Effects of Gamma Radiation on Mature Larvae of *Pectinophora gossypiella* (Saunders) and their F_1 Progeny

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Abstract: The mature larvae of *Pectonophora gossypiella* (Saunders) obtained from the laboratory culture maintained on casein wheat germ diet were irradiated at 35, 45, 55 and 65 Gy doses at a dose rate of 30.8 Gy/min. in a Cs-137 gamma irradiator. The pupation was delayed as the radiation dose increased. Furthermore, larval survival to pupal and adult stages were also susceptible to gamma radiation doses were increased. Females were more susceptible to gamma radiation than males. The effect of gamma radiation on reproduction in P_1 moths following irridation of mature larvae was dose dependent. As the dose of mature larvae increased, average egg production, hatch percentage and adult longevity reduced. Egg production, was reduced more drastically in the crosses Untreated Male x Treated Female (UTM x TF) and Treated male x Treated Female (TM X TF) than the crosses Treated Male x Untreated Female (TM x UTF). Complete sterility was recorded when treated males were paired with treated females at 45 Gy and higher doses of gamma radiation. The results on the egg production, hatch percentage and adult longevity of F_1 progeny of male parents following irridation of mature larvae showed that egg production was reduced significantly in crosses UTM x F_1 Female at 35 Gy and complete sterility was recorded at higher doses. In crosses F_1 Male x F_1 Female, complete sterility was recorded at all the test doses of gamma radiation. The radiation doses higher than 35 Gy were more lethal either in F_1 Male x F_1 Female. The adult longevity was unreliable in all the crosses. However, moths were short-lived in both F_1 Male x F_1 Female and UTM x F_1 Female progeny of treated pink bollworm females crossed with untreated males following irradiation of mature larvae indicated similar results as recorded in the case of male treated parents. However, complete sterility was recorded in F_1 Male x F_1 Female and UTM x F_1 Female crosses and a few eggs were laid in F_1 Male x F_1 Female crosses at 35 Gy dose with 14.76 percent egg hatch.

Keywords: *Pectinophora gossypiella* (Saunders), irradiation, Cs-137 gamma irradiator.

INTRODUCTION

Pink bollworm, *Pectinophora gossypiella* (Saunders) is a serious insect pest of cultivated cotton, *Gossypium spp.* in Pakistan and other countries of the world [1]. It is estimated that in Pakistan 20-30% of the crop losses occur every year in Pakistan due to the insect pests [2]. Farmers spray their cotton crops 10-17 times per season for the control of bollworms [3] which creates the problems like insect resistance to insecticides, disturbance in biological equilibrium and environmental pollution. As the problem with chemical insecticides has mounted, so has the pressure to develop other novel and biological alternative methods of pest management. This pressure was intensified with the advent of sterile insect technique (SIT), F_1 sterility technique and phenomenal control techniques.

The sterile insect release programme for pest population suppression required the mass cultured sterilized insects must complete successfully for mates with their native counter parts [4, 5]. Pink bollworm has exhibited typical characteristic lepidopteron response to gamma radiation [6, 7]. The F_1 sterility technique has successfully been employed for population suppression of many economically important Lepidopterans [5]. The irradiation of mature pink bollworm pupae at 100 or 150 Gy doses of gamma radiation indicated that reproduction of irritated males when confirmed with untreated female moths was reduced by 88% or more in F_1 progeny [8-11].

Studies were conducted on the effects of Gamma radiation on mature larvae and their F_1 progeny of *Pectinophora gossypiella*. The main objective of these studies was to determine suitable, radiation dose to induce sterility in F_1 generation which can appropriately be used for F_1 sterility and SIT to combat pink bollworm in the cotton fields.

MATERIALS AND METHODS

The mature larvae obtained from the laboratory culture maintained on casein wheat germ diet were irradiated at 35, 45, 55 and 65 GY of gamma radiation in a Cs-137 gamma irradiator (Nigu-5) at a dose rate of 30.8 GY per minute. Each batch of larvae for respective dose comprised of 200 larvae and replicated three times. The time of pupation and larval survival to pupation were recorded.

Upon pupation, the pupae were saxed and crossed in the following combinations inside the oviposition cages as described by [12].

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TM (Treated male)	X	UTF (Untreated Females)
TM (Treated male)	X	TF (Treated females)
UTM (Untreated male)	X	TF(Treated female)
UTM (Untreated male, Control)	X	UTF (Untreated female, Control)

Each combination comprised of ten single pairs per replicate, and each test was replicated four times. The observations on total egg production, number of eggs hatched, and number of spermatophores per female and adult longevity were recorded for each combination separately.

The F_1 adult emerging from each P_1 crossed separately with native/untreated moths to determine the effect of larval irradiation on fecundity, fertility and adult longevity of the F_1 progeny. The crosses were made as follows:

F_1 Male	X	UTF (Untreated female)
F_1 Male	X	F_1 Female
UTM (Untreated male)	X	F_1 Female
UTM (Untreated male, Control)	X	UTF (Untreated female, Control)

The eggs were collected from different crosses to determine the hatch percentages. There were 10 pairs in each combination replicated three times.

RESULT AND DISCUSSION

The results of irradiation of mature larvae on pupation exposed to 35, 45, 55 and 65 GY doses of radiation indicated that pupation was delayed as the radiation dose increased. Furthermore, larval survival to pupal stage was also reducing significantly as the radiation doses were increased (Table **1**). Females were more susceptible to gamma radiation than males. Structural deformities such as crumpled wings, twisted legs and reduced body size at 45 Gy and higher doses were observed.

The effect of gamma radiation on reproduction in P_1 moths following irradiation of mature larvae (Table **2**) was dose dependent. As the dose of mature larvae increased, average egg production, hatch percentage and adult longevity reduced. Egg production was reduced more drastically in the crosses UTM x TF and TM x TF than the crosses TM x UTF. Complete sterility was recorded when treated males were paired with treated females at 45 GY and higher doses of gamma radiation. The F_1 progeny was not available for this cross at 45 Gy and higher doses.

The results on the egg production hatch percentage and adult longevity of F_1 progeny of male parents following irradiation of mature larvae (Table **3**) showed that the egg production was reduced significantly in crosses UTM x F_1F at 35 Gy and complete sterility was recorded at higher doses of the test radiation. In crosses F_1M x F_1F complete sterility was recorded at all the test doses of gamma radiation. The hatch percentage was also dose dependent. However, radiation doses higher than 35 Gy were more lethal in F_1M x UTF and UTM x F_1F crosses. Number of egg hatch was not recorded in crosses F_1M x F_1F. The adult longevity was variable in all the crosses. However, moth was short-lived in both F_1M x F_1F and UTM X F_1F crosses when compared with F_1M X UTF.

The results on fecundity, fertility and adult longevity of F_1 progeny of treated pink bollworm females crossed with untreated males following irradiation of mature larvae (Table **4**) indicated similar results were obtained in the case of male treated parents. However, complete sterility was recorded in F_1M x F_1F and UTM x F_1F crosses, and a few eggs were laid in F_1M x UTF crosses at 35 Gy dose with 14.77 percent egg hatch. The 35 Gy crosses were short-lived compared with male treated progeny.

Radiation techniques are one of the potential alternatives to chemicals for insect pest management and for the improvement of efficiency of bio-control

Table 1: Larval and Pupal Survival of *Pectinophora gossypiella* Following Irradiation of Mature Larvae

DOSE (GY)	LARVAE IRRADIATED NOS	LARVAL SURVIVAL %	PUPAL SURVIVAL %
0	200	93.0	98.9
35	200	91.8	83.3
45	200	91.3	86.4
55	200	91.0	93.3
65	200	91.81	81.1

Table 2: Mating, Fecundity, Fertility and Adult Longevity of *Pectinophora gossypiella* Following Irradiation of Mature Larvae

Treatments	Dose (GY)	Spermatophore (%)	No. of eggs/female	Hatch (%)	Adult longevity	
					Male	Female
Control	0	100	114.6	9092	11	11.8
Treated male x untreated female	35	0.66 a	87.06 a	37.69 a	11 a	11.8 a
	45	0.20 c	63.53 b	19.60 b	09.093b	10.13 b
	55	0.20 c	40.93 c	06.83 c	08.66 c	11.06 a
	65	0.13 c	17.40 d	01.15 d	06.93 c	10.00 a
Untreated male x treated female	35	0.46 a	81.06 a	16.98 a	10.40 a	9.26 a
	45	0.06 b	13.73 b	01.93 b	11.00 a	8.06 a
	55	0.00 c	02.20 c	00.00 c	10.53 a	7.45 b
	65	0.00 c	00.00 d	00.00 c	10.00 a	6.06 c
Treated male x treated female	35	6.20 a	21.73 a	06.1 a	09.99 b	08.06 a
	45	0.00 b	05.73 b	00.00 b	10.20 a	08.80 a
	55	0.00 b	00.00 c	00.00 b	08.20 c	07.60 a
	65	0.00 b	00.00 c	00.00 b	07.06 c	06.13 b

Table 3: Fecundity, Fertility and Adult Longevity of F_1 Progeny of Treated *Pectinophora gossypiella* Male Crossed with Untreated Female Following Irradiation of Mature Larvae

Treatments	Dose (GY)	Spermatophore (%)	No. of eggs/female	Hatch (%)	Adult longevity	
					Male	Female
Control	0	100	106	80.57	10	10.80
Treated male x untreated female	35	0.86 a	89.13 a	8.68 a	9.20 a	10.20 a
	45	0.73 a	66.33 b	2.11 b	9.73 a	10.73 a
	55	0.50 b	26.50 c	0.00 c	0.00 b	10.3 a
	65	0.00 c	00.00 d	00.00 c	00.00 b	00.00 b
Untreated male X F_1 female	35	0.26 a	16.66 a	02.36	9.60 a	9.00 a
	45	0.13 b	06.53 b	00.00 b	9.53 a	7.46 a
	55	0.00	00.00 c	00.00 c	10.20 a	7.33 b
	65	0.00 c	00.00 c	00.00 b	00.00	0.00
F_1 male x F_1 female	35	0.00	09.00 a	00.00	8.33 a	8.33 a
	45	0.00	00.00 b	00.00 b	7.33 b	7.46 a
	55	0.00 b	00.00 c	00.00 b	9.00 a	9.00 a
	65	0.00	00.00	00.00	00.00	00.00

agents through genetic mutations for ecologically compatible management of insect pests [13]. Radiation of insects may affect of radiation is to induce sterility in insects without consequently affecting their ability to live and mate. Irradiations also affects mating (copulation frequency and sperm transfer) fecundity and fertility of eggs, adult longevity and post embryologic survival. The susceptibility of insects to gamma radiation varies with different life stages and doses [14-21]. The dose of gamma radiation tested against pink bollworm larvae to induce sterility in the resulting adults and their F_1 progeny had significant effect on pupation, adult susceptibility to radiation and reproduction of adults. Bartlett and Lewis [21] irradiated last instars (cut out) larvae at doses of 20-32 Krad of Co-80 gamma radiation. None of the doses tested had

Table 4: Fecundity, Fertility and Adult Longevity of F_1 Progeny of Treated *Pectinophora gossypiella* Female Crossed with Untreated Male Following Irradiation of Mature Larvae

Treatments	Dose (GY)	Spermatophore (%)	No. of eggs/female	Hatch (%)	Adult longevity	
					Male	Female
Control	0	100	106	80.57	10	10.80
Treated male x untreated female	35	0.40 a	36.06 a	14.76 a	6.20 a	9.33 a
	45	0.00 b	00.00 b	00.00 b	00.00 b	00.00 b
	55	0.00 b	00.00 b	00.00 b	00.00 b	00.00 b
	65	0.00 b	00.00 b	00.00b	00.00b	00.00 b
Untreated male x F_1 female	35	0.13	03.60 a	00.00	9.60	6.66 a
	45	00.00 b	00.00 b	00.00	00.00	00.00 b
	55	00.00 b	00.00 b	00.00	00.00	00.00 b
	65	00.00 b	00.00 b	00.00 b	00.00	00.00 b
F_1 male x F_1 female	35	00.00	00.00	00.00	7.93 a	6.20
	45	00.00	00.00 b	00.00 b	00.00 b	00.00 b
	55	00.00	00.00 b	00.00 b	00.00 b	00.00 b
	65	00.00	00.00 b	00.00 b	00.00 b	00.00 b

a significant effect on pupation of the treated larvae but the percentage of morphologically normal adults was reduced by more than 85 percent when doses exceeded 4 krad for the males and 2 krad to the females.

Complete sterility was recorded when treated females were paired with either treated or untreated males. High sensitivity of females to radiation at larval stage was observed. However, when adult males from treated larvae were mated to untreated females, the fecundity and fertility decreased as the dose increased. Bartlett and Lewis [21] reported that no reproduction occurred in any cross involving treated insect if the laid a few eggs which failed to hatch. However, Bartlett and Lewis [21] reported no reproduction if the females of a cross were treated by any dose exceeding 2 Krad. The reproductive ability of the F_1 progeny with treatments of 35 Gy was reduced significantly when compared with control (untreated) months. These results of the inherited sterility are in conformity to those reported by [22]. The results on the reproduction of adults resulting from the irradiated larvae showed that adults from 35, 45, and 55 Gy performed mating well (Spermatophore transferred). However, fecundity and fertility reduced significantly to produce F_1 progenies

There are many studies reported in literature on effects of gamma radiation on insects and application of SIT for population management of insect's pests. When larvae of *Spodoptera litura* were irradiated with different gamma radiation doses (1-7 Krad), treated larvae suffered a reduction in pupation and adult emergence [22]. Abon – Elela *et al.,* [14] irradiated fresh fly, *Parasarcophaga argyrostoma* larvae to various doses ranging from 1-90 Gy. Radiation in pupation and adult emergence were observed with increment in the radiation doses. At higher doses (30-70 Gy) pupae could not continue their development and died. Adult longevity and fecundity of insects from irradiated larvae were decreased [14]. Females were more sensitive to radiation than males. Daguang *et al.,* [23] treated mature *Helicoverpa armigera* female and male pupae with different doses of gamma radiation and out – crossed with untreated mates. Mating ability of both sexes was not affected by radiation. Treated females were sterile and laid significantly fewer eggs than untreated controls. Apu [24] reported population suppression of diamond back moth (DBM) *Plutella xylostella* (L). using releases of irradiated (200 Gy) substerial moths. Results showed that releasing F_1 sub sterile male and female DBM resulted in high level of sterility (73.03 and73.30%) in F_1 and F_2 generations, respectively in the untreated population. Mansour [16] studied radiation effects on codling moth*, Cydia omonella* and reported that egg production and egg hatch decreased with increasing radiation dose. Females were more sensitive to radiation than males. Irradiation of parental generation induced different sterility levels in offsprings. Female fall armyworm, *Spodoptera frugiperda* were more radiation sensitive than males [25]. The attraction of male *Pectinophora gossypiella* moths to irradiated virgin females decreased significantly with increasing the doses of radiation [19].

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