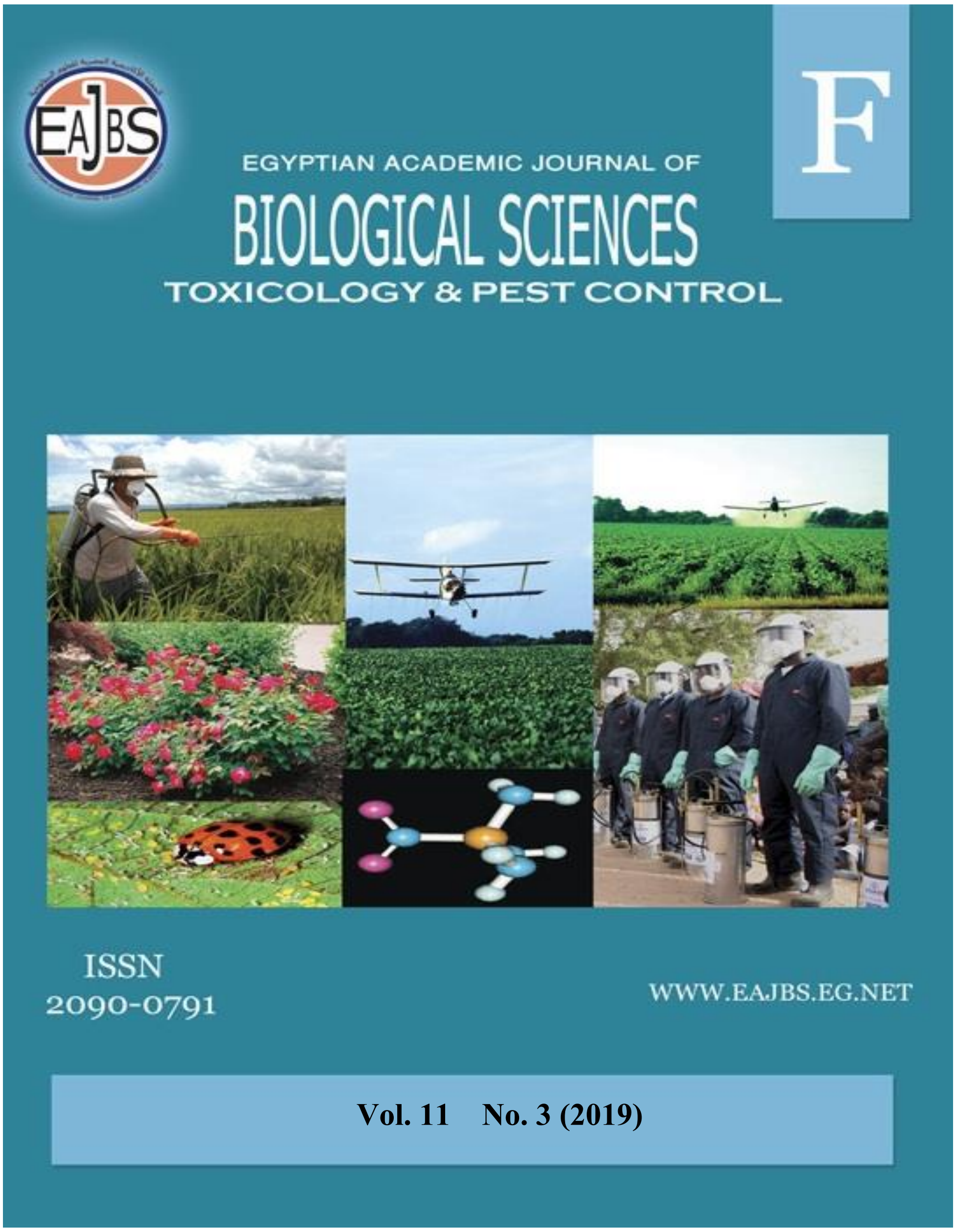

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Biological Studies on the Effect of Gamma Radiation and Thermal Treatment on the Angoumois Grain Moth, *Sitotroga cerealella* (Olivier)

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ABSTRACT

Gamma radiation and heat treatments are considered promising techniques for disinfestation treatments against stored product pests. This study aimed to evaluate the effects of thermal treatment with 40, 50, 70 and 90°C and different doses of gamma radiation from 40 to 350 Gy on Sitotroga cerealella stages. The result demonstrated that the LD50 of gamma-irradiation was 57.7, 61.9 and 74.0 Gy in irradiated eggs, pupae, and larvae, respectively. Concomitantly, the complete mortality (100 %) of heat treatment was recorded at 40°C, while the 90°C caused 100 % mortality to larva and egg stages. The results indicated that the egg stage is highly sensitive to irradiation doses than larvae and pupal stages, while the pupal stage is highly sensitive to the heat treatments than eggs and larval stages. Consequently, treatment with low doses 80 Gy and low heat condition 40°C was more effective than the other combination treatments. The results suggested that 80 Gy & 40°C was an effective treatment to prevent the reproduction of *S. cerealella* and could use for managing this pest with was the environment.

INTRODUCTION

The Angoumois grain moth, *Sitotroga cerealella* (Lepidoptera Gelechiidae is one of the serious pests of maize, rice and wheat grains in tropical and subtropical regions (Hansen *et al.,* 2004; Demissiea *et al.,* 2014). This pest can infest the grains during the developmental stages in the field and also in the stores after harvesting (Villacis *et al.,* 1972). The use of environment-friendly control methods is urgently needed for successful integrated this pest whereas the synthetic insecticides are mostly harmful to mammals and natural enemies such as methyl bromide, which has been widely used for stored-product pest control and as quarantine treatment (Arbogast, 1981; Chaudhr, 1997). Moreover, insect pests like *S. cerealella* develop resistance to chemical pesticides (Ross, 1999; Heather and Hallman, 2008). Gamma irradiation is considered one of the successful control methods against various insect pest and also it was recommended as an effective technique against stored product insects (Ayvaz and Tuncbilek, 2006). it is widely used as disinfestation treatment in many regions. The use of irradiation treatments as disinfestation treatment depends on kill or inhibit the development of immature stages in irradiated products (Ayvaz and Yilmaz, 2015; Hassan *et al.*, 2019). It has many advantages whereas able to deeply penetrate pallet loads of products, no development of insect resistance and no residue in irradiated food with low doses treatments (El-Naggar and Mikhaiel, 2011; Ayvaz and Tuncbilek, 2006; Hallman 2013). In the case of insect species that require high doses of radiation to prevent its reproduction, the combination treatment with other control techniques could be more pronounced than use one of them (Sayed and El-Helaly 2018). The extreme temperatures have been recommended as disinfestation treatments of stored product pests and could use as an effective supplementary control technique to gamma irradiation as an alternative to pesticides in grain storage for managing stored-product insect pests as ecologically based technique (Al-Zahaby *et al.*, 1997 & Opit *et al.*, 2011). The temperature degree that case complete insect mortality is varied by the type of stored product insect, insect stage and the time of treatment, so, it is important to identify the insect species and know their characteristics before establishing the heat application (Campolo *et al.*, 2013). The high degree of heating may cause a negative impact on commodities quality, while. The low degree may result insect survival after treatment (Dowdy and fields 2002). The use of other techniques as combination treatments with heat may help for increasing the efficacy of control method allowing success stored product insect management (Dowdy, 1999; Fields and White, 2002). Therefore, this investigation aimed to determine the effective combination treatment of gamma irradiation and heat temperature against *S. cerealella* as friendly control method.

MATERIALS AND METHODS

S. cerealella Rearing:

Laboratory stock cultures of *S. cerealella* were reared and maintained in Biological Applications Department reared at 26±1°C and 85± 5% R.H. The male and female moths were transferred into adult rearing jars; each jar contained a black zigzag paper as an oviposition site and was covered with muslin fixed with a rubber band. Each tape containing egg was kept separately Petri dishes on black paper circles. Newly hatched progeny from each treatment were kept in groups of 100 larvae in a glass jar (120 ml) provided with wheat kernels as rearing media rearing until pupation and emergence,

Gamma Irradiation Treatment:

Five replications of five hundred eggs were placed in plastic cups provided with 50 gm wheat kernels media were irradiated at different doses 0, 40, 60.80, 100 and 120 Gy) were placed in glass jars provided with wheat kernels media to record the hatching percentage. While, the larvae were collected from the culture according to Abdel-Hameid, (2018) and selected (five replicates with five hundred larvae per each) and placed in plastic cups provided with 50 gm wheat kernels media and irradiated with four sterilizing doses 200,250,300and 350Gy, the irradiated larvae were placed in glass jars provided with wheat kernels media until pupae. The same doses were applied in the pupal stage, the pupae were separated and selected from the culture following (Akter (2013), five replicates with five hundred pupae per each were placed in plastic petri dishes provided with 50 gm wheat media. The irradiated pupae were placed in glass jars provided with wheat media till emergence. The irradiation treatments were carried out by 60 Co-irradiator located at Cyclotron Project-Nuclear Research Center, Atomic Energy Authority, Cairo, Egypt, with the dose rate of 0.55 Gy/s.

Heat Treatment:

The groups of eggs, larvae, and pupae (five replicates with five hundred per each) were placed in glass jars supplied with 100 gm wheat media and subjected to thermal treatment for 30 min in incubators adjusted at 40, 50, 70°C and 90°C. Similar numbers of insect stages were kept at 26 ±1°C as control. After thermal treatment, the treated insect egg, larvae, and pupae) were transferred and kept to 26±1°C and 70±5% R.H. The mortality percentages were calculated in each treatment.

Combination Treatments:

The sub-lethal doses 40 and 80 Gy of gamma radiation were carried out before heat conditioning at two different treatments 40, 50°C. Five replicates with five hundred per each were conducted in eggs, larvae, and pupae which treated with four different combination treatments, 40 Gy & 40 C°, 40 Gy & 50 C°, 80 Gy & 40 C° and 80 Gy & 50 C°.

Statistical Analysis:

Dose-mortality regressions were calculated to determine the effective dose of gamma radiation for disinfestation treatment. Finney (1971) calculated slope and LD50s and LD 98 values according to the method Described. The data were analyzed using an ANOVA analysis technique and the mean separation was determined by Tukeys multiple-range test at P <0.005 (Steel and Torrie 1960).

RESULTS AND DISCUSSION

Effect of Gamma Radiation on *S. Cerealella* Eggs, Larvae And Pupae:

Data in Figure (1) showed that the mortality percentages of *S. Cerealella* eggs, larvae and pupae were increased gradually by increasing the applied doses of gamma radiation. The highest percentage (96.1 and 100%) were recorded by exposure eggs to the dose rates of gamma radiation 100 and 120 Gy, while the percentage of mortality was reached to 100 % at the dose rates 200 and 350 Gy of irradiated pupae and larvae, respectively. All effects of irradiation rats on egg mortality were significant; the same statistical data were obtained in the case of larval and pupal mortalities.

The results indicated that the larvae were more tolerant of gamma radiation than eggs and pupae. The LD_{50} of larvae pupae and eggs was recorded 75.7, 61.9 and 74.04 at irradiated egg, pupae, and larvae, respectively, while the LD_{98} was 109.6, 147.8 and 165.9 at irradiated egg, pupae and larvae, respectively (Fig 2). Similarly, Younes and Ahmed (2007) found that the lethal gamma irradiation dose of *O. surinamensis* eggs was 80 Gy. While Zolfagharieh (2002) reported that the dose of 150 Gy was prevented the development of irradiated *O. surinamensis* larvae to adults. These results are contradicted with Abd El-Aziz *et al.*, (2017) who found that the pupae and larvae were more sensitive to gamma radiation than eggs. These differences may be related to different rearing media and insect strains. The lethal gamma irradiation dose recommended by various researches that could be used in disinfestation treatment against stored product insects was varied by the different insect developmental stages and also by different species.

It is recommended that all stored product pests required a dose of 500 Gy to prevent their reproduction (Tilton, 1974; FAO, 2003). However, Hallman (2013) reported that the effective dose to prevent the production of Indian meal moth *P. interpunctella* was 600 Gy which is more tolerant than other insect species

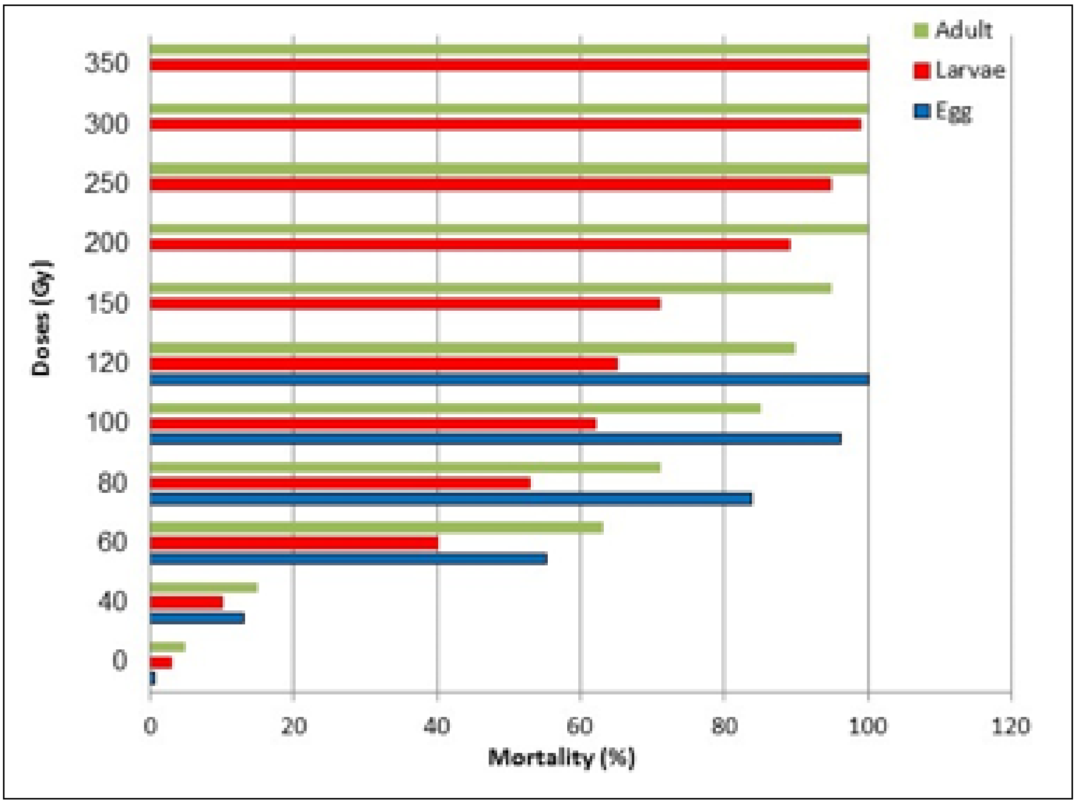

Fig (1): Mortality percentages of eggs, larvae, and adults of *S. cerealella* irradiated with different doses of gamma radiation

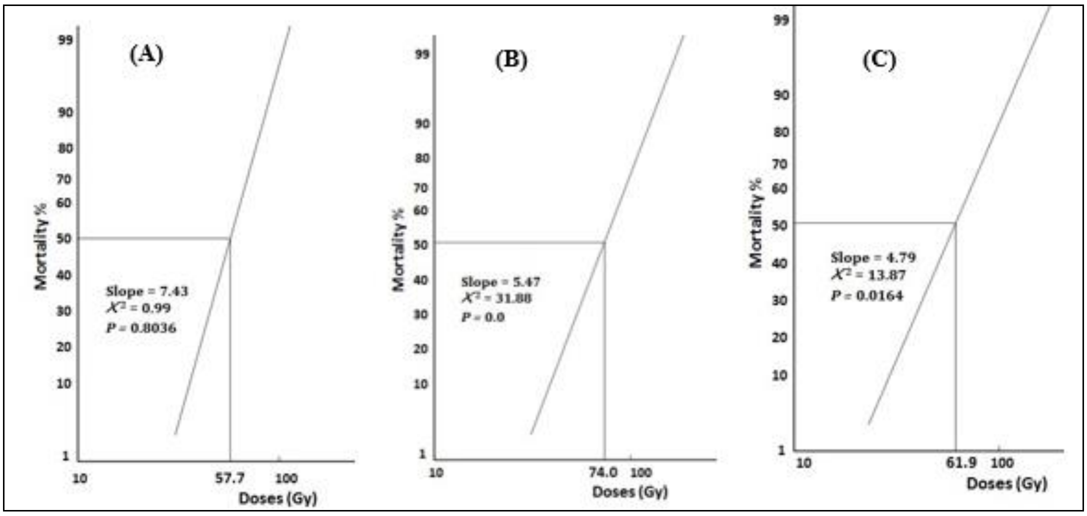

Fig (2): Mortality response of eggs (A), larvae (B) and adults (C) of *S. cerealella* irradiated with different doses of gamma radiation

Effect of Heat Condiations on *S. Cerealella* Eggs, Larvae and Pupae:

The data in Figure (3) showed that the S. *cerealella* pupae were more sensitive to heat treatment than eggs and larvae, the mortality percentage of pupae was 100 % at 40Co, while, the 100 % mortality was recorded at 90 Co in treated larvae and eggs.

Our results agree with those found by Evans (1981) who reported that the treatment 80°C for 4 minutes is adequate to disinfest 10 kg batches of wheat with all life stages of *S. cerealella* . Moreover, satisfactory results were noticed by the heat treatment (80°C to 100°C) for disinfestation of wheat against stored pest (Hallman *et al.*, 1994; Piyasena *et al.*, 2003; Banks, 1998).

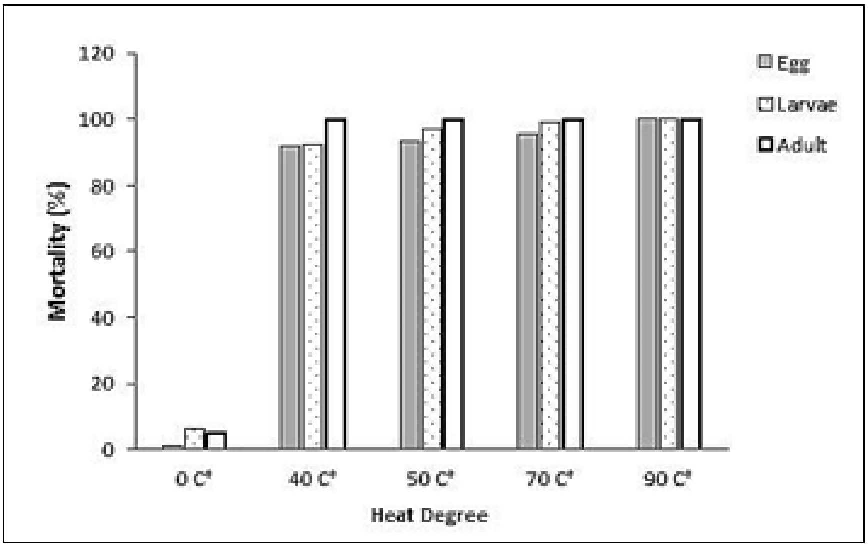

Fig (3): Mortality percentages of eggs, larvae, and adults of *S. cerealella* espoused to different temperature degrees.

The Combined Effect of Gamma Radiation and Heat Treatments on *S. cerealella Stages* :

Most of the stored products are very sensitive to heat treatments wheatears quality deterioration may be caused by the high temperature applied. Moreover, our results on the disinfestation treatment by gamma irradiation indicated that the larvae were required high doses that may also cause some of deleterious effects on food products. In this case the results of Fig (4) showed the effect of using low heat treatments 40 and 50 °C with low gamma radiation doses 40 and 80 Gy for disinfestation treatment against *S. cerealella*.

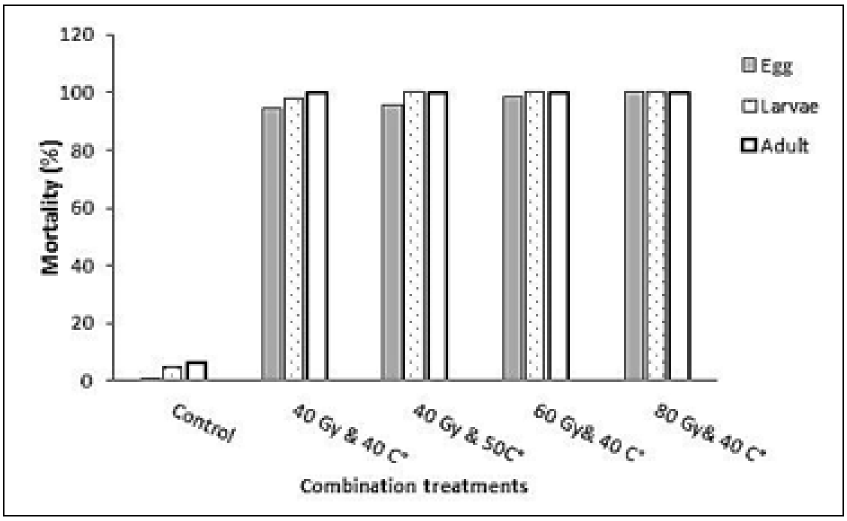

Fig (4): Mortality percentages of eggs, larvae, and adults of *S. cerealella* treated with the combinations of gamma radiation doses (40 and 80 Gy) and temperature degrees (40 and 50 C°)

The obtained results revealed that the combination treatment 80 Gy & 50C° caused 100 % mortality of all insect stages as compared with the other combination treatments. The obtained results agree with Abd Elghffar *et al* (2012) who found that the combinations thermal and gamma irradiation treatments decreased the fecundity, fertility, pupation and adult emergence of *Ephestia cautella.*

Conclusion

Both gamma radiation and heat temperature could use as alternate techniques for stored product management as disinfestation treatments in replacing to chemical pesticides. The combination treatment of (gamma radiation and heat) was carried out in this research on *S. cerealella* pest. The combination of low doses 80 Gy and low degree 40°C was an effective treatment to prevent its reproduction and could use for integrated *S. cerealella* management.

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