Reprint **ISSN 1923-7766 (Web Version)**

International Journal of Experimental Agriculture

(Int. J. Expt. Agric.)

Volume: 7 **Issue: 3** **November 2017**

Int. J. Expt. Agric. 7(3): 14-18 (November 2017)

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ISSN-1923-7766 (Online)
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Accepted for publication on 25 October 2017

ABSTRACT

Hossain MA, Khan SA, Howlader AJ (2017) Effect of gamma radiation on the pupal radiosensitivity and male sterility of the peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae). *Int. J. Expt. Agric.* 7(3), 14-18.

An experiment was conducted to know the effect of gamma radiation on the pupal radiosensitivity and male sterility of the peach fruit fly. Radiosensitivity of pupae was found to be decreased as the age increased. No adults were emerged from 1, 2, 3, 4, 5 and 6 day old pupae treated with 40, 150, 200, 300, 350 and 400 Gy doses accordingly. The LD_{50} values for 1, 2, 3, 4, 5 and 6 day old pupae were 23.98, 31.18, 38.73, 96.93, 112.07 and 123.55 Gy respectively. It revealed that late aged pupae are comparatively radioresistant than that of early aged pupae. Gamma ray significantly ($p<0.01$) increased the pupal duration and decreased the longevity of the peach fruit fly. The sterilizing dose of 60 Gy was recorded for 6 days old pupae of *B. zonata*.

Key words: *gamma radiation, sensitivity, sterility, peach fruit fly*

INTRODUCTION

The peach fruit fly, *Bactrocera zonata* (Saunders) (Diptera: Tephritidae) is considered one of the most destructive fruit pests, which spread in several regions of the world (Drew 1989). It has been frequently recovered from the peaches; hence it is called the peach fruit fly. It was recorded on more than 50 cultivated and wild plant species, mainly those with fleshy fruits (White and Elson-Harris, 1992; Kapoor *et al.* 1993; Drew and Romig, 2013). It attacks ripe fruits and inflict damage to the fruits directly through oviposition punctures and subsequent larval feeding on pulp or by causing blemished fruits, which limit marketing possibilities especially export of fruits. It is a major pest of mango, guava, custard apple, sapodilla, banana and star fruits in Bangladesh (Kabir *et al*. 1991) and is found throughout the country where cultivated fruits are grown (Leblanc *et al.* 2013; 2014). Considering the economic and quarantine importance control of this pest is frequently uttering in most of the countries of the world (Heather and Hallman, 2008).

The comparative radiation sensitivity on different ages of pupae of an insect pest is important in radiation control studies. The pupae are usually irradiated to induce sterility in Sterile Insect Technique (SIT). The dose applied on the pupae and the age at which irradiation is executed are the key factors relating to the success of SIT and phytosanitary irradiation. Recently, the effect of gamma radiation on the male sterility and other quality parameters of the peach fruit fly was studied (Draz *et al.* 2008; Mahmoud and Barta, 2011); in addition, the effect of gamma radiation on sperm competitiveness, fecundity and morphometric characters of the peach fruit fly was evaluated (Draz *et al.* 2016). In Bangladesh, no published data is available so far regarding the pupal radiosensitivity and male sterility of the peach fruit fly. Hence, an attempt was made to study the effect of Gamma radiation on the pupal radio sensitivity and male sterility of the peach fruit fly, *Bactrocera zonata* (Saunders).

MATERIALS AND METHOD

Stock culture

Laboratory cultures of *B. zonata* were maintained in the fruit fly laboratory, Insect Biotechnology Division, Institute of Food and Radiation Biology (IFRB), Atomic Energy Research Establishment (AERE), Savar, Dhaka. Larvae were maintained on wheat bran and sweet potato based artificial diet. Adult peach flies were stocked in a wooden frame cage (60×50×45 cm) covered with nylon net. The culture was usually supplied with an artificial diet (yeast extract: sugar: caesin/1:2:1) and water soaked cotton. In general, 1500-2000 adult fruit flies were maintained in a stock cage. Temperature and relative humidity of the rearing room were maintained at 28±2^{o}C and 70-80% respectively.

Pupae collection and irradiation

The larvae of *B. zonata* in the artificial larval diets were kept in plastic bowls with saw dusts at the bottom for pupation. The saw dusts were sieved after pupation for the collection of dust free pupae. Collected 100 pupae each of 1, 2, 3, 4, 5 and 6 days old were transferred into Perti-dishes and irradiated in a Co^{60} gamma irradiator of Institute of Food and radiation Biology, Atomic Energy Research Establishment, Savar, Dhaka. For pupal radiosensitivity studies, radiation doses ranging from 10 to 400 Gy were applied and for male sterility dose determination radiation doses ranging from 10 to 70 Gy were applied with a dose rate of 10 Gy/minute. Each dose group had 3 replications and was repeated 5 times. One batch of control was also maintained with equal number of replications.

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Sterility dose determination

Fifty male flies were collected from each of 10, 20, 30, 40, 50, 60 and 70 Gy treated 6 days old pupae and fifty females were also isolated from the control batch and allowed to mate with individual dose treated males in laboratory rearing cages. This experiment had 5 replications. After 2 days of mating, eggs were collected from a piece of banana placed inside as oviposition medium.

Data Analysis

Data on pupal duration, deformity, adult emergence and longevity were recorded for analysis. Corrected mortality was calculated using Abbott's formula (Abbott 1925). Probit analysis was done according to Finney (1947). ANOVA was done using Microsoft Excel Programme.

RESULTS AND DISCUSSION

Pupal radiosensitivity

The pupal duration, percent of deformed and normal adult emerged and adult longevity are shown in Table 1. No adult was emerged from 1, 2, 3, 4, 5 and 6 day old pupae treated with 40, 150, 200, 300, 350 and 400 Gy doses respectively (Table 1). The Pupal duration at different ages and different radiation doses varied significantly ($p<0.01$). Pupae aged 1, 2 and 3 days were relatively more radiosensitive and sensitivity decreased as the age increased. In all the cases, gamma radiation extend the pupal duration of the peach fruit fly (Table 1).

Table 1. Effect of different doses of gamma irradiation on pupal duration (Mean±SE), normal and deformed adult emergence (%) and longevity (days) of peach fruit fly, *B. zonata*

Pupal age (days)	Doses (Gy)	Pupal duration (Days)	Deformed (%)	Normal adult (%)	Longevity (Days) Mean±SE
1	10	9.10±0.07a	2.33	77.00	77.33b±0.88
	20	9.55±0.20b	3.33	52.33	73.67bc±0.88
	30	10.15±0.23c	4.66	20.33	68.67c±1.45
	40	---	---	---	-
	Control	8.64±0.27a	---	94.00	102.67a±1.45
2	10	9.00±0.09a	2.33	77.66	91.67b±1.45
	20	9.29±0.03ab	3.66	55.66	89.67bc±1.20
	50	9.63±0.16bc	4.33	26.33	86.67c±0.88
	100	9.90±0.08c	4.33	14.66	72.33d±2.03
	150	---	---	---	-
	Control	8.36±0.06d	---	95.33	104.33a±1.20
3	20	9.19±0.01a	2.66	64.00	87.33c±0.88
	50	9.42±0.05ab	3.66	40.66	82.67d±0.33
	100	9.68±0.11bc	4.33	23.66	76.33e±1.33
	150	9.78±0.04cd	2.66	8.33	94.67b±0.88
	200	---	---	---	-
	Control	8.62±0.20e	---	96.33	105.33a±2.73
4	50	8.89±0.02a	2.33	63.66	102.33b±0.67
	100	9.22±0.02b	3.66	44.00	95.33c±0.88
	150	9.43±0.05c	4.66	33.33	90.33d±0.67
	200	9.71±0.03d	5.66	22.33	81.33a±1.20
	250	9.95±0.04e	5.00	12.00	70.33a±0.67
	300	---	---	---	-
	Control	8.43±0.03f	---	94.66	110.00a±1.15
5	50	8.72±0.04a	3.33	68.00	104b±0.58
	100	9.12±0.02b	3.66	55.66	102.33b±1.20
	150	9.29±0.04c	4.66	43.66	94.67c±0.88
	200	9.53±0.04d	4.66	32.66	90d±0.58
	250	9.65±0.06e	5.00	22.00	84.67e±1.20
	300	9.89±0.02e	5.33	10.33	73.33f±1.45
	350	---	---	---	-
	Control	8.19±0.03f	---	95.33	107.33a±1.45
6	100	8.79±0.10a	2.66	62.00	101.33b±1.20
	150	9.17±0.03b	3.33	51.66	97.67bc±0.33
	200	9.38±0.07c	4.00	42.66	91.33d±1.45
	250	9.48±0.07c	4.33	29.33	86.33e±1.76
	300	9.73±0.03d	4.66	15.33	81.67f±0.88
	350	10.08±0.07e	5.00	5.33	74.33g±1.45
	400	---	---	---	-
	Control	8.26±0.02f	---	96.66	112.00a±1.53

Means followed by the same latter do not differ significantly

In the present study, no deformed adult was observed in the control batches. Some abnormalities in the emerged adults were observed. Abnormalities consisted mainly of wrinkled wings or wings that failed to expand upon emergence. In every cases, normal adult emergence percentage was highest in control batch and lowest was in the batch exposed to the highest dose. The adult longevity at different ages and different radiation doses varied significantly ($p<0.01$). In all the cases, the gamma radiation decreased the adult longevity of *B. zonata* (Table 1).

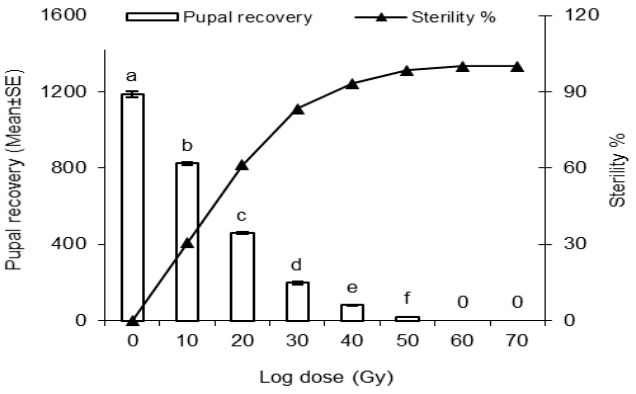
The LD_{50} values, regression equations, 95% confidence limits and χ^2 values have been presented in Table 2. The LD_{50} values for 1, 2, 3, 4, 5 and 6 day old pupae were 23.35, 30.25, 37.83, 80.84, 97.09 and 109.95 Gy respectively. The LD_{50} values showed that 6 day old pupae were the most resistant and 1 day old pupae were most susceptible than that of others (Table 2). In all the cases, χ^2 values indicated insignificant ($p>0.01$) heterogeneity in the experiment and best fit of the regression lines. The 95% confidence limits indicated a range within which probit of the true response was certain to stay.

Table 2. LD_{50} values, 95% confidence limits and χ^2 values of gamma rays against peach fruit fly, *B. zonata*

Ages (days)	LD_{50} values (Gy)	Regression equations	95% confidence limits		χ^2 values (df)
			Lower	Upper	
1	23.98	Y=0.1509+3.5139X	22.49	25.57	2.32 (1)
2	31.18	Y=0.7659+2.8342X	29.06	33.45	4.84 (2)
3	38.73	Y=1.2965+ 2.3320X	35.44	42.33	4.78 (2)
4	96.93	Y=0.3068+ 2.6715X	90.67	103.62	5.67 (3)
5	112.07	Y=0.3201+2.5958X	105.21	119.38	8.14 (4)
6	123.55	Y=1.1860+2.9571X	114.83	132.94	7.32 (4)

Significant prolongation of pupal duration which was observed in our study after irradiation of pupae may be due to hyper stimulation of the mechanism of repair to slightly damaged tissues. Most researchers (Balock *et al.* 1963; Manoto *et al.* 1992; Anwar *et al.* 1978; Yasmin *et al.* 2010) reported that gamma radiation extend the pupal duration of the fruit flies.

In a specific age group, normal adult emergence percentage was high in lower doses but the percentage was decreased as dose increased. The genetic material of pupae was damaged by high doses of gamma radiation and with increased dose the viability of the pupae decreases (Anwar *et al.* 1978; Heather and Hallman, 2008). The results are similar to that of the present findings. Sensitivity to irradiation of any biological entity varies with the stages of development. The research findings of many researchers (Balock *et al.* 1963; Manoto *et al.* 1992; Hallman 2000; Koyama *et al.* 2004) showed that the radio sensitivity of the fruit fly pupae decreased as age increased. The LD_{50} values of the present study hasvalue of the present study have proven that the radiosensitivity of peach fruit fly pupae decreased as age increased. Bakri *et al.* (2005) reported that fruit fly is more susceptible to radiation injury in an early stage of pupal development than during last stages. Manoto *et al.* (1992) studied the radiosensitivity of gamma radiation on the Oriental fruit fly, *B. dosalis* and reported that the LD_{50} values were 14 Gy, 18 Gy, 19 Gy, 110 Gy and 150 Gy for 1, 2, 3, 4 and 5 day old pupae respectively. Wadud *et al.* (2005) reported that the LD_{50} values were 28.52 Gy, 34.01 Gy, 58.45 Gy, 113.05 Gy and 189.14 Gy for 1, 2, 3, 4 and 5 day old pupae of melon fly respectively. The results of the present study are more or less similar to that of Manoto *et al.* (1992) and Wadud *et al.* (2005) and small differences of the LD_{50} values probably due to the species difference or geographical distribution difference.



Column with different letters do not differ significantly

Fig. 1. Mean pupal recovery and sterility percentage of peach fruit fly at different doses of gamma irradiation

Male sterility

Six days old pupae were irradiated and subsequently emerged male adults were allowed to mate with unirradiated virgin females. The eggs laid onto the host fruit were maintained for larval hatching, larval development and pupation. A sharp decrease of pupal recovery was recorded as radiation doses increased (Fig. 1). However, no pupa was obtained from rearing containing 60 and 70 Gy treated males. Pupal duration of

control flies were 8.26±0.12 days while those of 60 Gy treated male group required 9.69±0.15 days at laboratory condition. The percent of sterility attained in F_1 generation was 30.80, 61.29, 83.37, 93.20, 98.36, 100 and 100 at 10, 20, 30, 40, 50, 60 and 70 Gy dose treatment respectively (Fig. 1). The adult longevity of irradiated males at 60 Gy was 91.33±0.27 days while that of unirradiated control group was 110.39±0.79 days. However, considering the sterility rate and adult longevity, 60 Gy was appeared as an appropriate sterilizing dose for male peach fruit fly with possible use in field level application of peach fruit fly SIT.

Many reseachers (Balock *et al.* 1963; Manoto *et al.* 1992; Anwar *et al.* 1978; Mahmoud and Barta, 2011) determined the sterilizing dose of fruit fly pupae as 2-3 days before adult emergence this is done for the convenience of releasing them in the fields. Yasmin *et al.* (2010) reported that in case of 5 days old pupae of melon fly the sterility percentage was 36, 48, 63.34, 89.76, 92.72, 100 and 100 at 10, 20, 30, 40, 45, 50 and 60 Gy respectively. Islam *et al.* (2012) studied the male sterility of *B. tau* and observed that sterility percentage of 33.84, 46.55, 64.21, 86.54, 90.63, 100 and 100 at 10, 20, 30, 40, 50, 60 and 70 Gy respectively. Zahan *et al.* (2015) reported that in case of 5 days old pupae of oriental fruit fly the 100% sterility was attained at 60 Gy. Draz *et al.* (2008) suggested 50 Gy as a sterility of *B. zonata*. Mahmoud and Barta (2011) reported that 90 Gy as sterilizing dose of peach fruit fly for 7 days old pupae. Draz *et al.* (2016) studied the impact of gamma radiation on sperm competitiveness, fecundity and morphometric characters of peach fruit fly and reported that sterility dose of 70 Gy reduced the sperm competitiveness and egg viability. The sterile males are fully competent to mate with normal females. The results were almost similar to the present study. The little differences may be due to a type of irradiator cells, methodology of assay, genus of flies, age of irradiated pupae, as well as fitness of laboratory strains tested.

CONCLUSION

Data generated from this experiment on sterility dose, pupal duration and longevity of irradiated males of *B. zonata* clearly revealed that 60 Gy could be used as a sterilizing dose for possible field application in SIT and adult emergence data indicated that 400 Gy dose completely stopped the emergence of peach fruit fly. Further research on male competitiveness of sterile males and male ratio optimization will be required to generate a more suitable data for field application of SIT.

ACKNOWLEDGEMENT

The authors are grateful to Dr. Luc Leblanc, Curator and Manager, Willium F. Barr Entomological Museum, University of Idaho, ID 83844-2339, USA for molecular identification of the peach fruit fly.

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