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Latent effects of gamma radiation on certain biological aspects of the red palm weevil (*Rhynchophorus ferrugineus* Olivier) as a new control technology

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Certain biological aspects of three successive generations of the red palm weevil, *Rhynchophorus ferrugineus* Olivier resulted from the progeny of parental males and females irradiated with 10 and 20 krad were studied. Two crosses of treated males with normal females and normal males with treated females were examined and compared with normal males and females. The egg incubation period of the three successive generations of the red palm weevil was insignificantly differed except with 20krad in F_1 progeny. The total larval period of both F_1 and F_2 was significantly varied with the treatment by gamma radiation, whereas that of F_3 was insignificantly affected. The irradiation with 10 and 20 krad was significantly virulent on the pupal period duration of *R. ferrugineus* in F_1 generation only. Finally, the total life cycle of both F_1 and F_2 was significantly affected by 10 and 20 krad, while that of F_3 generation was insignificantly affected.

Key words: The red palm weevil, *Rhynchophorus ferrugineus*, irradciation, steralization, gamma radiation, biological aspects, progeny.

Introduction

The red palm weevil (RPW), *Rhynchophorus ferrugineus* Olivier (Coleoptera: Curculionidae), is one of the most severe pests of various palm species, including date palms (Giblin-Davis, 2001). The weevils develop within the tree trunk, destroying its vascular system and eventually causing the collapse and death of the tree. The pest is widely distributed in Oceania, Asia, Africa and Europe. It appeared in the Middle East in the 1980s and has heavily damaged date production by destroying many thousands of date palms (Murphy and Briscoe, 1999). Infestation was first reported in Israel and Jordan in 1999

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(Khan and Gangapersad, 2001). It is commonly accepted that RPW adults are attracted to dying and damaged parts of palm trees, but this does not preclude attacks to undamaged palms (Murphy and Briscoe, 1999). Females oviposit in the splitting bark (Abraham, *et al*., 1998), at the base of young leaves, or in wounds on the leaves and trunks (Ferry and Gomez, 2002). Eggs are laid close to the surface and the hole is cemented over. The hatched grubs tunnel into and feed on the surrounding tissue, thereby destroying it. Pupation occurs inside a cocoon. In young trees, cocoons are found at the base of the palm trunk, near or below the soil surface. Usually all life stages, including adults, are present within the same palm tree (Ferry and Gomez, 2002). With the exception of adults, the life cycle of RPW is mostly concealed within the tree trunk, so detection of infestation and treatment of infested trees are problematic. Current recommended methods for RPW management involve monitoring and mass trapping of adults with pheromone lures, cultural control, and chemical treatments (Abraham, *et al*., 1998 and Soroker, *et al*., 2005). It is common knowledge that intensive chemical treatment leads to the development of resistance, and therefore alternative methods should be considered.

The parasitoids, predators and pathogens are also not fully exploited in this pest. As a new approach to combat this pest problem in date palm, investigations on Sterile Insect Technique (SIT) were initiated. Area wide IPM is increasingly accepted especially for mobile pests where management on large scale is more effective and preferable to the uncoordinated field-by-field approach (Hendrichs *et al*., 2007). The sterile insect technique (SIT), within an area-wide integrated pest management (AW-IPM) approach has proven to be a powerful control tactic for the creation of pest-free areas or areas of low pest prevalence. In this concept of pest control, continuous release of large number of mass produced sterile insects into natural population would limit the reproductive ability of natural population which would result into reduction of density of natural insect population. As the density of natural population decreased, the influence of continuous release of sterile insects would increase and finally it may lead to possible elimination of insects from that area. Hence, the sterile insect technique has greater importance for the suppression of pest population below economic injury level, when the pest is at lower population densities (Dongre and Rananavare, 1999). The sterility technique all pests could play a prominent role in the management of some major insect pests like Red palm weevil. But before release of sterilized insects into nature, confirmation of sterility, behavior of sterilized insects and studies on the biological activities is necessary.

The present work aimed to carry out the detailed investigation on the inheritance of sterility induced by gamma radiation throughout three successive generations of the red palm weevil (RPW, *R. ferrugineus*) and the biological characteristics for genetic control.

Materials and methods

Insect rearing

A RPW colony was established in the laboratory in Plant Protection Research Institute, Giza, Egypt on sugarcane as both food and oviposition substrate, following Rahalkar, *et al.,* (1985). Adults were set to mate and oviposit in groups of at least five pairs placed on a substrate of moist sugar cane sawdust or on sugar cane logs. From the first larval stage to adult emergence, the RPWs were reared individually at 27-29 °C. For egg harvesting, the adults of both sexes were kept on sugarcane sawdust. Eggs were collected every 2 days.

Irradiation source

The late stage pupae of *R. ferrugineus* were irradiated by Co-60 source delivering gamma radiation at the Middle East Regional Radioisotope, Cairo, Egypt. The average dosage of the source when testing began was 70 Gy/minute and decay of the source was computed each month.

Experimental technique

The late stage pupae of *R. ferrugineus* (one day emergence) were collected before irradiation. Then these pupae were treated in a Co^{60} irradiator at a dose rate of 0.1 krad/min. Doses used were 0.0 (control) and sub sterilizing doses of 10 and 20krad. Immediately after irradiation, parental irradiated males were paired with unirradiated virgin females also, parental unirradiated males were paired with irradiated virgin females and equal numbers of control pairs were set up. Pairs were placed in groups (25 couples for each), each group was replicated three times and incubated at the previous mentioned controlled conditions, females were observed for egg laying and hatching. Eggs of each treatment were collected and reared on sugarcane. To study the post-embryonic development of progeny of irradiated males with 10 and 20 krad, the F_1 progeny of the treatments were used irradiated males with unirradiated virgin females , unirradiated males with irradiated virgin females and compared with untreated males with females. The same technique was repeated for F_2 and F_3

and every treatment was replicate three times. Incubation period of eggs, larval and pupal durations and total life span were recorded for progeny of different crosses for F_1 , F_2 and F_3 in both treatments with 10 and 20 krad.

Results and discussion

Effect of gamma radiation on F_1 progeny

Data presented in Table 1, indicated that the effect of irradiation of gamma radiation on F_1 generation for males and females of the red palm weevil, *R. ferrugineus* treated with 10 and 20 krad, where there two crosses of F_1 treated males with normal females and F_1 normal males with treated females were done. The incubation period was insignificantly prolonged in case of treatment with 10 krad, but with 20 krad it more significantly increased in case of treated males with untreated females than the untreated control. The total larval, pupal and life cycle periods were significantly prolonged due to irradiation with both 10 and 20 krad when compared with control. The total larval periods of F_1 progeny irradiated with 10 and 20 krad were 95.33±4.16, 96.33±3.51 and 88.33±1.53, 89.33±2.52 days for the two crosses of treated males with normal females and normal males with treated females, respectively, comparing with 88.00±2.00 days for untreated weevils. The pupal periods were 22.33±0.58 and 23.67±1.53 days in case of 10 krad , 21.33±0.57 and 20.00±2.00 days in case of 20 krad for the two crosses, respectively, while for the control it was 20.67±0.58 days. The total life cycle ranged between 130.33±2.52 and 129.33±2.51 days for weevils treated with 10 and 20 krad, consecutively, while that recorded for untreated weevils was 123.00±2.65 days.There was a great increasing in the total life cycle of F_1 male progeny irradiated with 10 and 20 krad. It increased significantly by 7 or 6 days more than control.

It is clear shown that transmission of lethality factors was higher in males and females progeny at the two tested radiation doses, where the all examines aspects were more longer with treated males than those with treated females. These results are in same trend with those obtained by Brower (1979), Korashy (1991) and Hanna *et al*., (2007) who reported that the survival of immature of F_1 progeny resulted in irradiated males of *Heliothis virescens*, *Plodia interpunctatella* and *Lobesia batrana* , respectively. In the contrary La Chance *et al*., (1973). indicated that the survival of immature stages of F_1 progeny of *Pectinophora gossypiella* was significantly decreased at all irradiation doses to F_1 males.

Table 1. Irradiation effect on different stages and life cycle durations of F_1 of red palm weevil (*Rhynchophorus ferrugineus*)

Treatment	Incubation period		Larval period		Pupal period		Total life cycle	
	10 krad	20 krad	10 krad	20 krad	10 krad	20 krad	10 krad	20 krad
Control	3.50±0.14 (3-5)		88.00±2.00 (86-90)		20.67±0.58 (20-21)		123.00±2.65 (120-125)	
F_1. Treated male & Normal female	3.95±0.17 (3-5)	4.25±0.20 (3-6)	95.33±4.16 (92-100)	96.33±3.51 (93-100)	22.33±0.58 (22-23	23.67±1.53 (22-25)	130.33±2.52 (128-133)	129.33±2.51 (127-132)
F_1. Normal male & Treated female	3.80±0.16 (3-5)	3.70±0.15 (3-5	88.33±1.53 (87-90)	89.33±2.52 (87-92	21.33±0.57 (21-22)	20.00±2.00 (18-22)	124.00±1.00 (123-125)	124.33±1.55 (123-125)
F test	N.S.	*	*	*	*	*	*	*
L.S.D. at 0.05	-	0.451	1.258	1.249	0.584	0.599	1.645	1.577

N.S. means showed non significant difference.
* means showed significant difference.

Effect of gamma radiation on F_2 progeny

Data in Table 2 showed the life cycle of F_2 progeny treated with 10 and 20 krad. The incubation period was insignificantly increased with the two crosses and ranged between 4.00±0.22 and 3.65±0.17 days for the treated individuals compared with 3.50±0.14 days for the control. The larval period of treated males or females significantly prolonged than control and it is interest to notice that F_2 males was little affected than the females. On the other hand the treated F_2 males and females with 10 or 20 krad less nonsignificantly increased the pupal period that ranged between 21.00±0.00 and 20.33±1.53 days compared with 20.67±0.58 days for the untreated weevils. The total life cycle of treated males or females was significantly prolonged than control due to irradiation effect. The F_2 irradiated males crossed with normal females recorded 128.67±1.55 and 123.67±2.52 days for total life cycle at 10 and 20 krad, respectively. But, that recorded for the F_2 irradiated females crossed with normal males recorded 126.33±3.51 and 124.33±1.15 days for total life cycle at 10 and 20 krad, respectively, compared with 123.00±2.65 days for untreated weevils. Carpenter, *et al* ., (1987) found that 10 krad dose of radiation had deleterious effects that inherited through the F_2 generation of the corn ear worm.

Table 2. Irradiation effect on different stages and life cycle durations of F_2 of red palm weevil (*Rhynchophorus ferrugineus*)

Treatment	Incubation period		Larval period		Pupal period		Total life cycle	
	10 krad	20 krad	10 krad	20 krad	10 krad	20 krad	10 krad	20 krad
Control	3.50±0.14 (3-5)		88.00±2.00 (86-90)		20.67±0.58 (20-21)		123.00±2.65 (120-125)	
F_2. Treated male & Normal female	4.00±0.22 (3-6)	3.65±0.17 (3-5)	92.00±3.61 (88-95)	90.67±2.52 (88-93)	21.00±0.00 (21-21)	20.33±1.53 (19-22)	128.67±1.55 (128-130)	123.67±2.52 (121-126)
F_2. Normal male & Treated female	3.85±0.02 (3-5)	3.70±0.15 (3-5)	91.00±4.00 (87-95)	88.33±2.51 (87-90)	20.33±0.58 (20-21)	20.67±1.16 (20-22)	126.33±3.51 (123-130)	124.33±1.15 (123-125)
F test	N.S.	N.S.	*	*	N.S.	N.S.	*	*
L.S.D. at 0.05	-	-	1.200	0.594	-	-	1.650	1.269

N.S. means showed non significant difference.
* means showed significant difference.

Effect of gamma radiation on F_3 progeny

As shown in Table 3, the all tested biological aspects of F_3 progeny of the red palm weevil as parents with 10 and 20 krad, were insignificantly affected with the radiation. The eggs of treated weevils hatched after 3.85±0.17 and 3.75±0.16 days comparing with 3.50±0.14 days for untreated weevils. The total life cycle of treated larvae ranged between 88.67±2.31 and 89.00±3.00 days comparing with 88.00±2.00 days for the control. The range of pupal periods for treated weevils were 21.00±1.00 and 21.33±1.55 days , compared with 20.67±0.58 days for the control in non significant manner. Finally, the total life cycle was nearly equal, where the range was 122.67±1.53 and 121.33±1.52 days for treated ones, compared with 123.00±2.65 days for the untreated ones, also in non significant manner. The obtained results indicated that the transmission of lethality was eliminated at the egg stage in three successive generations, but the larval span lethality appeared especially in the first and second generations only, while, it eliminated in the third one. Also, transmission of lethat factors occurred more with males than females. These data agree with the results of Brower (1979).

Table 3. Irradiation effect on different stages and life cycle durations of F_3 of red palm weevil *Rhynchophorus ferrugineus*.

Treatment	Incubation period		Larval period		Pupal period		Total life cycle	
	10 krad	20 krad	10 krad	20 krad	10 krad	20 krad	10 krad	20 krad
Control	3.50±0.14 (3-5)		88.00±2.00 (86-90)		20.67±0.58 (20-21)		123.00±2.65 (120-125)	
F_3. Treated male & Normal female	3.85±0.17 (3-5)	3.75±0.16 (3-5)	88.67±2.31 (86-90)	89.00±3.00 (86-92)	21.00±1.00 (20-22)	21.33±1.55 (20-22)	122.67±1.53 (121-124)	121.33±1.52 (120-132)
F_3. Normal male & Treated female	3.75±0.14 (3-5)	3.70±0.15 (3-5)	88.33±3.06 (85-91)	89.00±3.46 (85-91)	20.33±0.57 (20-21)	20.67±0.58 (20-21)	123.00±1.00 (122-124)	122.00±2.01 (120-124)
F test	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.
L.S.D. at 0.05	-	-	-	-	-	-	-	-

N.S. means showed non significant difference.
* means showed significant difference.

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