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Studies on the comparative radiosensitivity of susceptible and Cyanox resistant strains of pink bollworm *Pectinophora gossypiella* (Saund.)

Abstract - When susceptible and Cyanox resistant pink bollworm (*Pectinophora gossypiella* Saund.) pupae were irradiated at dose levels ranging from 50 to 500 Gy, fecundity and mating ability of the adults were greatly affected. The susceptible strain was more affected by radiation, and females were more radiosensitive. Mating ability of irradiated males of both strains did not significantly decreased at doses up to 300 Gy, however, mating ability of irradiated females was significantly reduced than irradiated males at doses of 200 Gy and above. Irradiated females of both strains had a tendency to mate with unirradiated males more often than unirradiated females with irradiated males. Moths of both strains showed a high correlation between the increasing of the dose and the number of depositing eggs or the percent of hatching. A dose of 200 Gy sterilized most (96.06%) males and all females of susceptible strain, while a dose of 300 Gy induced complete sterility for resistant females and 91.4% of sterility of their respective males.

Riassunto - *Studi sulla sensibilità ai raggi* γ *di ceppi di* Pectinophora gossypiella *(Saund.) suscettibili e resistenti al Cyanox.*

La fecondità e la capacità di accoppiamento di un ceppo di *Pectinophora gossypiella* (Saund.) suscettibile e di uno resistente al Cyanox sono fortemente influenzate da trattamenti delle pupe con raggi γ, a valori compresi tra 50 e 500 Gy. Il ceppo suscettibile e le femmine sono piú sensibili alle radiazioni. La capacità di accoppiamento dei maschi irradiati di ambedue i ceppi non diminuisce significativamente a dosi fino a 300 Gy, mentre quella delle femmine irradiate è piú ridotta che per i maschi a 200 Gy e oltre. Si nota una maggior tendenza all'accoppiamento di femmine irradiate con maschi non trattati piuttosto che di femmine non irradiate con maschi trattati. Ambedue i ceppi evidenziano un'elevata correlazione tra dosi progressivamente crescenti di raggi γ e deposizione delle uova o loro schiusura. A

200 Gy vengono sterilizzati il 96,06% dei maschi e il 100% delle femmine del ceppo suscettibile, mentre a 300 Gy si verifica la completa sterilità delle femmine resistenti ed il 91,4% di sterilità dei corrispondenti maschi.

Key words: *Pectinophora gossypiella*, radiation, Cyanox, susceptibility, resistant, strains.

INTRODUCTION

Ionizing radiation can be used to reduce the employ of chemical insecticides. Several species of moths are considered possible targets for eradication by the sterile-male technique, among them the pink bollworm *Pectinophora gossypiella* (Flint & Kressin, 1968). From 1968, in the San Joaquim Valley of California release of irradiated pink bollworm moths have been made daily during the cotton-growing season to prevent establishment of a native population (Miller et al., 1984). Our objective was to compare the radiosensitivity of susceptible and resistant pink bollworm strains to obtain data for fecundity, sterility, and mating ability that could be used to design competitiveness tests for release technique.

MATERIALS AND METHODS

1. *Rearing techniques*

A laboratory strain of susceptible pink bollworm has been reared on artificial diet for several generations as described by Abdel-Hafez et al. (1982). The resistant strain was obtained by conducting selective experiments with Cyanox(1) for 8 generations, i.e; LC_{50} of Cyanox was used as a selective agent until the 3rd generation.

The survived larvae of each generation were maintained to produce the next selective generation. At the 4th generation LC_{50} was determined again and used as a selective agent until the 8th generation.

2. *Irradiation techniques*

Pupal development is completed in about 8 days at 27°C ± 1. Preliminary tests indicated that complete sterility without inducing pupal mortality and adult malformation was achieved by irradiating 7-days old pupae (Ouye et al., 1964 a and Saleh et al., 1991). According to these results, rearing vials of both strains were examined daily, and the pupae were removed and sexed.

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(1) Trade Mark of Sumitomo Chemical Co.; a.i. cyanophos.

Group of pupae from each strain were exposed to different doses, i.e: 50, 100, 200, 300, 400, and 500 Gy of gamma radiation emitted by a Co^{60} source contained in an irradiation unit (gamma cell type 220) at the Nuclear Physics Department, Atomic Energy Authority, Egypt, which gave an average dose rate of 2.022 Gy/min. Another group of unirradiated pupae were maintaned as control.The emerging moths of each strain were crossed with unirradiated respective opposite sex as following:

1-5 irradiated (I) males x 5 unirradiated (U) females.
2-5 unirradiated (U) males x 5 irradiated (I) females.
3-5 unirradiated (U) males x 5 unirradiated (U) females.

Each cross was repeated 3 times and oviposition cages were held at 27°C ± 1 and 80 ± 5 R.H. Eggs were collected daily, counted and the percent of hatch was calculated. Also, the percent of sterility was calculated according to the equation of Toppozada et al. (1966):

$$\% \text{ of Sterility} = 100 - \left\{ \frac{\text{No eggs/♀ in treatment x \% of hatch in treatment}}{\text{No eggs/♀ in control x \% of hatch in control}} \right\} \text{x } 100$$

Therefore, a log-probit lines were plotted for percentage of sterility to estimate the required doses to produce 50% and 99% sterility of males and females of both strains (Finney, 1971). Females were dissected after death to determine the percent of mating, number of spermatophors per mated female, and percent of multiple mating (Ouye et al., 1964 b). Factorial analysis were done (Snedecor & Cachran, 1973).

RESULTS AND DISCUSSION

Mating ability – Irradiation of susceptible and cyanophos resistant pink bollworm pupae did not significantly decreased the mating ability of males at doses up to 300 Gy. Mating success of susceptible irradiated males decreased to 75% at the dose of 400 Gy and 70% at the dose of 500 Gy, while it decreased to 80% at the two doses for resistant males. Mating ability of unirradiated males with irradiated females of the two strains appeared to be normal at doses of 50 and 100 Gy, but it was significantly reduced at doses of 200 Gy and above.

The greatest average number of spermatophores per mated female (6.2) was recorded when resistant females were irradiated with 50 Gy and mated with unirradiated males, though the average number of spermatophores did not significantly differ from the control at doses of 200 Gy and less. Irradiated females of the two strains had a tendency to mate with unirradiated males more often than unirradiated females with irradiated males. Doses above 200 Gy

reduced significantly the multiple mating of irradiated males and females of both strains compared to the respective unirradiated control (Table 1). Miller et al. (1984) indicated that 20 Krad did not affect mating or frequency of mating of pink bollworm females.

Moths fecundity - Irradiation of susceptible and resistant pupae of pink bollworm at dosages of 50 Gy and above resulted in a sharp reduction in the number of eggs deposited by emerging moths. Moths of both strains showed a very high correlation between increased dose and decreased number of deposited eggs. These results are good agreement with those of Ouye et al., 1964 and Qurashi et al., 1993.

Results showed that all crosses involving irradiated males and females of the susceptible strain produced fewer eggs than those of the resistant strain. This demonstrates that the susceptible strain was comparatively more affected by gamma rays than the resistant strain, although they were statisticaly nonsignificant. This disagrees with the finding of Brower (1980) who indicated that the field strain of the Indian meal moth *Plodia interpunctella* (Hübner) was more sensitive to gamma radiation than the lab strain.

Statistical analysis showed highly significant differences between doses and between the two sex. Also, there was highly significant difference when the dose interacted either with the sex or with the strain. (Table 3).

Moths fertility and sterility - Percent of egg hatching was significantly reduced when either sex of both strains were irradiated with any dose (Table 2). The resistant strain was less radiosensitive than the susceptible one, also males and females of the same strain had different sensitivity. At 100Gy, percent of egg hatch decreased to 58.17% and 20.1% when males and females of the susceptible strain were irradiated, and to 64.09% and 48.53% when males and females of the resistant strain were irradiated, respectively. At every dose, egg hatching was significantly reduced in crosses of irradiated females than in crosses of irradiated males. A dose of 200 Gy reduced egg hatch to 16.37% and 53.78% when males of susceptible and resistant strains were irradiated, and the same dose reduced the percent of hatch to 0.0 and 22.33% when females of both strains were irradiated, respectively.

Percentage of adult sterility increased significantly as dose increased and the susceptible strain was more radiosensitive to the sterilizing effect of radiation than the resistant strain. Thus, females are more easily sterilized than males, and a dose of 200 Gy sterilized most males (96.06%) and all females of the susceptible strain. A dose of 300 Gy induced complete sterility for resistant females and 91.41% of sterility for their respective males. Log probit lines (fig.1) show that the dose required to sterilize 50% of the susceptible strain were 47.4 and 25.9 Gy for males and females, however doses of 91.9 and 35.25 Gy were required to sterilize 50% of males and females of the resistant strain,

Table 1 - Comparative mating ability of susceptible (S) and resistant (R) strains of pink bollworm moths irradiated as pupae (1-2 days before emerging).

Dose (Gy)	Irradiated ♂ × Unirradiated ♀						Unirradiated ♂ × Irradiated ♀					
	% Mating		Avg. No spermatophores/♀		% Multiple mating		% Mating		Avg. No spermatophores/♀		% Multiple mating	
	Strain		Strain		Strain		Strain		Strain		Strain	
	(S)	(R)	(S)	(R)	(S)	(R)	(S)	(R)	(S)	(R)	(S)	(R)
0	100	100	4.00	4.80	78.7	87.9	100	100	4.00	4.80	78.7	87.9
50	100	100	4.10	4.10	88.9	90.9	100	100	4.33	6.20	88.9	80
100	100	100	3.90	4.02	75	83.3	100	100	4.42	3.50	94.4	91.7
200	100	100	3.42	5.00	70	75.5	80	96.67	3.30	3.27	94.4	71.4
300	100	100	3.40	4.10	80	77.5	76.67	90.33	2.55	3.13	77.4	75
400	75	80	2.40	1.83	50	50	66.67	93.33	2.17	3.10	50	70
500	70	80	2.20	1.67	33.3	33.3	—	—	—	—	—	—

Table 2 - Comparative fecundity, fertility, and sterility of susceptible (S) and resistant (R) strains of pink bollworm moths irradiated as pupae (1-2 days before emerging).

Dose (Gy)	Irradiated ♂ × Unirradiated ♀						Unirradiated ♂ × Irradiated ♀					
	Avg. No eggs/♀		% Hatch		% Sterility		Avg. No eggs/♀		% Hatch		% Sterility	
	Strain		Strain		Strain		Strain		Strain		Strain	
	(S)	(R)	(S)	(R)	(S)	(R)	(S)	(R)	(S)	(R)	(S)	(R)
0	159.07	114.52	90.16	86.72			159.07	114.52	90.16	86.72		
50	76.36	93.07	69.77	72.74	62.85	31.83	44.51	60.13	52.43	60.56	83.73	74.61
100	50.44	70.82	58.17	64.09	79.54	54.30	12.82	37.38	20.01	48.53	98.21	87.35
200	34.47	63.88	16.37	53.78	96.06	65.41	4.93	11.20	0.00	22.33	100	98.26
300	19.91	22.13	7.12	38.00	99.99	91.41	2.30	9.60	0.00	0.00	100	100
400	13.66	15.97	0.00	29.63	100	95.23	0.00	8.53	—	0.00	—	100
500	8.00	12.80	0.00	0.00	100	100	0.00	0.00	—	—	—	—

Table 3 - Calculated «F» values and the corresponding L.S.D. values of fecundity, fertility, and mating ability of susceptible and resistant strains of pink bollworm moths irradiated as pupae (1-2 days before emerging).

Source of variable	Avg. No eggs/♀		% Hatching		% Mating	
	F	L.S.D.	F	L.S.D.	F	L.S.D.
Dose	402.24***	9.02	449.73***	4.72	61.29***	4.84
Strain	3.07 ns	5.21	65.08***	2.72	31.27***	2.80
Sex	130.14***	5.21	138.98***	2.72	19.84***	2.80
Interaction:						
Dose x St.	26.50***		17.70***		6.54***	
Dose x Se.	11.37***		18.65***		13,18***	
St. x Se.	0.27 ns		0.13 ns		22.58***	
Dose x St. x Se	1.35 ns		7.25***		4.61***	

Source of variable	Avg. No sperma-tophores/♀		% Multiple mating	
	F	L.S.D.	F	L.S.D.
Dose	22.95***	0.65	53.96***	6.15
Strain	11.44***	0.38	0.92 ns	3.55
Sex	0.05 ns	0.38	11.22 **	3.55
Interaction:				
Dose x St.	2.07 ns		5.14***	
Dose x Se.	5.54 ns		6.14***	
St. x Se.	0.09 ns		3.91 ns	
Dose x St. x Se	4.13 ns		6.35***	

*** Significant at the 0.001 level of confidence.
** Significant at the 0.01 level of confidence.
ns Not significant.

respectively. Also show that 99% sterility for males and females of susceptible strain occured at 231.96 and 119.4.2 Gy, respectively, while 527.9 and 202.1 Gy induced 99% of sterility for males and females of the resistant strain. Similar results were recorded by Proshold & Bartell (1972) and Wolfenberger & Guerra (1971) for field and laboratory strains of tobacco budworm.

It could be concluded that susceptible strain of pink bollworm should be used for release program since it appeared more radiosensitive, and a dose between 200 and 300 Gy can be recommended for competitiveness studies. The higher doses may not be suitable, since it reduced the mating ability of the sterilized moths.

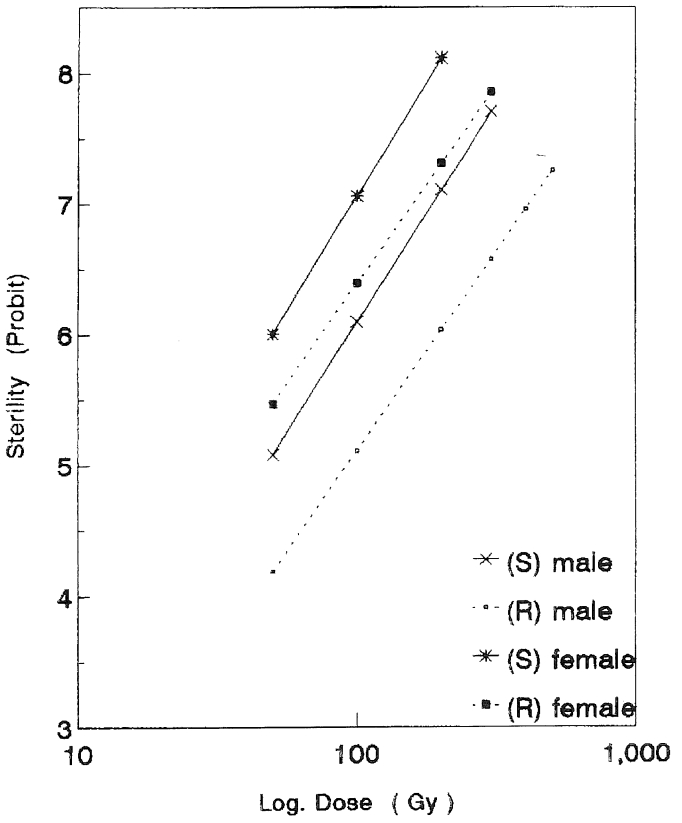

Fig. 1 - Log. probit lines of relationship between iradiation dose and percentage of sterility when males and females of susceptibles (S) and Cyanox resistant (R) strains of pink bollworm were paired with unirradiated moths of the opposite sex.

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