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EFFECT OF GAMMA IRRADIATION ON THE LABORATORY STRAIN OF ORIENTAL FRUIT FLY (*DACUS DORSALIS* HENDEL) IN NITROGEN

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Tao-Hsing Chang and Wen-Yung Lee (1984) Effect of gamma irradiation on the laboratory strain of oriental fruit fly (*Dacus dorsalis* Hendel) in nitrogen *Bull. Inst. Zool., Academia Sinica* 23(1): 193-197. The mature pupae (1-2 days before emergence) of the oriental fruit flies, *Dacus dorsalis* (Hendel) were irradiated by gamma with dose of 15, 17, 19, 21 krad in nitrogen and 13 krad in air. Both the percentage of emergence and sterility of these treatments were shown no significant difference. The percent mortality of 21 krad irradiated in nitrogen was shown significant difference with other treatments, but the difference was very small. In the laboratory tests, the mature pupae irradiated with the dose of 15 krad in nitrogen had the highest competitiveness value (0.97). They were significantly higher than those with irradiated to 13 krad in air (0.26).

The gamma irradiation in air was found by several investigators to reduce competitiveness of some tephritids (Ashraf, 1975; Economopoulos, 1972; Haisch, 1970; Hooper *et al.*, 1971; Hooper, 1971). For the sterilized insects, we need not only their sterility but also their vigor and sexual competitiveness. Proverbs (1969) suggested some possible methods of retaining the vigor of irradiated insects: (a) using chemicals to modify radiation damage to somatic cells, (b) using radiations of higher linear energy, (c) restricting the radiation to the section of the body containing the germ cells, (d) dose fractionation, (e) reducing the dose to the minimum level required to kill 100 percent of the gonial cells, (f) irradiating as late as possible in the life cycle. (a) and (f) were the most practical ways. Earle *et al.* (1979) reported a lowered oxygen tension (hypoxia or anoxia) during irradiation had been shown to reduce the damage to somatic tissue as well as to germ cells. LaChance *et al.* (1974) and Ohinata *et al.* (1977) reporting of enhanced competitiveness of sterile males in the laboratory after the treatment under conditions of hypoxia would seem to indicate that in certain species somatic cells may be protected more than germ cells. Ashraf *et al.* (1975), Hooper (1971), and LaChance *et al.* (1974) reported some tephritids appeared to be less genetic damaged (had greater vigor) when they were irradiated in a nitrogen atmosphere. Fletcher *et al.* (1976) tested the dispersal of artificially reared *Dacus oleae*, sterilized as pupae by 11 krad of Co-60 *r*-rays in nitrogen atmosphere were found no effect on the dispersing behavior in the field. Our test was, therefore, designed to explore the dose-sterility relationship in nitrogen of mature papae and to compare the sexual competitiveness of males treated as mature pupae with dose of 15, 17, 19, 21 krad in nitrogen and 13 krad in air.

MATERIALS AND METHODS

The mature pupae (1-2 days before emergence) of the oriental fruit fly were obtained from the mass-rearing section of Kuan-Hsi laboratory, where larvae were reared on the diet (yeast 140 g, sugar 240 g, wheat germ 480 g, sodium benzoate 4-5 g, concentrated Hydrochloric acid 15-20 ml, and H_2O 1.8 L). Pupae and test adults were maintained at the room temperature 25±2°C and 70±10% RH.

Irradiation was carried out in a pool-type Cobalt-60 irradiator of Radioisotope Laboratory Industrial Technology Institute, at a dose rate 1.07×10^5 rad/hr. Each dose treatment contained ca. 3000 mature pupae in a 500 ml glass vial with a rubber stopper that held inlet and outlet tubes through which high purity nitrogen were flushing thoroughly for 5 minutes, then clamped tightly the tubing at each end during the irradiation process. The mature pupae were irradiated with dose of 13, 15, 17, 19 and 21 krad, respectively, untreated mature pupae were as control of these tests. Adults were sexed within 24 hrs. after emergence in the room temperature at ca. 6°C. Food (a 4:1 mixture of sugar and yeast extract) and water were offered to the flies on the top of the cage. The percent emergence of both the irradiated and normal pupae were determined by picking 30 pupae randomly from each treatment. It was checked 3 days after the expected emergence date. All treatments were replicated 3 times. The percent mortality of both the irradiated and normal males were determined by picking 100 males randomly from each treatment to a 30-cm^3 screen cage. It was checked after 4 weeks. To determine the level of sterility of males, 30 irradiated (I) ♂♂ and 30 normal (N) ♀♀ were placed in a 25-cm^3 screen cage. The eggs were collected twice a week for 4 weeks. Eggs from each replication in each collection were placed on a moist blotting paper in a petri dish. A plastic egging device was inserted into the cage to collect eggs in the afternoon of given days. A piece of guava was placed inside the egging device. The percent hatch was scored after 3 days. For evaluating sexual competitiveness, 90 irradiated (I) ♂♂, 30 normal (N) ♂♂ and 30 normal (N) ♀♀ were placed in a 30-cm^3 screen cage one day after emergence. The number of eggs laid and the percent hatch were determined twice a week for 4 weeks. Each treatment was replicated 3 times. The competitiveness values for the irradiated males were calculated according to Fried (1971).

Fried's method $C=\frac{Hn-Hc}{Hc-Hs}\times\frac{N}{S}$

Hn—is % egg hatch from matings of N ♂♂×N ♀♀

Hs—is % egg hatch from matings of I ♂♂×N ♀♀

Hc—is % egg hatch from the combination of I ♂♂ and N ♂♂

N—represents the number of normal males

S—represents the number of irradiated males

RESULTS

Table 1 presents the effects of gamma irradiation on emergence and longevity. There were no significant difference among treatments in adult percent emergence. Although the data on percent emergence suggested that 15 krad in nitrogen had the highest percent emergence, 21 krad in nitrogen had the lowest percent emergence, statistical analysis indicated no difference among treatments. The data on percent mortality suggested that 15 krad in nitrogen had the lowest percent mortality, 21 krad in nitrogen had the highest percent mortality. Although statistical analysis indicated significant difference among treatments, the difference was very small.

Table 2 shows that males irradiated as mature pupae in air with 13 krad were 100% sterile, the dose of 15, 17, 19, and 21 krad in nitrogen were 99.83%, 99.87%, 99.92%, 99.96% sterile, respectively. The oreintal fruit flies irradiated as the mature pupae in nitrogen 15, 17, 19 and 21 krad were 3.73, 2.43, 1.69,

TABLE 1
The percent emergence and mortality of the oriental fruit flies irradiated in air or in nitrogen as mature pupae 1-2 days before adult emergence

Treatment		% emergence[a] Mean±S. D.	% mortality[a] of males Mean±S. D.
Dosage (krad)	Atmosphere		
0 (Control)	air	72.2± 5.1[a]	43.3±2.5[a]
13	air	67.8± 8.4[a]	44.7±2.5[a]
15	nitrogen	77.8±16.5[a]	42.0±2.0[a]
17	nitrogen	75.6±13.9[a]	44.7±1.5[a]
19	nitrogen	71.1± 7.0[a]	42.7±2.5[a]
21	nitrogen	66.6± 5.8[a]	49.3±3.1[b]

a: Average of 3 replicates. Means followed by the same letter are not significantly different, at the 5% level of probability.

TABLE 2
Sexual competitiveness of the oriental fruit fly males irradiated in air or nitrogen as mature pupae 1-2 days before adult emergence[a]

Dose (krad)	Atmosphere	Sterility test	Competition test	
		% egg hatch Mean±S. D.[c]	% egg hatch of ratio 90I ♂♂ : 30N ♂♂ : 30N ♀♀[b] Mean±S. D.[c]	Competitiveness value[d]
0 (Control)	air	88.3±7.1[ae]		
13	air	0[bf]	49.8±13.5[a]	0.26
15	nitrogen	0.17[bf]	22.7± 8.9[d]	0.97
17	nitrogen	0.13[bf]	33.2± 9.8[c]	0.56
19	nitrogen	0.08[bf]	37.9±12.8[bc]	0.44
21	nitrogen	0.04[bf]	42.9±10.9[ab]	0.35

a: 4 weeks test.
b: I=irradiated N=normal
c: Average of 3 replicates. Means followed by the same letter are not significantly different at the 5% level of probability.
d: Calculated according to Fried (1971).
e: 30N ♂♂×30N ♀♀
f: 30I ♂♂×30N ♀♀

and 1.35 times respectively as the mature pupae irradiated in air with 13 krad in competitiveness value. Males irradiated in nitrogen at 1-2 days before emergence with 15 krad were fully competitive with normal males. We can draw a conclusion that the degree of sexual competitiveness of the male oriental fruit flies irradiated as mature pupae in nitrogen is inversely proportional to the gamma dose they received. It is in harmony with Hooper (1971) reported in the Mediterranean fruit fly.

DISCUSSION

Iwahashi *et al.* (1983) pointed out the most essential prerequisite for successful application of the sterile insect release method to eradicate or control an insect pest were that mass-rearing sterilization had the least adverse effects on the behavior of release males. Ashraf *et al.* (1975) pointed out irradiation of the pupae in nitrogen might be preferred in a sterile-release program, because it would minimize problems of handling large numbers

of insects and would avoid subsequent recovery of fertility of released flies. Hooper *et al.* (1971) reported the egg hatch reflected the total interaction within a specified spatial situation of such factors as mating ability, sperm complement and sperm competitiveness. However, it should be pointed out that some factors, e. g. pheromones, flight vigor, might not be operative in small cages. Earle *et al.* (1979) reported even under ideal conditions, laboratory studies were often difficult to simulate the situation in the field. Obviously, laboratory competitiveness studies do not measure all attributes of males that contribute to their sexual performance in the field. Until we are aware of all factors affecting male behavior and can devise ways to measure them in the laboratory, we must rely on field tests to give us a meaningful estimate of the overall sexual performance of sterile males. Economopoulos (1977) reported if we wanted the lab-reared *r*-ray sterilized flies to survive longer and perform well sexually, the best sterilization technique so far was irradiation in nitrogen. Of course, it is difficult to predict how well these insects are going to perform in nature. In the SIT (sterile insect technique) program, one of the most important problem to be solved is to increase the sexual competitiveness of the release sterile fruit flies. To improve the quality of the mass-rearing insect is very important. The another most possible way to increase the sexual competitiveness of the release sterile fruit flies will be the irradiation on mature pupae in the atmosphere of nitrogen. Although our results in the laboratory tests gave a highest sexual competitiveness of 15 krad gamma irradiation on oriental fruit fly in nitrogen, for the field applicability further evaluation of 15 krad in nitrogen as the sterilizing dose for male oriental fruit fly in small field environments is both warranted and desirable.

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在氮氣中經伽瑪射線照射對東方果實蠅之影響

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東方果實蠅羽化前 1～2 天之老熟蛹在氮氣中經過 15 krad，17 krad，19 krad，21 krad 和在空氣中經過 13 krad 之照射處理，在羽化率和不孕率方面的結果，均呈現不顯着差異。在死亡率方面，雖然在氮氣中經過 21 krad 照射處理者，和其他處理之間呈現出顯着差異，然而這種差異非常小。在室內實驗結果顯示，在氮氣中經過 15 krad 照射處理者有最高的性競爭值 (0.97)，遠超過在空氣中經過 13 krad 照射處理者 (0.26)。