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EFFECT OF GAMMA RADIATION ON GROWTH AND DEVELOPMENT OF RUST RED FLOUR BEETLE *TRIBOLIUM CASTANEUM* (HERBST.)

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Abstract: Study on the sterilizing and lethal effects of Cobalt-60 gamma radiation on the larval and adult stages of rust red flour beetle *Tribolium castaneum* (Herbst.) was done at 0, 10, 30, 50, 70, 100, 150, 300 and 500 gray (Gy). Irradiation severely affected pupal period, pupal formation and survivability of larvae and adults. The developmental period of the pest was found to increase along with the increase in the radiation doses. The irradiation at 70 Gy was found to cause complete sterility in the insect.

Key words: *Tribolium castaneum,* gamma radiation, growth and development, sterility, radio-sensitivity

INTRODUCTION

Rust red flour beetle, *Tribolium castaneum* (Herbst.), is a serious secondary pest of stored grains, containing starchy material, found throughout the warmer parts of the world. Damage is caused mainly by the larvae and adults which feed extensively on previously holed or broken grains, or grains damaged by other pests.

Synthetic pyrethroids such as permethrin, cypermethrin, decamethrin, fenvalerate etc. and fumigants e.g. phosphine, methyl bromide, ethylene dibromide etc. have been most commonly used for the control of *T. castaneum* in storage (Rajendran 1990). Use of these chemicals however, has been found to be highly hazardous causing serious environmental problems. This problem therefore has necessitated the investigations on developing alternative means of control. Gamma irradiation technique seems to offer solutions that are desirable in many respects. Control of storage pests using irradiation techniques has been investigated to a limited extent. Control of pests like *Sitotroga cereailella, Callosobruchus maculates, Sitophilus oryzae* etc. by this technique has proved promising (Arthur and Wiedl 1993; Tsan *et al.* 2002).

Gamma radiations are used to produce mortality or sterility in the insects. This technique can be used by irradiating the insects at doses sufficiently high to produce the desired effects.

MATERIALS AND METHODS

Third instar larvae and adults (aged one week), used for the experiments, were obtained from the nucleus culture of *T. castaneum* reared on wheat flour disinfested at 70°C for 1.30 h. The larvae and adults were exposed to radiation by a Co-60 gamma source in 'Gamma chamber 900'. For exposure, the larvae and adults were transferred separately into tissue cultures tubes which were capped. Each tube containing 10 larvae or adults were exposed to doses 0 (control), 10, 30, 50, 70, 100, 150, 300 and 500 Gy and three replication for each treatment were taken. The irradiated adults and larvae were then maintained in the laboratory to observe adult longevity, pupal period, pupal formation, adult emergence and adult mortality. Complete Randomized Design (CRD) was used to analyze the data.

RESULTS AND DISCUSSION

Effect of gamma radiations during larval stage on the pupal formation, pupal period, adult emergence and adult longevity are presented in table 1. It is evident that there was no pupal recovery at doses higher than 70 Gy. The increase in radiation doses showed a significant decrease in number of pupae formed. The pupal period increased along with increase in radiation doses. The pupal period of pupae arising from non-irradiated larvae and that irradiated at 10 Gy showed a non-significant difference.

There was no adult emergence from the larvae irradiated at doses higher than 50 Gy. At 70 Gy some pupal recovery was seen but the pupae died and there was no adult emergence. Adult emergence in irradiated larvae at 10 Gy showed a significant decrease over control. Longevity of adults emerging from irradiated larvae was observed to decrease along with increase in the radiation dose.

Effect of gamma radiation on *T. castaneum* irradiated during adult stage is shown in tables 2 and 3. The survivability of adults was found to decrease along with

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Table 1. Effect of larval irradiation on pupal formation, pupal period, adult emergence and adult longevity of *T. castaneum*

Radiation dose [Gy]	No. of pupae formed	Pupal period [Days]	No. of Adult emergence	Adult longevity [Days]
0	6.00±0.82	6.30±0.78	5.33±0.94	37.3±0.47
10	3.33±0.40	6.93±0.98	3.00±0.00	30.8±0.12
30	2.33±1.20	7.87±1.20	1.33±0.40	21.9±0.33
50	1.33±1.80	9.50±1.14	1.00±0.82	12.7±0.87
70	0.33±0.47	12.10±3.10	0.00±0.00	–
100	0.00±0.00	–	0.00±0.00	–
150	0.00±0.00	–	0.0±0.00	–
300	0.00±0.00	–	0.00±0.00	–
500	0.00±0.00	–	0.00±0.00	–
SEM	0.5930	1.9206	0.4216	0.7872
CD (p = 0.01)	2.5608	8.5996	1.8870	2.7591
CD (p = 0.05)	1.8274	6.0502	1.3280	1.8735

Three replications of 10 larvae each

Table 2. Per cent survivability of irradiated adults of *T. castaneum*

Days	Doses [Gy]								
	0	10	30	50	70	100	150	300	500
1	100.0	98.1	80.0	98.3	86.6	93.3	73.3	83.3	83.3
5	100.0	93.3	80.0	93.3	83.3	83.3	70.0	83.3	80.0
10	100.0	86.6	76.6	90.0	80.0	76.6	66.6	73.3	66.6
15	100.0	86.6	76.6	83.3	76.6	73.3	66.6	53.6	53.6
19	90.0	80.0	73.3	80.0	73.3	73.3	56.6	40.0	16.6
30	90.0	80.0	73.3	76.6	73.3	73.3	50.0	30.0	16.6
35	83.3	73.3	73.3	76.6	73.3	63.3	46.6	16.6	0.0
40	76.6	70.0	66.6	73.3	60.0	56.6	0.0	0.0	0.0
45	66.6	50.0	40.0	46.6	33.3	10.0	0.0	0.0	0.0
50	66.6	50.0	40.0	46.6	33.3	10.0	0.0	0.0	0.0
55	66.6	50.0	40.0	46.6	26.6	6.6	0.0	0.0	0.0
60	53.3	50.0	10.0	43.3	23.3	6.6	0.0	0.0	0.0
65	43.3	50.0	40.0	43.3	23.3	6.6	0.0	0.0	0.0
70	53.3	70.0	36.6	36.6	13.3	0.0	0.0	0.0	0.0
75	30.0	16.6	6.6	3.3	0.0	0.0	0.0	0.0	0.0
79	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
90	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 3. Effect on pupal formation, developmental period and adult emergence of irradiated adults of *T. castaneum*

Radiation-dose [Gy]	No. of pupae formed	Developmental period [days]	No. of adults emerged
0	5.30 ± 0.47	6.2 ± 0.88	5.00 ± 0.82 (94.33)
10	3.66 ± 0.47	9.0 ± 0.25	3.00 ± 0.00 (81.96)
30	3.33 ± 0.47	9.8 ± 0.82	1.66 ± 0.47 (49.84)
50	3.00 ± 0.82	10.4 ± 2.4	0.33 ± 0.47 (11.00)
70	1.00 ± 0.40	14.0 ± 3.4	0.00 ± 0.00 (0.00)
100	0.00 ± 0.00	–	0.00 ± 0.00 (0.00)
150	0.00 ± 0.00	–	0.0 ± 0.00 (0.00)
300	0.00 ± 0.00	–	0.00 ± 0.00 (0.00)
500	0.00 ± 0.00	–	0.00 ± 0.00 (0.00)
SEM	0.527	2.2550	0.330
CD (p = 0.01)	2.275	10.0969	1.4390
CD (p = 0.05)	1.623	7.10375	1.0269

Values in parentheses are the percentage of adult emergence

increase in radiation dose. In the present investigation 100 per cent mortality was observed in 35 days after irradiation in case of adults irradiated at 500 Gy and not in 79 days in case of non-irradiated adults. Longevity of adults emerging from irradiated larvae decreased along with increase in radiation doses (Table 2). Pupal recovery was maximum in control (5.30±0.47) and minimum in adults irradiated at 70 Gy (1.0±0.40). At doses greater than 70 Gy the pupae did not develop into adults.

The development period increased along with increase in radiation doses. It was maximum at 70 Gy (14.0±3.4 days) as compared to control (6.2±0.88 days). Similar results with the adult emergence were observed when pupae were irradiated with 70 Gy. No adult emergence was observed where as it showed significant decrease in adult emergence even at 10 Gy (3.0±0.0) as compared to control (5.0±0.82) (Table 3).

Results of this study indicate a close similarity in the radio sensitivity of larvae and adults of other genus and species. On irradiation at 100 Gy from 1 to 5 days old *T. freemani* complete sterilization was observed. Spermatogonial death was observed in testis of irradiated males (Blanco *et al*. 1990). Doses higher than 20 kGy causes mortality of the *T. confusum* while, lower doses caused inhibition of development and sterility of surviving insects (Ignatowicz and Zaedee 1995). Lethal and sterilizing effect of gamma radiation on eggs, larvae, pupae and adults of *Sitophilus granaries* were studied at different doses by Aldryhim and Adam (1999), studies revealed that eggs and larvae were unable to develop adults at doses 30–500 Gy and doses of 70 Gy at pupal and 4 weeks adults caused sterility.

From above study we conclude that a dose of 70 Gy and above is sufficient to control the larval and adult stages of *T. castaneum*. However, large scale tests involving bulk treatment of *T. castaneum* should be conducted to verify this projection before we could recommend a final dose.

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POLISH SUMMARY

WPŁYW PROMIENIWANIA GAMMA NA WZROST I ROZWÓJ TROJSZYKA GRYZĄCEGO *TRIBOLIUM CASTANEUM* (HERBST.)

Przeprowadzono badania nad sterylizacją i śmiertelnością trojszyka gryzącego *Tribolium castaneum* (Herbst.) w stadiach larwalnych oraz w okresie dorosłości poddanych ekspozycji promieniowania gamma izotopu ^{60}Co. Dawki pochłonięte wynosiły: 0, 10, 30, 50, 70, 100, 150, 300 i 500 gray (Gy). Napromieniowanie poważnie wpływało na owady w fazie poczwarki i tworzenie się poczwarek oraz przeżywalność larw i osobników dorosłych. Okres rozwojowy wydłużał się wraz ze wzrostem pochłoniętych dawek promieniowania. Napromieniowanie o wartości dawki 70 (Gy) powodowało całkowitą sterylizację insektów.