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**Research Article****Response of *Sitotroga cerealella* and *Trichogramma chilonis* to gamma irradiation exposure**Jawad Sarwar¹, Muhammad Zahid³, Muhammad Salman³, Syed Fahad Shah¹, Mukaram Shah², Adnan Ihsan¹¹Department of Entomology, The University of Agriculture, Peshawar, Pakistan.²Agriculture Research Institute Tarnab Farm, Peshawar, Pakistan.³Plant Protection Division, NIFA – Peshawar, Pakistan.**ABSTRACT**

The present study was carried out to evaluate the response of gamma irradiation on *Sitotroga cerealella* and *Trichogramma chilonis* under laboratory conditions. Two different egg stages of *S. cerealella*, aged 12 and 24 hours, were exposed to four levels of gamma radiation (35, 55, 75 and 95 Gy) and control (no dose). The result indicates that low irradiation doses egg viability compared to higher doses. Exposure to 35 Gy resulted in the hatching rate (55.3%) and prolonged incubation period (7.06 days) for *S. cerealella* eggs. In *T. chilonis*, parasitism percentage was significantly higher at 86%, with maximum adult emergence at 87.3% and adult longevity of 7.13 days; however, these values remain lower than those observed in the untreated (control), where maximum parasitism, adult emergence and longevity were observed. The treatment with 95 Gy resulted in the lowest values for incubation, adult emergence, parasitism, and adult longevity. Irradiation of pupae also yielded significantly higher adult emergence (86.66%) and longevity 7.46 days at 5 Gy, pupae irradiated at 20 Gy resulted in significantly lower adult emergence and adult longevity. Based on these findings, lower irradiation doses are recommended to increase shelf life of *S. cerealella* and *T. chilonis* without causing significant detrimental effects on the quality of parasitoid and its host. The approach ensures the year around availability of parasitoids in insectaries for research and field releases.

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<https://creativecommons.org/licenses/by/4.0>**INTRODUCTION**

Radiation is of great help in finding out solutions to different agriculture obstructions for instance minimizing the post-harvest losses due to insect pests, food-borne diseases and to help prolong the beneficial life of any agriculture commodity (Andress et al., 1994; Emovon, 1996). Production of parasitoids and environmental friendly insects on larger scale has been achieved through many ways and radiation is one of them. It has been noted that irradiated eggs of moth pest were also parasitized by the egg parasitoids in a very effective manner (Marston and Ertle., 1969; Mannion et al., 1995). In tropical and subtropical areas, the Angoumois grain moth, *S. cerealella* (Lepidoptera; Gelechiidae), is one of the most harmful pests to maize, rice, and wheat grains (Hansen et al., 2004; Demissie et al., 2014). This insect can infest grains both in the field during their development and in storage facilities after harvest (Villacis et al., 1972). While synthetic insecticides like methyl bromide, which has been widely used for stored-product pest control and as a quarantine treatment, are mostly harmful to mammals and natural enemies, the use of environmentally friendly control methods is urgently required for the successful integration of this pest (Arbogast, 1981; Chaudhr, 1997). Gamma irradiation is regarded as one of the efficient strategies for management of a variety of insect pests.

It has also been suggested as a successful strategy for stored product insects (Ayvaz and Tuncbilek, 2006). In many areas, it is a commonly utilized method of treating infestations. Irradiated materials must be destroyed or treated to prevent the growth of immature stages in order for them to be used as a disinfection therapy (Ayvaz and Yilmaz, 2015; Hassan, et al., 2019). It has various benefits, including the ability to thoroughly permeate pallet loads of products, the prevention of insect resistance development, and the absence of residual radiation in irradiated food when used in low levels of treatment (El-Naggar and Mikhael, 2011). The combined treatment with other control strategies may be more effective than using only one of them in the case of bug species that need high doses of radiation to stop their reproduction (Sayed and El-Helaly, 2018).

MATERIALS AND METHODS

Effect of Radiation on *S. cerealella*

Batches of 50 eggs each of *S. cerealella*, aged twelve and twenty-four hours, were pasted to cards and exposed to four different doses of gamma radiation 35, 55, 65, 75 Gy and with one control group. The experiment was repeated three times for each dose. Percent hatching and hatching duration (incubation period) were recorded. The design used for this experiment was factorial completely randomized design.

Effect of Irradiation on *S. cerealella* Eggs and Subsequent Effect on Emerging *T. chilonis*

In this experiment fresh eggs of *S. cerealella*, aged 12 and 24 hours were pasted on cards and exposed to four different doses of 35, 55, 75, 95 Gy gamma radiation along with a control group (no dose). The radiated eggs were then exposed to two fresh pairs of *T. chilonis* adults which laid their eggs in those radiated eggs. Data of % parasitism, % adult emergence and adult longevity were recorded. For each dose the experiment was replicated three times.

Effect of Irradiation on *T. chilonis* Pupae

Fifty fresh pupae of *T. chilonis* in a tube were irradiated with four different doses: 5, 10, 15, 20 Gy and a control (no radiation). The experiment was replicated three times for each dose. Data of percentage adult emergence and adult longevity were recorded.

RESULTS AND DISCUSSION

Effect of Irradiation on Incubation Period and Hatching of *Sitotroga cerealella*

The results presented in table (1) indicate that different radiation doses (Gy) and egg age (h) significantly affected the incubation period and hatching of *S. cerealella* eggs. Among the treatments, lowest radiation dose (35 Gy) yielded significantly higher incubation period and hatching for *S. cerealella* eggs for both 12h (7.5 days, 55.3%) and 24h (7.66 days, 53.3%) aged eggs, which were non-significantly different. Highest radiation dose (95 Gy) resulted in lower incubation period and hatching of *S. cerealella* eggs for both 12h (5.23 days, 15.3%) and 24h (5.40 days, 11.6%) aged eggs. Table (1) reveals that higher percent hatching of *S. cerealella* was observed with lower dose and vice versa. Also control gave higher percent hatching of *S. cerealella* as compared to the irradiation doses. Our results are in agreement to that of some previous researchers. Hallman (2000) observed that some Lepidopterous pest related to stored products, particularly *S. cerealella* and *P. interpunctella* on exposure to irradiation showed high tolerance. Mikhael (2011) stated that gamma radiation resulted in decreased hatching % from *S. cerealella* eggs. Boshra (2006) reported the effect of gamma radiation on the *S. cerealella* and hatchability percentage of eggs. Doses used were (50, 100 and 150Gy). Hatching (%) of (48%) was recorded for 50Gy followed by (18.8%) for 100Gy and no hatching was noted for 150Gy, which explains that with increase in radiation dose hatching (%) is reduced. The present findings are in contrary to that of (Muhammad et al., 2013). They observed lower % percent hatching of *S. cerealella* eggs for 50Gy, and with increase in dose from 5 to 50Gy the percent hatching was reduced from 88% to 0.6% for 50Gy.

Effect of Irradiation on Parasitism, Emergence and Adult Longevity of *Sitotroga cerealella* Eggs

Table (2) reveals the effect different radiation doses (Gy) and egg age (h) significantly affected parasitism, emergence percentage and adult longevity of *S. cerealella* eggs parasitized by *T. chilonis*. Among the treatments, lowest radiation dose (35 Gy) yielded significantly higher parasitism of *S. cerealella* eggs and subsequent emergence and adult longevity of *T. chilonis* adults for both 12h (86.00%, 86.03%, 7.13days) and 24h (84.00%, 87.31%, 6.76 days) aged eggs, which were non-significantly different. Highest radiation dose (95 Gy) resulted in lowest parasitism, emergence and adult longevity of *S. cerealella* eggs by *T. chilonis* for both 12h (15.33%, 30.15%, 4.10days) and 24h (12.00%, 33.96%, 3.50days) aged eggs.

Table 1. Effect of different radiation doses (Gy) and Egg age (h) on incubation period of *S. cerealella* eggs under laboratory conditions.

Dose (Gy)	Egg age (h)	Incubation Period (days)	Hatching (%)
35	12	7.50a	55.3 b
	24	7.66a	53.3 b
55	12	6.00b	44.3 c
	24	5.83bc	42.3 c
75	12	5.86bc	30.6 d
	24	5.60bcd	29.3 d
95	12	5.23d	15.3 e
	24	5.40cd	11.6 e
Control	12	3.00e	90.0 a
	24	3.00e	87.3 a
LSD Value	-	0.53	4.13

In control, parasitism, emergence and adult longevity of *S. cerealella* eggs by *T. chilonis* was significantly higher than all the treatments for both 12h (92.00%, 95.68%, 8.06days) and 24h (92.66%, 93.57%, 8.13days) aged eggs. Our results clearly show that with lower dose of 35Gy the *T. chilonis* parasitization % was higher as compared to that with the higher dose. In control the parasitization percentage was higher than all the irradiation doses. Our findings are also in accordance with the findings of some previous researchers. Hamed et al. (2009) observed the parasitism behavior of *T. dendrolimi* on irradiated eggs of Chinese Tussar moth and reported 80% parasitism without any detrimental effects on adult emergence. (Muhammad et al., 2013) stated that production ability of *T. chilonis* can be enhanced with efficient use of gamma irradiation in a range of 5-55 Gy and reported parasitization of 45% for 55Gy. (Tuncbilek et al., 2009) irradiated eggs of *S. cerealella* with doses from (5 to 50) Gy and observed parasitization potential of *T. chilonis*. They reported that with increase in radiation dose the parasitization percentage was declined and lower parasitization potential was noted for 50Gy. Our results are in agreement with (Tuncbilek et al., 2012) who reported that irradiated eggs of *S. cerealella* and *P. interpunctella* can be efficiently use in mass rearing of *T. evanescens*. No previous research work was found on adult longevity of *T. chilonis* emerged from irradiated eggs of *S. cerealella*.

Table 2. Effect of different radiation doses (Gy) and egg age (h) on *S. cerealella* eggs parasitism (%), Emergence (%) and adult longevity of *T. chilonis* under laboratory conditions.

Dose (Gy)	Egg age (h)	Parasitism (%)	Emergence (%)	Adult Longevity (days)
35	12	86.00b	86.03b	7.13 b
	24	84.00b	87.31b	6.76 b
55	12	48.66c	53.33c	5.93 c
	24	46.66c	50.00c	5.53 cd
75	12	34.00d	39.18d	4.83 de
	24	29.33e	38.68de	4.36 ef
95	12	15.33f	30.15f	4.10 fg
	24	12.00f	33.96ef	3.50 g
Control	12	92.00a	95.68a	8.06 a
	24	92.66a	93.57a	8.13 a
LSD Value		3.83	5.21	0.71

Effect of Irradiation on Emergence and Adult Longevity of *T. chilonis*

Data pertaining to Table (3) reveals that different radiation doses (Gy) significantly affected the percent emergence and adult longevity of *T. chilonis* from pupae. Among the treatments, lower radiation dose (5 Gy) yielded significantly higher percent emergence and adult longevity of *T. chilonis* (86.66%, 7.46 days) from irradiated pupae's, which was significantly different from the rest of radiation doses. Highest radiation dose (20 Gy) resulted in lower emergence percentage and adult emergence of *T. chilonis* (32.0%, 4.43 days). In control, percent emergence and adult longevity of *T. chilonis* was significantly higher than all the treatments (94.66%, 8.76days). Our results are in agreement with that of some earlier researchers. (Tuncbilek et al., 2012) stated that with increase in radiation there is a gradual

decrease in fecundity of *T. chilonis*. And also reported that effect of gamma irradiation on pupal emergence of *T. euproctidis* and found that with the increase in irradiation dose the emergence % from pupae gradually decreased and no emergence was observed for 30Gy.

Table 3. Effect of different radiation doses (Gy) on emergence (%) of *T. chilonis* from irradiated pupae under laboratory conditions.

Dose (Gy)	Emergence (%)	Adult Longevity (days)
5	86.66 b	7.46 b
10	70.00 c	6.33 c
15	55.33 d	5.50 d
20	32.00 e	4.43 e
Control	94.66 a	8.76 a
LSD Value	2.81	0.63

CONCLUSION AN RECOMMENDATIONS

Based on the above findings it is suggested that application of lower doses of radiation results in higher hatching (%), incubation period, parasitism (%), adult emergence (%) and adult longevity for both eggs and pupae, and with increase in dosage the parameters studied declines gradually. So, in forthcoming research experiments other lower doses ranging between 5-25 Gy should be applied.

AUTHOR'S CONTRIBUTION

Conceived and designed the experiments: J Sarwar, M Zahid, M Salman Performed the experiments J Sarwar, Analyzed the data: M Shah, A Ihsan, Wrote the paper: J Sarwar, SF Shah.

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