Effects of Different Doses of Gamma Rays on The Dispersal and Flight Ability Index of Mediterranean Fruit Fly Ceratitis Capitata (Wiedmann) (Diptera: Tephritidae)

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Abstract

This investigation concentrated on studying the effect of gamma rays on the flight ability index and on the dispersal of irradiated males because these two parameters were very important for applying the sterile male release technique. The results of this study showed that the flight ability index of irradiated males as pupae of 3, 4 and 5 days with doses ranged from 60 to 120 Gy were highly significant p≤0.05 compared with control treatment during an experiment carried out under field conditions. The results showed that there were a reverse relationship between flight ability index and gamma rays doses. Furthermore, the results of this investigation also showed that there were a reverse relationship between the mean average of males captured by the pheromone traps and gamma rays doses after 1,2,3, and 4 days from the release.

Keywords : Ceratitis capitata, Gamma rays, Flight ability, Irradiated males.

1. Introduction

Insects are an important element in maintaining the natural balance of the environment, although some of them threaten food security, especially agricultural crops, including the Mediterranean fruit fly Ceratitis capitata, which is considered a dangerous pest for many kinds of fruit trees. This pest is completing its life cycle, especially the larvae, which are obligate parasitoids inside the fruit and thus cause serious losses in orchards [1].

As a result of the rapid spread of this pest in Iraq, it has become a threat to the fruits of these crops, which contribute effectively to the “filling” of a large part of the food needs of the Iraqi people and the futility of using chemical pesticides to reduce their damage, as well as the ability of these pesticides to contaminate the ecosystem, which may have negative effects on human and animal life and the emergence of resistance to the action of these pesticides [2]. This led to the search for safer alternative methods “in health and less harmful ” on the ecosystem one of these is the sterile insect release technique. This technique proved to be a "great success" in the eradication of the spiral worm fly to the new world Cochliomyia hominivorax from Koraku Island [3]. Many successes have followed in the eradication of many pests around the world [4]. As the flight is an important factor in the success of the control process through the release of sterile insects and their competition for wild insects [5].

The current study aims to study the effect gamma rays on flight ability index of irradiated males and to study of the spread of males emerging from 5 days old pupae.

2. Materials and Methods

2.1 Rearing of Mediterranean fruit fly Ceratitis capitata

The infested citrus fruits with the Mediterranean fruit fly, Ceratis capitata were collected from orchards in September 2015. The fruits were placed in organic glass cages (30 cm in height, 30 cm in diameter). The cages were transferred to the growth chamber under temperature 27 ±2 °c, relative humidity 60 ± 10 % and light period 8:16 ( L: D). Then the pupae were collected into sterile glass bottles (14 cm in height, 9 cm diameter) covered with an organza fabric fastened with a rubber
band and supplied with a quantity of dry sugar, then placed in incubators in the same conditions of the growth chamber. The adult insect was identified according to the diagnostic key [6].

2.2 Describe the growth chamber and the source of radiation

The growth chamber of the Center for Integrated Control (IMC)/Agricultural Research Service/Iraqi Ministry of Science and Technology (7 m long, 4 m wide, 3 m high), with a temperature controlled air-conditioning and ventilation unit with light bulbs (fluorescent), was used with the timer model T102 American-origin for lamp-time control. The growth chamber has container vessels on the water to obtain the desired relative humidity and for this purpose use the hygrometer to control the desired relative humidity rate [7]. The gamma cell 220 (atomic energy of Canada Ltd) was used in irradiation of the Mediterranean fruit fly, *C. capitata* with radiation dose according to [8]. The radioactive is Cobalt at the Department of Physics, Faculty of Science, Baghdad University.

2.3 Preparation of the Mediterranean fruit fly colony

The two-dimensional cages (40×40 cm$^2$) made of organic glass were used open from above and each side was covered with Saran fabric, had a side door for dealing with insects, and to feed adult insects, cages were supplied with bread yeast as a protein source for females and to improve male activity [9]. A diabetic solution 5% was also added [10]. Both water and food were to be used every day. Healthy oranges fruits were used as a natural medium to place eggs after washing them with water many times, then adults were transferred to the growth room, leaving at least after the third generation where the affected fruits samples were collected daily for use in the different experiments of this study [11].

2.4 The effect of radiation on flight ability

Emergence males were isolated in glass bottles after being treated by radiation in pupae stage at 3-5 days and by radiological doses (60, 80, 100 and 120) Gy. The experiment was conducted using an open-ended cylinder (14 cm in a height, 4 cm in a diameter) made from the X-ray paper, it was covered from the outside with black paper to prevent light. A talc powder was put inside of the cylinder to prevent the insect from standing and walking on the inner surface and placed vertically on the bottom of the Petri dish [12]. 100 pupae aged 5 days were treated for each radiation dose (60, 80, 100 and 120) Gy and transferred to the incubator until the adult emergence. One day old insects were placed in the refrigerator at 4-8 °C for 4 minutes to control insects when placed in a petri dish. Insects started flight attempts when they regain their activity. The cylinder was covered after 30 minutes and the insects that could not get out of it was locked out [13].

The equation shown below was used to calculate the index of the ability of adults to fly (F.A.I (Flight Ability Index)) [14].

\[
F.A.I = \frac{\text{fully emerged} - (\text{Residual flies} + \text{deformed flies})}{\text{(fully emerged)}} \times 100
\]

The developed adults from pupae were in the following forms:
- Fully emerged adults, including deformed adults and adults unable to fly (residual flies).
- Partial emerged adults.
- Undeveloped pupae into adults.

2.5 The releasing of males in the field and type of traps

The study was conducted in the citrus orchards of Wasit province during the spring season in 2016 with four separate sites spaced between each other. The irradiated males were dyed with a red fluorescent dye in the pupa stage by the contamination of the pupae with the dye was prior to the emergence. Non-treated males were dyed with blue color to distinguish released insects and wild insects at the time of screening. The releasing site was identified, traps were set at several distances from the releasing center and at different locations, with 2 traps per distance, as shown in figure (1). The Delta-traps were used in white color with adhesive to touch the target flies with a plastic basket to carry the Trimedlure, which is specialized in attracting males to the *Ceratitis capitata*.

2.6 Statistical analysis

Split plot design with RCBD used with L.S.D test to ascertain the significance of differences between different treatments averages and probability level at 5% by SPSS program.
3. Results and Discussion

3.1 The effect of gamma rays in the index of flight ability under field conditions

The results shown in table (1) that the index of flight capability of irradiated males of Mediterranean fruit fly decreased with increasing radiation dose for all tested ages, with high significant differences observed for the three-day male flight ability index and for all tested radiological doses. There were also significant differences in the index of flight among irradiated males of four days but to a lesser extent than the above at 100.00, 90.35, 78.75, 64.25 and 60.50 at the age of three days, while 95.5, 90.45, 81.15, 76.5 and 76.00 at the age four days at the doses of 0, 60, 80, 100 and 120 Gy, respectively. Whereas, there were not significant differences of irradiated males in the five-day period of pupae treatment, 94.5, 93.65, 86.05, 82.00 and 80.25 for the same doses, respectively.

Thus, it can be concluded that there is an adverse relationship between the flight ability index (F.A.I) with the increased radiation dose, as well as that there were no significant differences in the F.A.I for wild males and irradiated males treated at different doses at the age of pupae for 5 days. These results can be used when planning to use the sterile male technique to control this pest, especially if we know that flight ability is an important factor for the success of the control operation by releasing sterile insects and its competition for wild insects. The results are consistent with what he emphasized [15], stating that the F.A.I is inversely proportional to the increased radiation doses, which encourages the recommendation that the pupae be treated at this age for subsequent tests, especially for the release and diffusion experiments.

Table 1. The effect of Gamma rays on the flight ability index of the Mediterranean fruit fly male at field conditions.

| Index of flight ability | Age of treated pupae (day) |
|-------------------------|----------------------------|
| Radiation doses (Gy)    | 3  | 4  | 5  |
| 0                       | 100.00 | 95.5 | 94.5 |
| 60                      | 90.35 | 90.45 | 93.65 |
| 80                      | 78.75 | 81.15 | 86.05 |
| 100                     | 64.25 | 76.5  | 82.00 |
| 120                     | 60.5  | 76.00 | 80.25 |
| LSD                     | 3.18  | 6.14  | 3.20 |

3.2 The effect of gamma radiation on the spread of the C. capitata males

The tables (2, 3, 4, 5) show that irradiated males (treated pupae) at five days with radiation doses of 60, 80, 100 and 120 Gy, which is released in the field, were less spread by increasing radiation doses with high significant differences. These tables show that the percentage of males caught is inversely proportional to the increase in doses, as well as the increased distance between the catch and the launch center. The percentage of caught males at one day after release (30, 29, 26, 14 and 7) % at doses 0, 60, 80, 100 and 120 Gy for all distances, respectively. While, it at two days after release 45, 43, 30, 20 and 13% at the tested doses respectively, there was not significant difference at doses 0 and 60 Gy, whereas, the high-significant difference at doses was 80, 100 and 120 Gy. Table (4) shows that the percentage of males caught after 4 days and for all distances was 21, 14, 35, 30% and 20% of the same doses registered high significant variations at all doses with an increase in the percentage of males caught at doses of 80 and 100 Gy, as a positive indication.
Radiation can have an impact on male behavior, which has increased the competition between sterile males and wild males for normal females mating, thus increasing the chances of successful control and eradication of this pest, this was observed in table (5), with the final percentage of males caught in pheromone traps installed at different distances and different directions at four days after release as 100, 100, 100, 84 and 68%. Thus, it can be concluded that a dose of 100 Gy can be used on a five-day pupa that may take place as a complete treatment for males when a successful control program for this lesion is carried out using sterile male technique. These results are consistent with what they found [16], that the release of the spiral worm fly male after treating the pupae at 45 and 75 Gy doses and after 8 days the number of insects caught in the 25 meters was more than the insects caught in the setting traps at 300 meters, whereas the distances were 525, 650 and 900 m. No insect was caught, while the five-day-old treated insects with a dose of 90 Gy reached a distance of 900 meters. These results also correspond to what they found [17-19], who results were interpreted on the grounds that radiation affects the precise structure of mitochondrial of flight muscles and decreases the rate of phosphorus oxidation, meaning that radiation may affect the enzyme (αGDH).

**Table 2.** The effect of the Gamma radiation on the percentage of males caught in the *C. capitata* in the traps at different distances by one day after releasing.

| Distance (m) | Dose (Gy) | 0 | 60 | 80 | 100 | 120 |
|-------------|-----------|---|----|----|-----|-----|
| 50          |           | 9 | 13 | 9  | 5   | 2   |
| 100         |           | 11| 7  | 7  | 4   | 2   |
| 150         |           | 9 | 5  | 7  | 4   | 1   |
| 200         |           | 1 | 4  | 2  | 1   | 2   |
| 300         |           | 0 | 0  | 1  | 0   | 0   |
| 400         |           | 0 | 0  | 0  | 0   | 0   |

0.65 LSD for doses at the same distance
0.60 LSD for distances at the same doses
1.33 LSD for interference between doses and distances

**Table 3.** The effect of gamma radiation on the percentage of caught males by the *C. capitata* with attractive traps set at different distances by two days after releasing.

| Distance (m) | Dose (Gy) | 0 | 60 | 80 | 100 | 120 |
|-------------|-----------|---|----|----|-----|-----|
| 50          |           | 12| 7  | 10 | 4   | 2   |
| 100         |           | 16| 14 | 8  | 4   | 4   |
| 150         |           | 13| 7  | 7  | 3   | 4   |
| 200         |           | 3 | 8  | 1  | 5   | 1   |
| 300         |           | 1 | 7  | 3  | 3   | 2   |
| 400         |           | 0 | 0  | 1  | 1   | 0   |

0.80 LSD for doses at the same distance
0.85 LSD for distances at the same doses
1.75 LSD for interference between doses and distances

**Table 4.** The effect of gamma radiation on the percentage of caught males by *C. capitata* fly with attractive traps set at different distances by three days after releasing.

| Distance (m) | Dose (Gy) | 0 | 60 | 80 | 100 | 120 |
|-------------|-----------|---|----|----|-----|-----|
| 50          |           | 5 | 6  | 10 | 7   | 0   |
| 100         |           | 5 | 4  | 9  | 13  | 6   |
| 150         |           | 5 | 3  | 8  | 5   | 7   |
| 200         |           | 3 | 1  | 5  | 4   | 4   |
| 300         |           | 1 | 0  | 1  | 1   | 2   |
| 400         |           | 2 | 0  | 2  | 0   | 1   |

1.00 LSD for doses at the same distance
1.08 LSD for distances at the same doses
2.55 LSD for interference between doses and distances
Table 5. The effect of gamma radiation on the percentage of caught males of *C. capitata* with attractive traps set at different distances by four days after releasing.

| Distance (m) | Dose (grey) | 0 | 60 | 80 | 100 | 120 |
|-------------|-------------|---|----|----|-----|-----|
| 50          | 0           | 0 | 0  | 0  | 0   | 0   |
| 100         | 0           | 0 | 0  | 0  | 8   | 8   |
| 150         | 0           | 4 | 3  | 7  | 9   |     |
| 200         | 2           | 5 | 3  | 1  | 4   |     |
| 300         | 1           | 4 | 0  | 3  | 4   |     |
| 400         | 1           | 3 | 0  | 1  | 3   |     |

1.43 LSD for doses at the same distance

1.7 LSD for distances at the same doses

2.85 LSD for interference between doses and distances

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