation in larval and pupal development in diflubenzuron than lufenuron. In contrast was happened in the adult stage; high reduction in total eggs, hatchability% and longevity.

At current work, the additive compound of *B. thuringiensis* + azadirachtin had potentiating effect than *B. thuringiensis* or azadirachtin singly. Meanwhile, Rafiq *et al.* (2012) conducted that azadirachtin extracts in different parts of plants showed significant mortality response against 3rd instar larvae of cotton *P. gossypiella, S. litura* and *H. armigera*. The surviving insects showed the behavior with a decrease in insect weight and slower feeding activity as compared to the control. The efficacy of these extracts may be further enhanced by using 1st and 2nd instar larvae of these insects in bioassays as well as optimizing dose concentration and treatment time. Also, Dawkar, *et al.* (2019) suggested that azadrachtin targets more than one protein in *H. armigera* and hence could be a potent biopesticide.

For evaluation the field performance of Low-Volume spraying machines; Pneumatic motor sprayer (Cifarilli) (20 L/Fed.) and Hydrulic Matabi sprayer (56L/fed.) ,respectively ; to spray *B. thuringiensis, B. thuringiensis* + 160 Gy, *B. thuringiensis* + 320 Gy, *B. thuringiensis* + 640 Gy, Azadirachtin, *B. thuringiensis* +Azadirachtin, and Diflubenzuron using two ground spraying equipment and varied spraying with total recommended dose. A satisfactory coverage was obtained on cotton plants, the droplet spectrum was obtained in field experiment was agreed with the optimum droplet sizes mentioned by (Mathews,1992), in case of low volume equipment. It could be recommended to use these compounds with LV spraying equipment with not less than (20 L./Fed.). Also, the best equipment in this respect was Pneumatic motor sprayer (Cifarilli) (20 L/Fed.) followed Hand-held Hydraulic sprayer (Matabi) (56 L.\fed.), the tested equipment under study. The rate of performance of Pneumatic motor sprayer (Cifarilli) (20 L./fed.) , the sprayer was 12 Fed./day. It was the best equipment, but the lowest rate of performance was Hand-held Hydraulic sprayer (Matabi) (56 L.\fed.) since it could spray only 3.45 Fed./day. (18 L/fed.) droplets/cm^2 and the lost spray-on ground, and these results agreed with Hindy *et al.* (2004), Genidy *et al.* (2005) which recommended KZ oil and Pyriproxyfen followed by Agerin using low volume spraying because of reducing the time lost in process filling the machines, improve the homogeneity of the spray solution on the Cotton plant leaves and saving the lost spray on the ground, these results also in agreement with Bakr *et al*. (2014) they recommended by using Profenofos followed by Pyriproxyfen and Spinosad with Agromondo sprayer (20L/fed.). Dar *et al.* (2019) showed that Motorized Knapsack sprayer (Agromondo) (20 L.Fed.) was the best equipment to control seedling pests at the early season of Cotton. The rate of performance of Knapsack motor sprayer (Arimitsu) was 15.25 Fed./day. It was the best equipment, but the lowest rate of performance was Hand-held Hydraulic sprayer (Matabi) (56 L.\fed.) since it could spray only 3.4 Fed./day. Also, the lowest spray volume, the lowest percentage 9.4% of lost spraying between plants occurred by Pneumatic motor sprayer (Cifarilli) (20 L/Fed.), this result was agreed with Hindy *et al.* (1997), who mentioned that there was a positive relationship between rate of application and lost spray-on ground. Also, the best equipment in this respect was Knapsack motor sprayer (Cifarilli) (20 L/Fed.) followed by Hand-held Hydraulic sprayer (Matabi) (56 L.\fed.) the tested equipment under study, these results were in agreement with Dar *et al*. (2020) . Spray Quality was near to 1 in case of Pneumatic motor sprayer (Cifarilli) (20 L/Fed.) and Hand-held Hydraulic sprayer (Matabi) (56 L.\fed.) which indicated high spray coverage homogeneity and best controlling of the three boll pests, this result were agreed with (Mathews,1992), Dobson (2001) whom illustrated the typical values for spray quality (homogeneity)=more than 2.5 (very poor) for Hydraulic nozzle, whereas = 2 for air-shear nozzle.

CONCLUSION

Generally, it could be concluded that Pneumatic motor sprayer (Cifarilli) (20 L/Fed.) contribute to success more control than Hand-held Hydraulic sprayer (Matabi) (56 L.\fed.) due to more homogenous spraying and a higher rate of performance.

It could be recommended to *B. thuringiensis*, *B. thuringiensis* + 160 Gy, *B. thuringiensis* + 320 Gy, *B. thuringiensis* + 640 Gy, Azadirachtin, *B. thuringiensis* +Azadirachtin, and Diflubenzuron with low volume (LV) spraying equipment with not less than (20 L./fed.) which revealed successful results. There was a negative complete correlation between (VMD) and the reduction percentage of the three boll pests of Cotton while there was a positive complete correlation between N/cm² and the reduction percentage of the three boll pests of Cotton in all treatments. Moreover, gamma radiation doses (160, 320 &640 Gy) improve the potentiating *B. thuringiensis* action to become the efficacy action was the highly if it compared with *B. thuringiensis* without exposing to gamma radiation doses or both of them used singly.

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ARABIC SUMMARY

التأثير التعاونى بين آشعة جاما وتوزيع قطيرات الرش لبعض المبيدات الحيوية لمكافحة ثلاث آفات على لوز القطن في مصر.

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أجريت تجربة حقلية فى محطة بحوث وقاية النباتات – قها – محافظة القليوبية خلال موسمى قطن ٢٠١٨ و٢٠١٩. استخدم نوعان من آلات الرش (موتور رش ظهرى Knapsack motor sprayer - رشاشة ظهرية Economy micron ulva sprayer) طبقت فيها ٧ معاملات تتبع مجاميع ٣ مبيدات آفات مختلفة، أحدهم بكتيريا الباسيلس ثورينجينسيز تم تعريضها لجرعات آشعة جاما (١٦٠- ٣٢٠- ٦٤٠ جراى) بغرض تقوية الفعل الإبادى لمستحضر البكتيريا.

المعاملات المستخدمة كانت كالتالى: بكتيريا *Bacillus thuringiensis* – بكتيريا + ١٦٠ جراى- بكتيريا + ٣٢٠ جراى- بكتيريا + ٦٤٠ جراى- بكتيريا + مستخلص الأزدراكتين – مستخلص الأزدراكتين والبكتيريا منفردين – مانع الانسلاخ الدايفلوبنزيرون.

تم تقييم المعاملات السابقة حقليا لخفض التعداد والاصابة لثلاثة آفات تصيب لوز القطن وهى دودة اللوز القرنفلية *Pectinophora gossypiella* ودودة اللوز الشوكية *Earias insulana* وبقة بذرة القطن *Oxycarenus hyalinipennis* .

حققت معاملات الرش بالموتور الظهرى نتائج أفضل من معاملات الرشاشة الظهرية. كما تعتبر معاملة البكتيريا + ٦٤٠ جراى ومعاملة الدايفلوبنزيرون أفضل المعاملات خفضا للنسبة المئوية للتعداد والاصابة للآفات الثلاثة يليه فى ذلك بكتيريا + ٣٢٠ جراى – بكتيريا + ١٦٠ جراى ثم بكتيريا +أزدراكتين - الأزدراكتين منفردا –بكتيريا منفردة.

بالاضافة الى ما سبق ساهمت المركبات المستخدمة وخاصة معاملات بكتيريا + ٦٤٠ جراى فى تحسين صفات محصول القطن من عدد البذور ووزن الشعر والبذرة/ ١٠٠ لوزة متفتحة خلال موسمى الاختبار ٢٠١٨ و٢٠١٩.

ولذلك اتضح ان أشعة جاما لها فعل تقوية للبكتيريا ليصبح تأثيرها أكثر فاعلية بالمقارنة باستخدام المركب منفردا دون التعريض للاشعاع. كما ان معاملات الرش بالموتور الظهرسيفاريللى أفضل من معاملات الرشاشة الظهرية فى نجاح مكافحة الافات بحجم الرش ٢٠ لتر\فدان حقق أعلى النتائج يليه الرشاشة ميتابى الهيدروليكية بمعدل ٥٦ لتر\فدان.

تم الحصول على تغطية مرضية على نباتات القطن المعاملة وتراوح مدى طيف قطيرات الرش ما بين ١٢٢- ١٨٥ ميكرون مع أعداد كافية من القطيرات\سم² تراوحت ما بين٣٣-٢٥٣ قصيرة\سم² في المعاملات المختلفة. وكانت معدل كفاءة الموتور الظهرى سيفاريللى ١٢ فدان\يوم باثنان من العمال بينما أقل كفاءة كانت الرشاشة الظهرية ميتابى ٥ ٣,٤فدان \يوم باثنين من العمال.

يمكن التوصية بأن استخدام حجوم الرش القليلة أكثر اقتصادية في مكافحة افات اللوز الثلاثة و تقليل الوقت في اعادة التعبئة و تحقيق تجانس محلول الرش على نباتات القطن المعاملة توقير الفاقد من الرش على نباتات القطن.