EFFECT OF GAMMA IRRADIATION ON MORTALITY AND STERILITY OF THE CONFUSED FLOUR BEETLE, *TRIBOLIUM CONFUSUM* DUV., REARED ON WHEAT AND CORN FLOUR

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(Received 11-8-2004)

INTRODUCTION

The confused flour beetle, *Tribolium confusum* Duv., is a serious economic pest of stored products in many areas of the world, and it is a secondary pest of stored grains. Concern that pesticides residues in the foodstuffs may be a potential health hazarded has led to intensive investigation of non-chemical methods for insect control. One promising method is the application of ionizing radiation to insect population infesting grain and other foods. (Cornwell, 1966; Cogburn *et al.*, 1972; Dramola, 1980; Ducoff and Bosma 1983; Hasan, *et al.*, 1989 and Nainwall *et al*, 2001).

Although a great deal of work has been carried out on the effect of gamma irradiation on the different developmental stages of stored product insects, various attention has been paid to the effect of diet on the susceptibility of these insects to irradiation. Food is an important governing factor in influencing insect survival and developmental behavior and may modify its intrinsic sensitivity towards irradiation stress (Shipp 1966; Seth, 1995; Tuncbilek and Kansu 1996 and Khattab *et al.*, 2000). In addition, learning the factors that affecting the radiosensitivity of insect are imperative to determine the minimum effective dosage required to kill the most resistant age and metamorphic stage expected to be found in packaging operation for commercial applications of gamma radiation. This is vital to keep the cost of treatment at an economic level and to minimize any detrimental effects on products.

Consequently, the present work aims to evaluate the effect of gamma irradiation on the mortality and the sterility of adult confused flour beetles *Tribolium confusum* Duv., reared on two different diets(wheat flour and maize flour).

MATERIAL AND METHODS

Rearing and maintenance of insect:

Adults of *Tribolium confusum* were extracted from laboratory culture and released on sterilized diet of wheat flour and maize flour for six generations. Insects were maintained at 27 ± 5C° and 65 ± 5% R.H before and during all tests. Eggs were obtained by placing adults on finely rearing flour medium for 24 hr and then eggs were separated by a 90-mesh sieve from the flour medium to remove egg laid. The collected eggs were placed in clean petri dishes dusted lightly with fine rearing medium. Larvae were sifted from exactly aged stock cultures, and pupae were obtained from cultures cleared of all pupae 1 day earlier. Pupae were sexed and placed in small glass container. Unmated adults were obtained from these confined pupae. Equal numbers of male and female adult were used.

Adult mortality by irradiation:

Fifty adults of 2-3 days old from each diet and sex were irradiated with 0, 100, 300, 600, 900 and 1200 Gy of gamma radiation at an average dose rate of 3.7 rad/sec to study the mortality. After irradiation, each group from different treatments was placed in separate glass vials each containing 20-gram diet. Each treatment was replicated three times. Observations, to the extent that mortality is concerned, were made every 3 days through 19 days after irradiation. Declining insects, which were unable to walk, and those which showed weak movements on their disturbance together with insects showing no signs of life were all considered dead.

Effect of irradiation on F1 progeny:

To study the effect of irradiation of adult stage on the number of F_1 progeny, 1-3 days old beetles raised from each of the two diets (wheat flour and corn flour) were irradiated with 0, 50,150, 250, and 350 Gy of gamma rays and then paired according to the different mating combination (irradiated male x un-irradiated female), (un-irradiated male x irradiated female), (irradiated male x irradiated female) beside (un-irradiated male x un-irradiated female). Ten pairs were used for each mating combination and four replicates were utilized for each treatment. Afterwards, the adult beetles were transferred to small glass jar containing equal amount of diet to lay eggs for a period of four days. After that, insects were removed

and the medium with deposited eggs was left until adult emergence. Emerged adults from each treatment were counted daily until no more adults had emerged. The number of F1 adults was used as a criterion for evaluation.

Statistical Analysis:

Data were analyzed using polo, a computer program for probit or logit analysis, from Leora software (1987) according to Finney (1964). The LT_{50} (the time required, following irradiation for fifty percent of a population to die), LD_{50} (the dose of irradiation that kill fifty percent of a population) and SD_{50} (the dose of irradiation that sterile fifty percent of from population) were used as parameters for comparison. Also, the data of F_1 progeny were subjected to analysis of variance (ANOVA Randomized Complete Blocks) at the 1% level of significance, and Duncan's Multiple Range Test according to Steel and Torrie (1980) using a computer program of Costat.

RESULTS AND DISCUSSION

Mortality of irradiated adults:

Data illustrated in Fig. (1) demonstrate that irradiation treatment caused a progressive increase in the percent mortality of *T.confusum* adults as the dose of irradiation or days after irradiation increased. This effect was observed for either irradiated males or females in both wheat and corn flour diet. In general, different diets lead to variation in the percent of mortality, as, the adults reared on wheat showed the highest percent mortality as compared with those reared on corn at almost all irradiation doses or interval times post irradiation. For example, the mean percent mortalities of males reared on wheat at the dose level of 1200 Gy were close to 12, 99 and 100 at 4, 7, 10 days post treatment respectively, in contrast, it were 13, 66 and 99 at the same previous interval time for males reared on corn. Also, sex played a considerable role since; the most percent mortalities of males reared on either wheat or corn flour were greater than those of females reared on the same previous diets.

Radiosensitivity of adults as measured by LT_{50}:

Data in Fig (2) indicate that, the irradiated male or female adults reared on wheat flour lived shorter than those reared on corn flour at nearly of all the irradiation doses. For instance, the values of LT_{50} were 10.9, 9.6, 9.3, 8.6, and 6.9 days for female adults reared on wheat flour at the dose level of 100, 300, 600, 900, 1200 Gy respectively, The respective values were 13.1, 12.5, 12.0, 8.7, and 7.8 days for adult female reared on corn flour. On the other hand, the irradiated males reared

on either wheat flour or corn flour at approximately of all the used irradiation doses were more susceptible than adult females reared on the same previous diets.

Radiosensitivity of adults as considered by LD_{50}:

Data illustrated in Fig.(3) indicate that, the effect of diets on radiosensitivity of adults was started to be noticeable at the seventh day post treatments. The LD_{50} values were less for adults reared on wheat flour than those adults reared on corn flour at almost observation times post treatment. These signify that, adults reared on wheat flour were less radio-resistant than adults reared on corn flour. In addition, the values of LD_{50} for males reared on corn or wheat flour were less than female adults reared on the same diets at almost examination times post treatment. This may indicate that, males reared on wheat flour or corn flour were less sensitive to irradiation than females. For example, the values of LD_{50} ten days post treatment were 151.2Gy,493.7Gy,271.5Gy and 945.5Gy,for males reared on wheat, males reared on corn, females reared on wheat and females reared on corn respectevely.

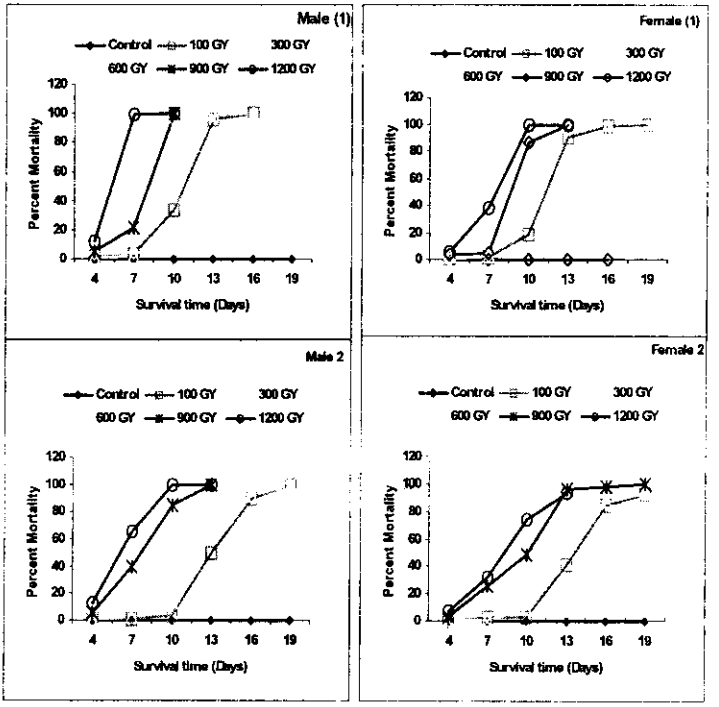

Fig. (1): Percent mortality of gamma irradiated *T.confusum* Duv., adults reared on wheat flour (1) and corn flour (2).

Fig (2): Comparison of LT50 values of gamma irradiated of *T. confusum* Duv., adults reared on wheat flour or corn flour.

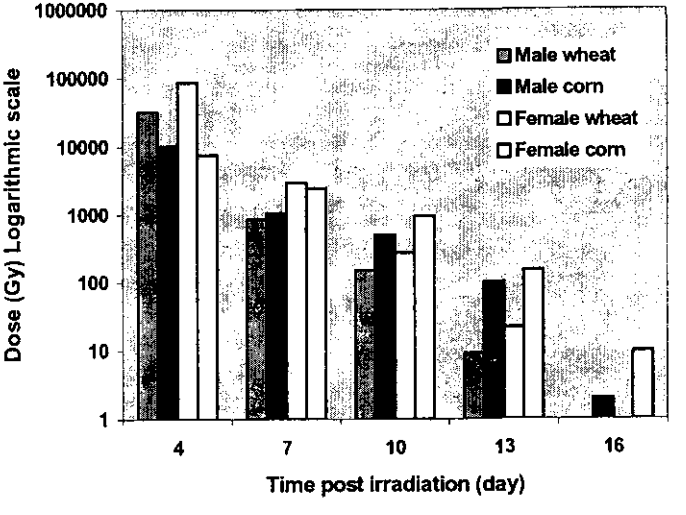

Fig (3): Comparison of LD_{50} values of gamma irradiated *T. confusum Duv.*, adults reared on wheat flour or corn flour.

F_1 Progeny production of irradiated adults:

ANOVA for *T. confusum* progeny indicated that, irradiation doses and mating crosses as main factors regardless of anther factors have a significant effect (P> 0.01) in decreasing total number of the F_1 progeny produced. On the other hand the diet as a main factor in spite of other factor has no significant effect on reducing the number of F_1 progeny (Table 1). As well, Statistical analysis showed that the interaction between crosses and dose or between the dose and diet had significant effect in reducing the number of F_1 progeny of irradiated adults while the interaction between the effect of crosses and diet or the effect of irradiation dose, Cross and diet was found to be insignificant.

TABLE (I)

ANOVA for gamma irradiated *T. confusum* adults progeny, reared or wheat flour or corn flour, using costata computer program (Tests of randomized complete blocks)

Source	df	F	P
Blocks	3	60.9	.0000 ***
Main Effects			
Cross	3	67.47	.0000 ***
Dose	4	70.04	.0000 ***
Diet	1	3.02	.845 ns
Interaction			
cross x dose	12	8.55	.0000 ***
cross x diet	3	1.55	.2049 ns
dose x diet	4	3.98	.0046 **
cross x dose x diet	12	0.59	.8450 ns

Duncan's Multiple Range Test

Factor one: Crosses		Factor two: dose		Factor three: Diet	
LSD .01 = 55.91		LSD .01 = 62.51		LSD .01 = 39.53	
Cross	Tot. Progeny	Dose(Gy)	Tot. Progeny	Diet	Tot. Progeny
NMNF	544.87 a	0	544.87 a	Wheat	387.9 a
IMNF	380.37 b	50	465.34 b	Corn	361.7 a
NMIF	316.95 c	150	396.15 c		
IMIF	257.15 d	250	269.68 d		
	350	198.12 e			

Means with the same letter are not significantly different inside vertical columns I= irradiated, N= Normal, M= Male, F= Female

In general, irradiation decreased progeny production with the increase of the dose, also, the cross of irradiated females with irradiated males produced the fewest progeny than that of the combination of irradiated females with normal males followed by the Cross of irradiated males with normal females for either wheat flour or corn flour (Table 2). However, The greatest efficiency was obtained at the dose level of 350 Gy when irradiated female reared on wheat were paired with irradiated males or with non- irradiated males. Since, the relative percent of F_1 progeny from the control (100%) were 1 and 3 respectively.

TABLE (II)

Mean of F1 progeny produced from gamma irradiated *T. confusum Duv.*, adult reared on (Wheat flour or Corn flour).

Dose (Gy)	IMXNF	%Relative	NMXIF	%Relative	IMXIF	%Relative
Mean ±SE (Wheat flour)						
0	585.50 ±76.49 a	100	585.50 ±76.49 a	100	585.50 ±76.49 a	100
50	583.00 ±84.03 a	99.57	484.25 ±77.71 ab	82.71	440.00 ±69.63 ab	75.15
150	404.25 ±45.02 ab	69.04	331.50 ±42.1 bcd	56.62	222.50 ±32.02 c	38.00
250	252.75 ±28.04 bcd	43.17	165.50 ±17.11 de	23.27	40.50 ±6.25 d	6.92
350	125.75 ±7.27 d	21.48	18.50 ±8.98 e	3.16	6.0 ±1.00 d	1.02
Mean ±SE (Wheat flour)						
0	504.25 ±112.0 a	100.00	504.25 ±112.0 ab	100.00	504.25 ±112.0 a	100.00
50	441.25 ab ±84.58	87.51	375.25 ±70.34 bc	74.42	308.25 ±65.97 bc	61.13
150	457.25 ±96.51 ab	90.68	378.50 ±106.2 bc	75.06	285.50 ±87.59 bc	56.62
250	275.75 ±18.57 bcd	54.69	190.0 ±32.8 cde	37.68	143.25 ±48.49 cd	28.41
350	223.50 ±105.00 cd	44.32	136.25 ±61.7 de	27.02	34.75 ±14.81 d	6.89

Means with the same letter are not significantly different inside vertical columns

I=irradiated, M=Male, N=Normal, F=Female LSD = 179.77 .

To examine the susceptibility of insects from each rearing medium to radiation sterilization, numbers of offspring at each dose level were expressed as percentage of the control transformed to probit and its relationship with log dose

was established (Fig. 4). The SD_{50} (values dose of irradiation that sterilizing the 50% of from population) for wheat flour were 21.31, 15.22, and 9.25 for the crosses of irradiated males with normal females. Irradiated females with normal males and irradiated males with irradiated females respectively. But for corn flour it was 34.79, 18.74, and 10.04 at the same order of the previous crosses.

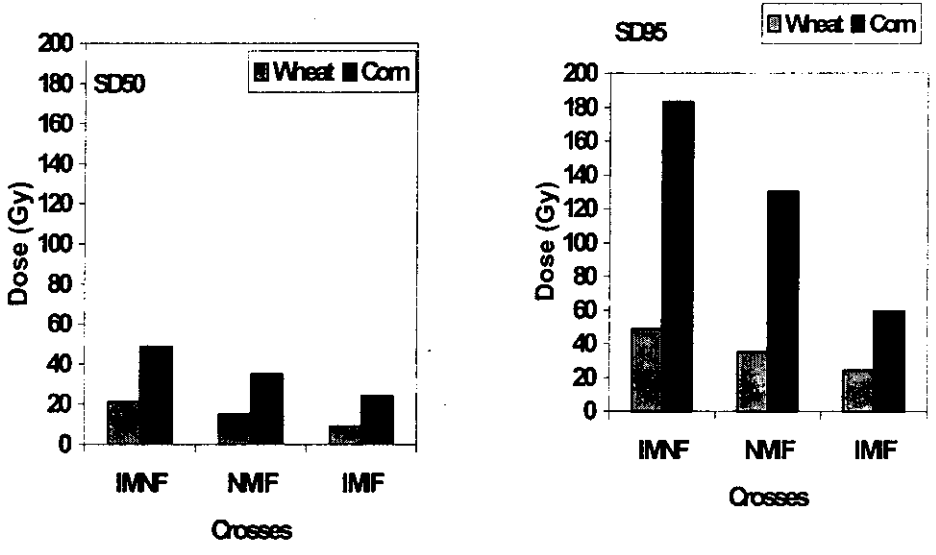

Fig (4): SD_{50} and SD_{95} values of F_1 progeny produced from gamma irradiated *T. confusum Duv.*, adults reared on wheat flour or corn flour.

The result from this study indicated that, the irradiation doses, time post irradiation, type of diet and sex of insect have a considerable role in the survival and radiosensitivity of adults and their F_1 progeny production. The main purpose of this investigation was a comparison of susceptibility of *T.confusum* weevils reared on the two kinds of flour as a rearing medium to gamma radiation. The present results revealed that, the irradiated adults reared on wheat flour were more susceptible to gamma radiation than those reared on corn flour when LT_{50} or LD_{50} parameters were used as a comparison. Shipp (1966) reported that, the rate of development of *T. confusum* on various milling fractions was affected by chemical composition. Rapidly developing beetles are more susceptible to lethal effects of gamma radiation. These observations are confirmed by Tuncbilek and Kansu (1996), who concluded that, beetles of *T. confusum* reared on barely flour were more susceptible to killing by gamma radiation than those reared on maize flour. They added, wheat

and barley flour also, produced heavier pupae and beetles than maize flour, on which development was slow. As well, Abdel Bake (1996) found a variation in the radiosensitivity of *Lasioderma serricorne* due to rearing on different diets. In general, differential radiosensitivity owing to diet has been reported for several species by Clark and Rubin (1961) on the new Bracon species; Watters (1968); Fadel (1980) on *Ceratitis capitata.*; Gonzalez, *et al* (1988) on *Spodoptera frugiperda;*, Kovacs, (1991); Khattab *et al.*, (2000) on *Tribolium castaneum* and Ahmed, (2001) on *Tribolium confusum.* The present results also indicated that, the decrease in the progeny production of irradiated adult was conditional on the diet, dose of irradiation, type of irradiated sex and interaction between them. The susceptibility of insects reared on wheat flour to irradiation sterilization, number of offspring was less compared to those reared on corn flour. Tuncbilek and Kansu (1996) on *T. confusum* stated that, differences between rearing media for beetles in relation to sterilization by irradiation were nevertheless generally small. Pacheco (1973), on his work on *Sitophilus oryzae* L, suggested that, the apparent density or nutrient values of food substrates decisively influence the sterilizing doses for *Sitophilus oryzae* L. Thus, the rice and maize which are apparently denser and (or) of higher nutrient value than macaroni, insects are sterilized by a dose of 7 Krad, while in macaroni the sterilizing dose decreased to 5 Krad.

SUMMARY

Studies were accomplished to select irradiation doses required to kill or to discontinue reproduction of F_1 progeny of *T. confusum* reared on wheat and corn flour. Gamma irradiation was applied at five-dose levels ranging from 100-1200 Gy for mortality studies and at four dose levels between 50- 350 Gy for sterility studies. LT_{50} and LD_{50} values were determined, together with sterilizing dose levels (SD_{50} and SD_{90}). Data indicated that, the irradiation doses, time post irradiation, type of diet and sex of insect have a considerable role in the survival and radiosensitivity of adults and their F_1 progeny production. The irradiated male or female adults reared on wheat flour was more susceptible to killing or sterilizing by gamma radiation than those reared on corn flour at almost of all irradiation doses or interval times post irradiation. Also, The irradiated male or female adults reared on wheat flour lived shorter time than those reared on corn flour at nearly of all the irradiation doses. In addition, males reared on wheat or corn flour were less sensitive to killing by irradiation than females.

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