

SUSCEPTIBILITY OF THE PUPAL STAGE OF Plodia interpunctella  
TO GAMMA IRRADIATION AS AFFECTED BY RADIATION  
DOSE, AGE, SEX AND TEMPERATURE

M.Y.Y. Ahmed, M.A.R. Daoud<sup>\*</sup>, E.S. EL-Hawary<sup>\*\*</sup>  
and S.A. Boshra

Radiobiology Department, Nuclear Research Center,  
Atomic Energy Authority, Cairo, Egypt.

-----  
ABSTRACT

When 1-d-old male pupae of the Indian meal moth, Plodia interpunctella were irradiated at 0, 5 and 9 krad and kept at 25°C, percent male emergence was 84.0, 53.3 and 24.0%, respectively, while it was 82.7, 44.0 and 10.7% at 30°C, respectively. When female pupae were irradiated at 0, 5 and 7 krad and kept at 25°C the percent emergence was 86.0, 45.3 and 28.0% at 25°C, respectively, while it was 80.7, 34.0 and 14.7% at 30°C.

Fully grown pupae were more resistant to gamma irradiation than 1-d-old pupae. Male pupae were more resistant than females. Pupal irradiation caused a significant reduction in fecundity of the resulting females. Fecundity of irradiated females paired with unirradiated males was significantly reduced than that of unirradiated females mated with irradiated males.

One-day-old females mated with males irradiated in the pupal stage, the percentage fertility was decreased progressively as the dose was increased at all temperatures used.

---

<sup>\*</sup> Plant Protection Dept., Faculty of Agric., Ain Shams Univ.,  
Cairo, Egypt.

<sup>\*\*</sup> Faculty of Agric., Tanta University, Egypt.

The sterilizing dose for females was 6 krad, while it was 9 krad for males at all temperatures used. Fully grown pupae irradiated at 40 krad produced sterile females at 25°C. While male pupae needed 60 krad to produce the same effect.

## INTRODUCTION

If gamma radiation is to be used as a means of controlling insects in grain and other stored commodities the dose must be sufficient to kill within a predetermined time period all species present at the time of treatment. Therefore, the comparative radiation sensitivity of all species and developmental stages commonly found infesting these products must be determined. This paper describes the effect of gamma radiation on the pupal stage of P. interpunctella as affected by dose, age, sex and temperature.

## MATERIALS AND METHODS

All test insects were obtained from laboratory stock cultures maintained at  $25 \pm 1^\circ\text{C}$  and  $65 \pm 5\%$  R.H. Insects were reared in 3.8 L. jars half filled with rearing media as described by Silhacck and Miller (1972). Throughout the experiments, the cultures were maintained at the above mentioned conditions.

Groups of 100 larvae from each sex were placed in glass jars, half filled with the rearing media. When larvae reached maturation, corrugated cardboards were placed in the jars as a pupation sites. This cardboards were removed daily and incubated to obtain the pupal stage at different ages for irradiation. Pupae were irradiated either early (1-d-old) or late

(6-d-old). One-day old pupae were irradiated at doses ranging from 1 to 12 krad, while fully grown pupae were exposed to doses ranging from 5 to 100 krad. Post irradiation, pupae were kept at 25 or 30°C  $\pm$  5% R.H. Samples of 25 pupae were taken for each treatment and replicated 3 times.

Pupae were allowed to develop into adults and percentage adult emergence was determined. The effect of pupal irradiation on fecundity, fertility and longevity of the emerging adults were also investigated. The following mating combinations were made:

- 1- 5 irradiated (I) males X 5 unirradiated (U) females.
- 2- 5 U males X 5 I females
- 3- 5 I males X 5 I females
- 4- 5 U males X 5 U females

Five pairs of moths were confined in inverted 0.95 L. jar with screen tops and allowed to mate and oviposit. Six jars were used for each irradiation dose as three were kept under one of each temperature used (25 or 30°C). Eggs were collected in open petri-dishes and samples of 100 eggs from each treatment were placed on black construction paper in petri-dishes surrounded by rearing medium, that served as food for the hatched larvae. Eggs were examined daily to determine percent hatch. The experiment was replicated 3 times.

## RESULTS

The percentage of adult emergence was positively correlated with the age of irradiated pupae, but negatively correlated with the irradiation dose.

Table (1) shows that when 1-d-old male pupae were irradiated at 0, 5 and 9 krad and kept at 25°C the percent male emergence was 84.0, 53.3 and 24.0%, respectively, while it was 82.7, 44.0 and 10.7%, at 30°C, respectively. When female pupae were irradiated at 0, 5 and 7 krad and kept at 25°C the percent emergence was 86.0, 45.3 and 28.0% at 25°C, respectively, while it was 80.7, 34.0 and 14.7% at 30°C.

Table (1): Effect of gamma irradiation on percent adult emergence of P. interpunctella irradiated as 1-d-old pupae and reared under different temperatures.

| Dose<br>(krad) | Adult emergence % |        |      |        |
|----------------|-------------------|--------|------|--------|
|                | 25°C              |        | 30°C |        |
|                | Male              | Female | Male | Female |
| 0              | 84.0              | 86.0   | 82.7 | 80.7   |
| 1              | 78.7              | 81.3   | 77.3 | 76.0   |
| 3              | 66.7              | 61.3   | 62.7 | 50.7   |
| 5              | 53.3              | 45.3   | 44.0 | 34.0   |
| 7              | 38.7              | 28.0   | 29.3 | 14.7   |
| 9              | 24.0              | 11.1   | 10.7 | 0.0    |
| 10             | 16.0              | 0.0    | 0.0  | 0.0    |
| 12             | 0.0               | 0.0    | 0.0  | 0.0    |

Fully grown pupae were more resistant to gamma irradiation than 1-d-old pupae. Male pupae were more radioresistant than females.

Table (2) shows that fully grown pupal irradiation caused a significant reduction in fecundity of the resulting females.

Oviposition potential of irradiated females paired with unirradiated males was significantly reduced than that of unirradiated females mated with irradiated males.

Table (2): Effect of gamma irradiation on P. interpunctella fecundity irradiated as fully grown pupae and reared under different temperatures.

| Dose<br>(krad) | Average number of eggs/female |             |
|----------------|-------------------------------|-------------|
|                | 25°C                          | 30°C        |
|                | <u>I♂ x U♀</u>                |             |
| 0              | 72.1 ± 5.11                   | 63.8 ± 4.40 |
| 5              | 53.2 ± 23.00                  | 44.6 ± 4.50 |
| 15             | 49.0 ± 2.00                   | 38.4 ± 1.81 |
| 25             | 41.0 ± 1.53                   | 31.2 ± 1.66 |
| 35             | 36.0 ± 1.44                   | 25.1 ± 1.18 |
| 45             | 27.4 ± 1.14                   | 20.0 ± 0.83 |
| 55             | 20.0 ± 0.81                   | 10.0 ± 0.42 |
| 60             | 13.0 ± 0.60                   | 0.0         |
|                | <u>U♂ x I♀</u>                |             |
| 0              | 68.2 ± 4.05                   | 60.0 ± 4.27 |
| 5              | 46.0 ± 2.21                   | 40.0 ± 2.21 |
| 15             | 35.3 ± 1.38                   | 31.2 ± 1.17 |
| 25             | 26.0 ± 1.10                   | 17.0 ± 1.33 |
| 35             | 19.0 ± 0.64                   | 12.0 ± 0.92 |
| 40             | 14.0 ± 0.60                   | 7.6 ± 0.66  |
| 45             | 9.2 ± 0.58                    | 0.0         |
|                | <u>I♂ x I♀</u>                |             |
| 0              | 72.0 ± 5.09                   | 60.2 ± 5.14 |
| 5              | 41.8 ± 2.14                   | 38.0 ± 2.25 |
| 15             | 30.0 ± 1.55                   | 25.0 ± 1.53 |
| 25             | 21.0 ± 0.72                   | 12.0 ± 0.99 |
| 30             | 14.6 ± 0.50                   | 7.8 ± 0.76  |

When (U) 1-d-old females mated with males irradiated (I) in the pupal stage, the percentage fertility was decreased progressively as the dose was increased at all temperatures used. The same trend was noticed with the other mating

combinations, Table (3). The sterilizing dose for females was 6 krad, while it was 9 krad for males at all temperatures used. Fully grown pupae irradiated at 40 krad produced sterile females at 25°C. While male pupae needed 60 krad to produce the same effect (Table 4).

Table (3): Effect of gamma irradiation on P. interpunctella fertility irradiated as 1-d-old pupae and reared under different temperatures.

| Dose<br>(krad) | % Hatchability |  |
|----------------|----------------|--|
|                | 25°C           | 30°C   |
|                |                | <u><math>I\sigma^{\uparrow} \times U\varnothing</math></u> |
| 0              | 86.0           | 74.0   |
| 1              | 46.0           | 37.0   |
| 3              | 33.0           | 23.1   |
| 5              | 25.7           | 16.1   |
| 7              | 15.0           | 8.0  |
| 9              | 0.0            | 0.0  |
|                |                | <u><math>U\sigma^{\uparrow} \times I\varnothing</math></u> |
| 0              | 85.0           | 75.3   |
| 1              | 32.7           | 26.3   |
| 3              | 23.1           | 15.8   |
| 5              | 10.8           | 3.7  |
| 6              | 0.0            | 0.0  |
|                |                | <u><math>I\sigma^{\uparrow} \times I\varnothing</math></u> |
| 0              | 85.0           | 75.3   |
| 1              | 28.0           | 21.1   |
| 3              | 16.0           | 11.3   |
| 5              | 0.0            | 0.0  |

The present data showed that fully grown pupal irradiation decreased longevities of the resulting adults and this effects was positively correlated with the dose (Table 5).

Table (4): Effect of gamma irradiation on P. interpunctella fertility irradiated as fully grown pupae and reared under different temperatures.

| Dose<br>(krad) | % Hatchability                                      |      |
|----------------|---|------|
|                | 25°C  | 30°C |
|                | <u><math>I\sigma^{\uparrow} \times U\phi</math></u> |      |
| 0              | 86.0  | 76.7 |
| 5              | 68.7  | 61.0 |
| 15             | 58.7  | 50.0 |
| 25             | 45.0  | 40.0 |
| 35             | 35.0  | 27.3 |
| 45             | 20.3  | 14.9 |
| 55             | 9.3   | 0.0  |
| 60             | 0.0   | 0.0  |
|                | <u><math>U\sigma^{\uparrow} \times I\phi</math></u> |      |
| 0              | 87.7  | 77.0 |
| 5              | 50.0  | 44.0 |
| 15             | 34.0  | 29.0 |
| 25             | 19.6  | 12.0 |
| 35             | 7.5   | 0.0  |
| 40             | 0.0   | 0.0  |
|                | <u><math>I\sigma^{\uparrow} \times I\phi</math></u> |      |
| 0              | 87.7  | 77.0 |
| 5              | 38.3  | 33.0 |
| 15             | 24.5  | 21.0 |
| 25             | 10.8  | 4.8  |
| 30             | 0.0   | 0.0  |

Table (5): Effect of gamma irradiation on P. interpunctella longevity irradiated as fully grown pupae and reared under different temperatures.

| Dose<br>(krad) | Longevity (days) |        |      |        |
|----------------|------------------|--------|------|--------|
|                | 25°C             |        | 30°C |        |
|                | Male             | Female | Male | Female |
| 0              | 6.2              | 5.7    | 5.2  | 4.8    |
| 5              | 5.6              | 5.3    | 5.0  | 4.7    |
| 15             | 5.3              | 4.7    | 4.9  | 4.1    |
| 25             | 4.9              | 4.4    | 4.6  | 3.6    |
| 35             | 4.1              | 3.8    | 3.9  | 3.3    |
| 40             | 3.7              | 3.9    | 3.5  | 2.6    |
| 45             | 3.3              | 3.4    | 3.1  | ---    |
| 55             | 2.8              | ---    | 2.7  | ---    |
| 65             | 2.5              | ---    | ---  | ---    |

## DISCUSSION

A renewed interest recently happened for the application of physical methods to control insect pests. The promising method with many advantages over conventional methods of control is the application of gamma radiation. One of the major prerequisites for using this method, however, is determination of the minimum effective dosage of radiation required for control.

Pupal irradiation decreased percentage of adult emergence and this reduction depends on the dose. This is in agreement with the findings of Hassaballa et al., (1985) on pupae of Corcyra cephalonica and Johnson (1987) on Carpophilus hemipterus.

A pronounced reduction in adult emergence was observed in the irradiated pupae kept under higher temperatures more than 25°C. These results agreed with those obtained by Amin et al., (1982) on Ceratitis capitata and Teruyo (1984) on pupae of Dacus cucurbitae.

The present study showed that the females of P. interpunctella were more radiosensitive to the effect of gamma radiation than the males. The present results agreed with those of Hassaballa et al., (1987) on Cylas femicarius pupae.

Longevities of the adults emerged from irradiated pupae were negatively correlated with the temperature on which pupae were incubated post irradiation. These results agreed with those of Bhatia and Kaul(1966) on Dysdercus koengii and Dawes et al., (1987) on Cylas formicarius.

Our studies showed that adult fecundity was decreased when female irradiated as pupae and mated with normal male. When both adults were irradiated and mated together, fecundity was decreased more than the previous mating. These results are in agreement with those of EL-Gendy, (1979) on Plodia interpunctella and Hassaballa (1984) on Epehestia cautella.

It is found that the number of eggs per female were decreased when pupae were kept at higher than 25°C post irradiation. This finding agrees with those of Bhatia and Kaul (1966) on Dysdercus koenigii and Daniels (1967) on Schizaphis graminus.

#### REFERENCES

- Amin, A.H., A.M. Wakid, A. Shoukry and A.M. Fadel (1982). Factors influencing sterility of Ceratitidis capitata. Isotope & Rad. Res., 2: 137-145.
- Bhatia, S.K. and H.N. Kaul (1966). Effect of temperature on the development and oviposition of red cotton bug, Dysdercus koenigii and application of Prodhon's equation relating temperature to the development. Indian J. Entomol., 28, Pt., pp. 45-54.
- Daniels, N.A. (1967). The effects of high temperature on green bug, Schizaphis graminum reproduction. J. Kans. Entomol. Soc., 40: 133-7.
- Dawes, M.A., R.S. Saini, M.A. Mullen, J.H. Brower and P.A. Loreton (1987). Sensitivity of sweet potato weevil to gamma radiation. J. Econ. Entomol., 80: 142-6.
- EL-Gendy, A.M. (1979). The effect of gamma radiation on the biology of the Indian meal moth, Plodia interpunctella. M.Sc. Thesis, Faculty of Science, Cairo University.

- Hassaballa, Z.A. (1984).  
     Studies on the effects of gamma irradiation on Ephestia cautella (Walker).  
     Ph.D. Thesis, Fac. Agric., Ain Shams University.
- Hassaballa, Z.A., M.Y.Y. Ahmed and M.A. R. Mostafa (1985).  
     Effect of gamma radiation on the immature stages of Gorcyra cephalonica.  
     J. Agric. Sci., 16: 291-8.
- Johnson, J.A. (1987).  
     Sensitivity of larvae, pupae and adults of the dried fruit beetle to gamma radiation.  
     J. Econ. Entomol., 80: 1302-5.
- Silhacek, D.I. and G.L. Miller (1972).  
     Growth and development of the Indian meal moth, Plodia interpunctella (Lepidoptera : Phyeitidae) under laboratory mass-rearing conditions.  
     Ann. Entomol. Soc. Am., 65: 1084-7.
- Teruya, T. (1984).  
     Sterilization of the Melon fly, Dacus cucurbitae sterility of flies irradiated under a low temperature condition.  
     Appl. Econ. Entomol., 64: 1337-8.

LA SENSIBILITE DU STADE NYMPHAL DE *PLODIA INTERPUNCTELLA*  
AUX RAYONS GAMMA EN RELATION AVEC LA DOSE,  
L'AGE, LE SEXE ET LA TEMPERATURE

M.Y.Y AHMED, A. DAOUD et S. BOSHRA

Radiobiology Department, Nuclear Research Center  
Atomic Energy Authority  
Cairo, Egypt

RESUME

On a montré que de nombreuses espèces d'insectes des produits stockés présentent une tolérance variable aux rayons gamma pouvant varier considérablement au sein d'un même genre (Cornwell et coll. 1975). Etant donné que le mécanisme de ces variations n'est pas bien compris, la seule méthode pour établir des doses efficaces pour éliminer les insectes ravageurs est de rechercher cette dose létale expérimentalement pour chaque espèce.

On a lancé un programme de recherche sur la désinsectisation par irradiation gamma pour définir les doses nécessaires pour des applications commerciales. Les buts de ce programme sont de mesurer la dose efficace minimum nécessaire pour stériliser l'insecte à l'âge et au stade où il est le plus résistant et de mesurer la dose efficace minimum nécessaire pour entraîner sa mort immédiate aux stades de son développement où il est le plus susceptible d'infester les produits au cours des opérations d'emballage.

La radiosensibilité de la teigne des fruits secs, *Plodia interpunctella*, aux radiations gamma, en fonction de la dose, l'âge, le sexe et la température n'a pas fait l'objet d'études antérieures. La présente étude a donc été entreprise afin de préciser ces effets.

\* Plant Protection Department, Faculty of Agriculture, Ain Shams, University, Cairo, Egypt