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EFFECT OF GAMMA RADIATION (γ) AND ULTRA VIOLET LIGHT (UV) ON THE POTATO TUBER MOTH, PHTHORIMAEA OPERCULELLA (ZELLER) (LEPIDOPTERA, GELECHIIDAE)

BY

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ABSTRACT

Two experiments were carried out to investigate the response of Phthorimaea operculella (Zeller) pupae to certain doses of gamma rays and ultra violet light.

In the first experiment , 2-days old pupae were irradiated with doses ranging from 1 to 20 krad of gamma rays from CO^{60} sucrose. In the second experiment,pupae of the same age were exposed to 5.4, 10.8, 21.6 and 32.4 Jol/cm²/second of ultra violet light (UVL).

Gamma rays as well as (UVL) had adverse effect on some biological aspects of the insect. In general, these effects were greater as the treatment increased in the parental generation and the first generations. Sterility reached 91.9% and 86.6% after pupal treatments with 15 krad and 32.4 Jol/cm²/sec., respectively.

Therefore, the use of gamma rays and UVL is recommended for any sterile-male technique for the control of the potato tuber moth,Phthorimaea operculella (Zeller).

INTRODUCTION

Phthorimaea operculella (Zeller) is a cosmopolitan pest of potato and other solanaceous crops in temperate and tropical regions. Radcliffe (1982) mentioned that P. operculella caused damages to foliage and tubers. In Egypt, it has long been established as a major pest of potato crop. The larvae act as leafminers of the potato plants and as borers of tubers in the field and in storage (Assem, 1966).

Considerable work on the rearing techniques and on the biology of this insect pest has been carried out by many authors such as Sharaby et al.(1987) , Gomaa et al.(1978) and Dorest and Nieves (1968).

The effect of pesticides on this pest was studied out by Raman and Midmore(1983) and Tayeb et al.(1991). Moreover, Nabil (1983) studied the effect of Chemosterilants on the same pest. The effect of Juvenoides on this pest was tested by Ciamoir et al.(1979) and Hamdy and Salam (1986).

The use of insecticides for the control of this insect pest may be effective but is undesirable,hence safer and more effective methods of control are being thought of particularly the use of insect irradiation with γ and UVL. These methods are expected to be cheaper and less hazardous to the environmenta (Abdel Rahman et al., 1990).

The main reasons, which promoted the authors to undertake the present study are (1) The scancity of studies pertaining to the effect of γ radiation and UVL on the insect under study,(2) The success of the so-called sterile-male technique "SMT" for controlling some major pests in different parts of the world,(3) To what extent,the treatment will negatively affect some

fitness component that could be useful in controlling the insect or reducing its damage.

Therefore, this investigation was initiated to show the effects of γ radiation as well as the UVL on some biological aspects of the potato tuber moth in P_1 and F_1 generations. Such basic sterile-male-technique "SMT" programmes for the control of the insect pest under study either by releasing gamma sterile-males in the fields or by using UVL source in potato tuber stores.

MATERIALS AND METHODS

I. Rearing of the insect:

P. operculella (Zeller) was successfully reared for four generations under laboratory conditions of 24 ± 2°C and 70 ± 5% R.H. The rearing technique was carried out according to the method described by Dorest and Nieves(1968).

II. Experimental procedures:

The following two experiments were conducted:

A- Two-days old pupae were exposed to six γ radiation dose levels, 1, 5, 7, 10, 15 and 20 krad with a dose rate of 13.32 rads/second. Irradiation with rays was carried out by using CO^{60} cell in the unit of the Middle Eastern Regional Radioisotopes Centre for the Arab Countries at Dokki, Cairo, Egypt.

B- Pupae of 2-days old were exposed to the near ultra violet light at different doses of 5.4, 10.8, 12.6 and 32.4 Jol/cm²/sec. Short waves of UV were emitted from a germicidal lamp App. N. 8 B. 2610 C, 36 erg/mm²/sec..

Crosses:

In the preceding experiments four pairing

combinations were set up for each dose level as follows:

A-Treated females (T ♀) x treated males (T ♂).

B-Treated females (T ♀) x untreated males (U ♂).

C-Untreated females (U ♀) x treated males (T ♂).

D-Untreated females (U ♀) x untreated males (U ♂).

Each treatment was replicated five times. For each treatment, a group of 120 pupae at the age of two days were collected at random from the stock culture of the insect pest and put in Ca. 10 x 20 cm muslin sac to be used for each dose of exposure. The untreated pupae of the same age were used as control. The emerging adults were sexed within 24 hrs. to avoid uncontrolled matings. These emerging adults were released in specimen glass tubes (2 cm dia. x 6 cm long) for mating. Percentages of adult emergence, malformations, hatchability, dominant lethals, pupation as well as life span of adults , and number of eggs/female were recorded , for the first generation after pupal treatment (P) and for the first offspring generation (F_1).

Deposited eggs on a black strip were incubated at a temperature of 24±2°C and 75% R. H. The neonated larvae of the previous crosses were reared on potato tubers till pupation.

The induced dominant lethal percentages were computed according to the formula described by Abrahamson and Herskowitz (1957) as follows:

$$\text{Induced dominant lethal \%} = \frac{\text{Unhatched treated eggs \%} - \text{Unhatched control eggs \%}}{100 - \text{Unhatched control eggs \%}} \times 100$$

RESULTS AND DISCUSSION

I. Effects of gamma radiation:

Irradiation of 2-days old pupae of Phthorimaea operculella with different doses of gamma rays significantly reduced the percentages of adult emergence increased malformation percentage and decreased the moth life-span. It was clearly observed that the obtained results were dose dependent. It was also found that 50% of the pupae irradiated with 20 krad , failed to emerge into adults (Table 1.).

Similar findings were reported by Bartleet et al.(1973) on the pink bollworm Pectinophora gossypiella , Carpenter et al.(1983) on Spodoptera fruqiperda and El-Kady (1988) on Spodoptera littoralis.

As the dose increased, the life span of the survivals after pupal irradiation significantly decreased. this was stated by Ward et al.(1986) on the adult range caterpillars and also by Elsey and John (1984) on the pink bollworm.

The obtained results illustrated in Table (2), show that in all cases the females produced from treated pupae laid the lowest numbers of eggs. For example, in the treatment with 20 krad, the cross in (A) deposited an average of 10.0 $\pm$ 10.0| eggs compared with 258.3 $\pm$ 9.95 eggs for the control (D). Therefore it is important to state that females crossed with males induced from treated pupae were less productive than those crossed with untreated males.

Egg-hatchability was greatly affected and reduced by increasing doses of γ to reach 5.3 $\pm$ 3.3% in the cross (A) after treatment with 20 krad, while in the control it was 94.5 $\pm$ 1.67% (Table 2).

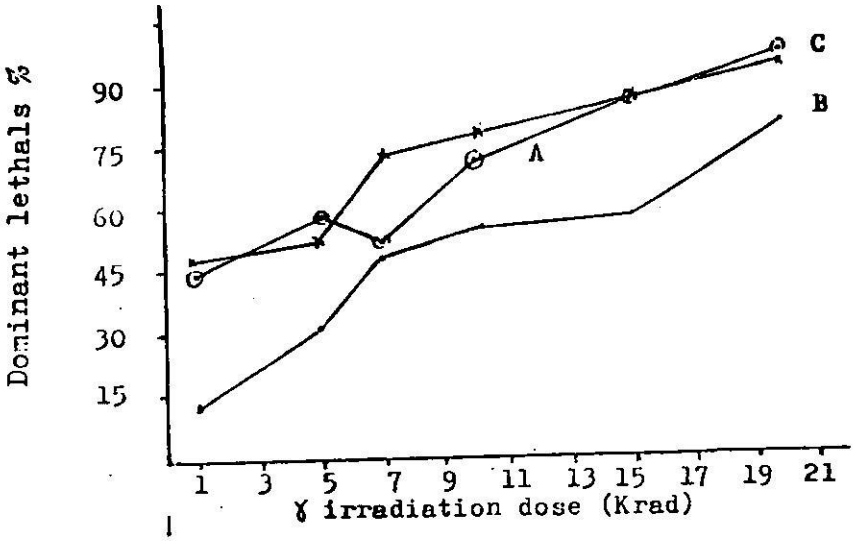
Table (1). Effect of gamma rays (γ) on the adult emergence (%), adult malformation (%) and the moth life-span of pathorimaea operculelia (Zeller).

Dose (krad)	Total No. of treated pupae.	Emergence (%)	Malformation (%)	Moth life span (days)	
				Female	male
1	120	87.5 ± 3.82	8.5 ± 2.10	4.7 ± 0.33	3.8 ± 0.31
5	120	86.2 ± 5.19	14.4 ± 3.00	4.2 ± 0.31	3.8 ± 0.40
7	120	82.5 ± 4.91	22.7 ± 4.25	3.7 ± 0.33	3.5 ± 0.34
10	120	81.2 ± 5.11	23.1 ± 4.64	3.3 ± 0.33	2.7 ± 0.21
15	120	62.5 ± 7.20	36.0 ± 5.02	2.7 ± 0.21	2.3 ± 0.21
20	120	50.0 ± 8.43	55.0 ± 5.42	1.6 ± 0.31	1.6 ± 0.21
0 Control	120	95.0 ± 2.77	1.13 ± 0.90	9.7 ± 0.49	6.8 ± 0.31
F.		11.3 **	8.45 **	8.04 **	7.6 **
L.S.D.		10.56	5.72	0.81	1.75

Table (2). Effect of gamma rays (ϑ) on the fitness components and the induced dominant lethals (%) in the parental generation (P_1) of *P. operculella* (Zeller).

Dose (Krad)	crosses	No. of deposited eggs per female $\bar{X} \pm S_{\bar{x}}$	Hatchability (%) $\bar{X} \pm S_{\bar{x}}$	Pupation (%) $\bar{X} \pm S_{\bar{x}}$	Adult emergence (%) $\bar{X} \pm S_{\bar{x}}$
	A	57.6 ± 9.61	51.7 ± 4.36	32.7 ± 1.45	79.3 ± 7.91
	B	76.0 ± 8.34	83.2 ± 1.50	29.3 ± 9.84	80.7 ± 8.34
	C	144.0 ± 23.18	51.7 ± 7.08	27.7 ± 11.36	75.9 ± 7.66
5	A	55.7 ± 12.88	45.2 ± 4.71	17.0 ± 4.16	70.5 ± 6.54
	B	56.0 ± 6.67	65.5 ± 2.67	22.7 ± 5.37	79.7 ± 9.70
	C	142.3 ± 29.19	39.0 ± 5.51	32.3 ± 7.32	71.3 ± 7.41
7	A	46.3 ± 23.19	25.8 ± 13.8	11.7 ± 6.02	40.2 ± 1.33
	B	50.7 ± 26.15	49.0 ± 24.6	14.0 ± 7.38	66.3 ± 8.99
	C	109.3 ± 5.55	47.1 ± 4.94	23.3 ± 4.81	50.4 ± 7.67
10	A	40.7 ± 22.26	21.9 ± 10.9	7.3 ± 3.72	8.5 ± 3.34
	B	40.0 ± 20.16	43.1 ± 21.7	9.3 ± 5.82	50.3 ± 6.45
	C	139.0 ± 10.79	27.1 ± 5.12	11.7 ± 2.66	9.6 ± 7.92
15	A	18.3 ± 9.29	14.6 ± 14.88	1.7 ± 1.30	0.0
	B	35.3 ± 18.99	39.8 ± 20.25	11.7 ± 6.39	2.9 ± 3.71
	C	105.0 ± 6.51	14.2 ± 3.53	7.0 ± 2.66	2.1 ± 7.35
20	A	10.0 ± 10.01	5.3 ± 3.3	0.0	-
	B	13.3 ± 8.46	18.7 ± 10.9	1.0 ± 1.01	-
	C	104.0 ± 8.89	5.3 ± 2.64	0.0	-
Cont.	D	258.3 ± 9.95	94.5 ± 1.67	96.3 ± 3.35	95.2 ± 3.41
F.		50.2**	12.98**	70.27**	57.4**
L.S.D.		20.41	26.48	13.50	6.3

Fig. 1. a. The effect of ɣ rays on the dominant lethals % of the P_1 generation.



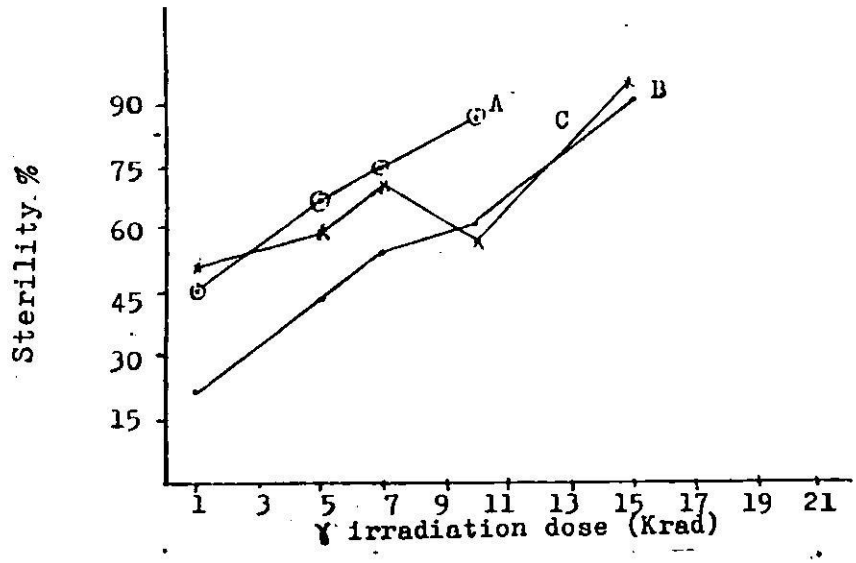


Fig. 1.b. The effect of ɣ rays on the inherited sterility % of F_1 generation.

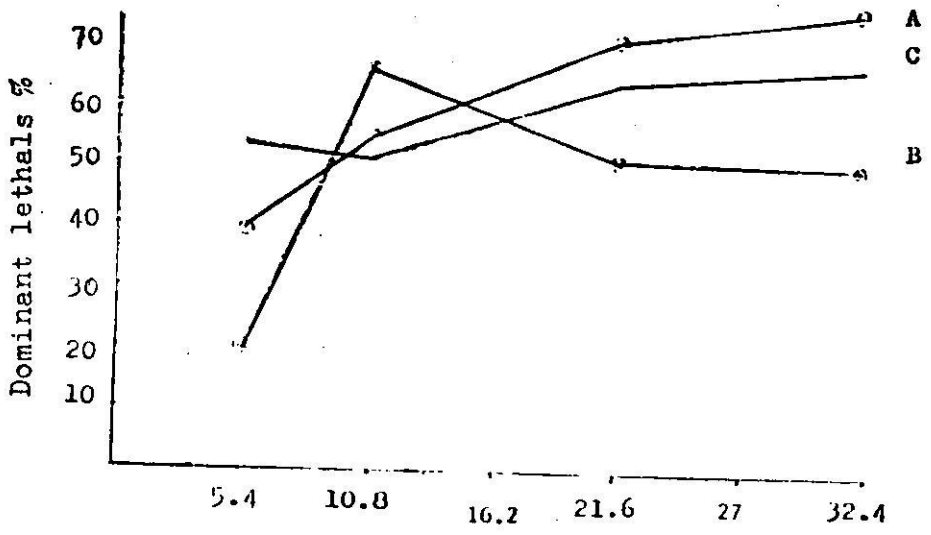
With respect to the induction of dominant lethal percentages, it may be clear in Fig. (1,a) that gamma rays induced high rates of lethal genes. The dominant lethal percentages gradually increased as the dose increased, being 45.3 and 94.3 for the Crosses (A) at dose level of 1 and 20 krad, respectively (Table 2). The results obtained by El-Kady (1988) on Spodoptera littoralis and Younes et al. (1980) on Lasioderma serricorne confirm the findings obtained in the present study. The decrease in pupation % is related to the increase of gamma dosage. The larvae obtained from the pairing combinations, (A) and (C) after pupal treatments with 20 krad died before pupation. Only 1.01 of larvae produced from case (B) in the treatment of 20 krad, but in the control the percentage of adult emergence was 95.2 $\pm$ 3.41.

The inherited influence of γ rays at different dose was also studied in the first offspring generation (F_1).

In general, it was found that the average number of eggs/female, and the percentages of hatchability, pupation and emergence were reduced as the irradiation dose increased. The rate of inherited sterility was also calculated. The rate of sterilization in the offspring highly depended on the dose of treatment in the parental generation and the kind of the treated sex. The value of inherited sterility in F_1 generation fluctuated from 19.9% in case of B with 1 krad to 94.3% in the case of C at 20 krad (Table 3).

It is quite clear that complete sterility was attained in the progeny resulting from case (A) at the dose of 15 krad. Reproduction occurred at the dose level of 20 krad for the three cases (A), (B) and (C) (Fig. 1,b). It thus appears that offspring derived from treated male parents were more sterile than those derived from the treated female parents.

Fig. 2.a. The effect of UVL on the dominant lethals of the P_1 generation.



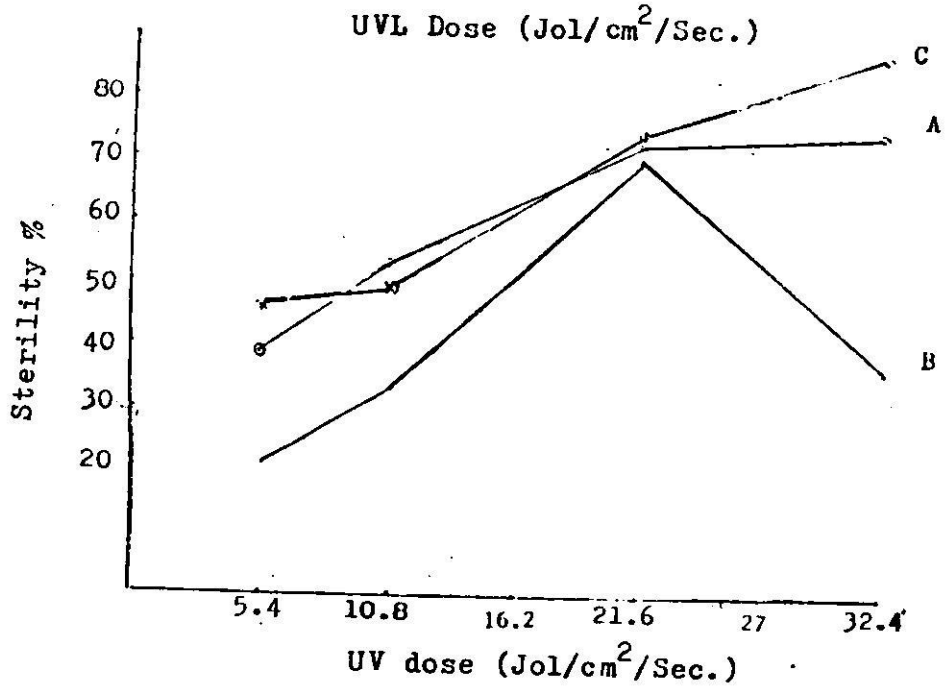


Fig. 2.b. The effect of UVL on the inherited sterility of F_1 generation.

Table (3). Effect of gamma rays (δ) on the bionomic and induced sterility in the first offspring generation (F_1) generation of P. operculella (Zeller).

Parental dose (Krad)	Parental crosses	No. of deposited eggs per female $\bar{X} \pm S_{\bar{x}}$	Hatchability (%) $\bar{X} \pm S_{\bar{x}}$	Pupation (%) $\bar{X} \pm S_{\bar{x}}$	Adult emergence (%) $\bar{X} \pm S_{\bar{x}}$
1	(A)	61.0 ± 8.97	54.8 ± 3.11	19.0 ± 12.31	80.2 ± 15.60
	(B)	86.7 ± 2.80	80.1 ± 4.67	33.3 ± 15.20	81.9 ± 8.91
	(C)	92.0 ± 2.52	49.2 ± 6.54	30.0 ± 9.90	78.3 ± 18.80
5	(A)	40.7 ± 21.3	32.8 ± 16.45	9.3 ± 8.11	72.1 ± 22.40
	(B)	52.7 ± 22.6	56.5 ± 13.29	16.7 ± 11.20	80.6 ± 21.20
	(C)	89.7 ± 3.7	40.6 ± 16.30	17.0 ± 12.91	73.2 ± 15.60
7	(A)	30.0 ± 15.29	25.3 ± 12.73	5.7 ± 3.10	50.3 ±11.90
	(B)	36.7 ± 18.60	47.3 ± 23.70	17.3 ± 8.91	68.5 ± 9.60
	(C)	79.3 ± 7.45	30.5 ± 2.60	13.7 ± 7.31	52.4 ± 8.40
10	(A)	13.7 ± 8.77	13.3 ± 1.37	1.7 ± 1.10	12.5 ± 9.96
	(B)	15.0 ± 7.65	40.0 ± 2.21	6.0 ± 2.11	55.3 ± 6.35
	(C)	73.0 ± 12.03	23.0 ± 5.21	8.7 ± 3.21	15.4 ± 3.55
15	(A)	-	-	-	-
	(B)	6.7 ± 3.38	9.2 ± 2.32	0.0	0.0
	(C)	67.0 ± 6.51	5.7 ± 6.31	2.7 ± 3.91	2.2 ± 1.21
20	(A)	-	-	-	-
	(B)	-	-	-	-
	(C)	-	-	-	-
Cont.	D	226.7 ± 23.50	91.0 ± 3.41	246.7 ± 3.91	94.3 ± 3.45
F.value		16.14**	6.27 **	203.3 **	25.3**
L.S.D.		31.37	24.28	10.48	18.2

Table (4). Effect of ultraviolet (UV) light on the adult emergence (%), adult malformation (%) and the life-span of P. operculella (Zeller).

Dose Jol/cm²/sec (time)	No of pupae treated	Emergence (%)	Malformation (%)	Moth life span (days)	
				Female	male
5.4 (15 min)	120	93.3 ± 3.75	1.61 ± 0.45	6.8 ± 0.6	5.0 ± 0.26
10.8 (30 min)	120	88.3 ± 4.20	2.82 ± 1.05	5.5 ± 0.34	6.3 ± 0.42
21.6 (60 min)	120	83.3 ± 4.90	8.06 ± 2.40	3.3 ± 0.33	2.7 ± 0.42
32.4 (90 min)	120	73.3 ± 6.40	25.07 ± 3.11	3.4 ± 0.31	2.3 ± 0.21
0 Cont.	120	95.0 ± 3.50	1.13 ± 0.32	9.7 ± 0.49	6.8 ± 0.31
F.		1.85	15.3 **	1.13	1.35
L.S.D.				3.69	3.3

Table (5). Effect of ultra violet (UV) light on the fitness components and the induced dominants lathals (%) in the first generation (P_1) post pupal treatment of P. operculella.

Dose Jol /cm²/sec (time)	Crosses	No. of deposited eggs / female $\bar{X} \pm S_{\bar{x}}$	Hatchability (%)	Pupation (%) $\bar{X} \pm S_{\bar{x}}$	Adult emergence (%)
5.4 (15 min)	A	82.0 ± 8.15	57.1 ± 5.14	45.0 ± 17.41	86.2 ± 0.24
	B	81.7 ± 8.14	75.6 ± 2.75	26.3 ± 2.85	89.3 ± 2.31
	C	175.3 ± 6.51	43.8 ± 7.01	30.0 ± 2.31	82.1 ± 4.41
10.8 (30 min)	A	74.7 ± 7.89	42.5 ± 1.16	22.7 ± 5.70	70.7 ± 3.31
	B	82.3 ± 9.60	68.1 ± 6.43	21.3 ± 2.85	76.5 ± 3.57
	C	175.7 ± 3.12	45.7 ± 2.21	30.7 ± 4.64	71.5 ± 8.32
21.6 (60 min)	A	51.0 ± 4.13	27.1 ± 12.57	10.7 ± 6.07	64.9 ± 8.44
	B	48.3 ± 14.30	46.4 ± 23.21	19.7 ± 9.85	74.3 ± 4.66
	C	156.7 ± 8.91	34.1 ± 1.91	25.7 ± 4.34	67.2 ± 4.61
32.4 (90 min)	A	40.6 ± 9.61	22.3 ± 12.40	6.7 ± 3.30	40.2 ± 6.42
	B	23.3 ± 9.55	47.6 ± 23.80	9.3 ± 4.70	70.9 ± 5.38
	C	136.3 ± 7.12	30.9 ± 15.40	10.7 ± 6.01	50.5 ± 2.33
Cont.	D	258.3 ± 9.95	94.5 ± 1.67	95.3 ± 8.1	95.2 ± 3.41
F.		22.06 **	3.01 *	7.93 **	61.50 **
L.S.D.		6.44	28.07	42.48	10.10

Table (6). Effect of ultra violet (UV) light on bionomics and induced sterility in the first offspring generation (F_1) of P. operculella (Zeller).

Parental Dose (Joule/cm²/sec.)	Parental crosses	No. of deposited eggs / female $\bar{X} \pm S_{\bar{x}}$	Hatchability (%) $\bar{X} \pm S_{\bar{x}}$	Pupation (%) $\bar{X} \pm S_{\bar{x}}$	Emergence (%) $\bar{X} \pm S_{\bar{x}}$
5.4	A	73.3 ± 19.45	61.8 ± 5.58	17.7 ± 9.3	87.2 ± 5.62
	B	75.7 ± 6.94	78.9 ± 3.48	20.3 ± 7.5	90.9 ± 8.31
	C	96.0 ± 11.15	55.1 ± 2.99	29.7 ± 3.93	88.1 ± 9.12
10.8	A	69.3 ± 14.69	47.8 ± 3.46	10.3 ± 3.80	71.6 ± 11.22
	B	70.0 ± 13.07	67.0 ± 3.70	17.3 ± 2.70	79.5 ± 10.31
	C	98.0 ± 5.51	51.3 ± 5.78	21.0 ± 4.94	73.5 ± 7.84
21.6	A	53.0 ± 27.09	27.7 ± 13.90	9.7 ± 4.92	66.6 ± 9.44
	B	50.3 ± 25.39	30.3 ± 15.15	13.0 ± 6.51	76.9 ± 7.52
	C	96.0 ± 3.01	27.4 ± 13.73	12.3 ± 6.23	70.1 ± 7.39
32.4	A	45.7 ± 23.38	26.4 ± 13.29	10.7 ± 5.40	45.4 ± 12.92
	B	41.0 ± 3.52	62.9 ± 12.91	7.3 ± 0.88	73.2 ± 6.91
	C	91.0 ± 4.17	13.4 ± 6.91	8.7 ± 4.49	51.3 ± 13.71
Cont.	D	226.7 ± 23.48	91.0 ± 3.41	246.7 ± 6.49	94.3 ± 7.82
F.		6.38 .*	6.21**	123.02**	24.3**
L.S.D.		20.41	22.21	13.84	17.6

II. Effect of ultraviolet (UV) light:

The use of (UV) light for the control of the potato tuber moth P. operculella has not yet been studied in Egypt.

The present results, however, indicate that the (UV) light caused reductions in the percentages of adult emergence, increased the adult malformation and shortened the life-spans of moths of both sexes. The pupae exposed to 32.4 Jol/cm²/sec. produced 25.07 ± 3.11% of adult malformation. The percentage of adult emergence dropped from 95.0 ± 3.50% in the control to 73.3 ± 6.4% in the treatment with 32.4 Jol/cm²/second (Table 4).

It is interesing to find out that the effect of the (UV) light and γrays were almost identical in reducing the biological aspects of the (P_1) generation. For example, the average number of eggs deposited/females, hatchability %, pupation % and adult emergence % graduaily decreased as the dose of pupal exposure increased (Table 5). On the other hand, the dominant lethal percentages increased as the dose increased in the cases (A) and (C) (Fig. 2,a).

The inherited sterility in the first offspring generation (F_1) was noticed and the results are illustrated in Fig. (2,b). It may be obvious that sterility percentage fluctuated from 21.1% in the case (B) at the dose 5.4 to 86.6% in (C) at 32.4 Jol/cm²/sec.

In case (B) the inherited sterility reached 69.7% at the dose 21.6 and dropped to 37.1 at 32.4 Jol/cm²/sec. (Fig. 2,b). The fecundity of the female, egg hatchability, % of pupation and emergence were greatly affected as the dose increased (Table 6).

In the light of results obtained from the two experiments, it could be concluded that treating pupae (2-days old) with lower doses of rays and longer exposure to UV light, caused great effects on (P_1) and (F_1) generations. It is worthy mentioning that offsprings derived from treated male parents were more sterile than those derived from treated female parents.

Such findings are valuable for initiating and developing the so-called sterile-male technique "SMT" for the control of the potato tuber moth. Moreover, the treated females were also affected and such effect was reflected on the biological aspects of P. operculella.

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الملخص العربي

اجرى هذا البحث لدراسة تاثير تعريض عذارى فراشة درنات البطاطس لجرعات مختلفة من اشعة جاما والاشعة الفوق بنفسجية .

فقد عرضت العذارى عمر يومين الى جرعات تتراوح مابين ١ الى ٢٠ كيلو راد من اشعة جاما الصادرة من الكوبلت ٦٠ وكذلك عن تعريض العذارى من نفس العمر الى الجرعات ٤ر٥ ، ٨ر١٠ ، ٦ر٢١ ، ٤ر٣٢ جول / سم٢ من الاشعة الفوق بنفسجية ، ولقد نتج عن هذا التعريض اثر كبير على بعض الصفات البيولوجية لهذه الحشرة.

وعموما يزيد التاثير بزيادة الجرعات ولقد ظهر هذا التاثير في جيل الاباء وكذلك في نسل الجيل الاول. ولقد وصلت نسبة العقم الى ٩ر٩١ ، ٦ر٨٦% بعد تعريض العذارى الى الجرعات ١٥كيلو راد من اشعة جاما ، ٤ر٣٢ جول من الاشعة الفوق بنفسجية على التوالى. وتشير النتائج المتحصل عليها الى امكانية استخدام هذه الطريقة كاحدى طرق مكافحة فراشة درنات البطاطس.