EFFECT OF GAMMA RADIATION ON *RHIZOGLYPHUS ECHINOPUS* (FUMOUZE AND ROBIN) AND *ALEUROGLYPHUS OVATUS* (TROUPEAU) (ACARI: ACARIDAE)

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ABSTRACT

Eggs, inert deutonymphs and young, virgin adults of *Rhizoglyphus echinopus* (Fumouze and Robin) and *Aleuroglyphus ovatus* (Troupeau) were treated with 5, 10, 15, 20, 40, 60, 80, and 100 krad of gamma radiation. Fecundity, egg viability, oviposition period, survival of developmental stages, and longevity of females were compared. Doses $\geq$ 40 krad completely inhibited egg development. Eggs of *A. ovatus* were more resistant to gamma radiation than those of *R. echinopus*. The effect of irradiation on the inert deutonymphs was more detrimental than it was on young adults. Effect of irradiation on the life span of females of both species was stimulatory at doses of up to 60 krad and inhibitory at higher doses. The oviposition period varied inversely with the irradiation dose. Irradiation with 5 krad caused, in both mite species, at least a 50% decrease in fecundity.

Key Words: Ionizing radiation, stored-product mites, development.

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INTRODUCTION

In comparison to other animals, insects and mites are very resistant to gamma radiation. Gamma radiation causes, however, various changes in mite reproduction, physiology, and behavior. Low doses may cause a beneficial effect on stored-product mites (Melville 1958) and higher doses sterilize or kill them (Burkholder et al. 1966; Davis 1972). Different species and various stages of the same species vary in their reaction to ionizing radiation (Chmielewski et al. 1970; Hemenway and Davis 1972). The effect of gamma radiation on *Acarus siro* (L.) and *Tyrophagus putrescentiae* (Schrank), has been studied (Burkholder et al. 1966; Davis 1972; Ignatowicz et al. 1983), but little work has been done on other stored-product mites. Czajkowska and Boczek (1983) found that irradiation of females of *Tyrophagus putrescentiae* had a greater influence on fecundity than the treatment of males. The effect of irradiation was stronger when young adults were treated. The irradiation of mites influenced the longevity, fecundity, and mortality during development of their F_1 and F_2 offspring.

Rhizoglyphus echinopus (Fumouze and Robin) is an important pest of onion, bulbs of ornamental plants, and processed fruits and vegetables. Because it is a very common element of soil mesofauna, the infestation of the above mentioned products takes place easily. *Aleuroglyphus ovatus* (Troupeau) is often found, occasionally in very large numbers, in grain, dried mushrooms, and medicinal herbs. The knowledge of sensitivity of various species and stages is necessary before recommendations on appropriate radiation control procedures can be made

for products that are infested with mites. The work reported here is a result of a study on the effects of gamma radiation on two additional important species of stored-product mites.

MATERIALS AND METHODS

Mites used in this study were from stock cultures maintained at 25°C and 85% RH at the Agricultural University of Warsaw, Poland. Eggs, inert deutonymphs, and adult mites were irradiated with a Co^{60} source of 128 rad/sec at the following doses: 5, 10, 15, 20, 40, 60, 80, and 100 krad.

Inert deutonymphs were removed from the stock culture and sexed 24 h later when they emerged as adults. Resulting 1-d old virgin adults (♀♀ & ♂♂) were then irradiated and paired. Each week, the number of eggs laid by the 12 - 25 females was counted and the eggs discarded. In addition, 200 eggs were selected from the stock culture to be irradiated and after 7 d these eggs were counted, their viability determined, and the number of adults that developed from these eggs was noted. In another test, deutonymphs were irradiated, sexed 24 h later and paired. Each pair was placed in a separate chamber and fecundity, longevity of the pair, and egg viability were determined for at least 20 pairs and 200 eggs, respectively. Means and standard error of the means were calculated.

RESULTS AND DISCUSSION

The effect of irradiation of young adult mites on egg production was similar in both species of mites (Table 1). In general, numbers of eggs oviposited varied inversely with the radiation dosage. Mites irradiated with 5 krad oviposited ca. 50 percent less eggs when compared to the control. Slightly higher but non-significant numbers ($P > 0.05$) of eggs were oviposited at 40 krad in *R. echinopus* and at 15 krad in *A. ovatus* than were oviposited at the lower doses. At 60 and 80 krad only a few (< 31) eggs per ♀ were deposited and, when 100 krad dose was applied, no eggs were oviposited for either species.

The irradiation of inert deutonymphs affected fecundity more strongly than when virgin adults were treated. At the lowest dose applied, 5 krad, only about ½ as many eggs were laid as in the control group. At a dose of 20 krad in *R.*

Table 1. Fecundity of females of *R. echinopus* and *A. ovatus* irradiated as virgin females or inert deutonymphs.

Dose krad	Irradiated females				Irradiated deutonymphs			
	Rhizoglyphus echinopus $\bar{x} \pm$ SE		*Aleuroglyphus ovatus* $\bar{x} \pm$ SE		*Rhizoglyphus echinopus* $\bar{x} \pm$ SE		*Aleuroglyphus ovatus* $\bar{x} \pm$ SE	
0	139.2	14.56	592.6	47.90	139.2	14.56	592.6	47.89
5	73.3	6.26	218.5	19.46	45.3	5.32	143.7	25.03
10	70.5	8.48	149.4	18.97	47.9	6.46	153.6	26.78
15	40.8	7.76	192.0	18.43	31.2	7.27	92.9	18.95
20	29.2	4.76	110.7	11.14	6.6	1.09	96.5	5.12
40	36.8	3.31	33.3	7.47	3.9	0.92	15.9	0.22
60	7.3	1.23	20.5	6.82	0.3	0.15	0.3	0.00
80	0.7	0.29	0.6	0.27	0.5	0.31	0.0	0.00
100	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00

echinopus and 40 krad in *A. ovatus*, only a few eggs (< 16) were laid. No eggs were laid at 100 krad in *R. echinopus* or at 80 and 100 krad in *A. ovatus*.

Viability of eggs from irradiated females was distinctly lower at 10 krad for *R. echinopus* and at 5 krad for *A. ovatus* (Table 2). Adult survivors of such eggs (expressed as a percentage of eggs that reached the adult stage) were, moreover, reduced in *R. echinopus*. Even at the lowest doses only a few adult mites emerged. However, in *A. ovatus* this effect at doses 5 - 15 krad was not observed; the number of adult mites resulting from irradiated eggs was even higher at 5 and 15 krad than in the controls (Melville 1958). This number was lower at 20 krad while at doses higher than 20 krad, no adults were observed.

Table 2. Viability of eggs of irradiated *R. echinopus* and *A. ovatus* adults and deutonymphs expressed as percent of eggs hatched after irradiation and percent of those eggs that reached adulthood.

	Irradiated females and males		Irradiated deutonymphs	
Dose krad	*Rhizoglyphus echinopus*	*Aleuroglyphus ovatus*	*Rhizoglyphus echinopus*	*Aleuroglyphus ovatus*
0	86(62)	97(57)	86(62)	97(57)
5	85(12)	60(72)	29(34)	79(39)
10	58(10)	49(54)	20(9)	20(14)
15	19(6)	40(63)	0(0)	34(51)
20	6(0)	19(30)	0(0)	9(30)
40	0(0)	0(0)	0(0)	0(0)
60	0(0)	0(0)	0(0)	0(0)

When inert deutonymphs were irradiated, both egg viability and adult survival in *R. echinopus* were strongly affected. At ≥ 15 krad no viable eggs were produced. In the case of *A. ovatus*, the irradiation affected both egg viability and, to a lesser extent, survival. At 40 krad and greater no viable eggs were laid.

A comparison of the fecundity of non-irradiated and irradiated females (Tables 3 and 4) revealed several differences. One-wk-old non-irradiated females of *R. echinopus* (Table 3) and 2-wk-old non-irradiated females of *A. ovatus* (Table 4) were observed to have the highest fecundity. Later, fecundity decreased, but a second period of higher egg production was recorded in *R. echinopus* during weeks 13 - 15. The same pattern of egg-laying was observed in mites irradiated at 5 krad. A prolonged oviposition period was observed in *A. ovatus* exposed to 5 - 10 krad while a distinct shortening of this period was observed in *R. echinopus* treated with doses higher than 10 krad. At higher doses the oviposition period for both species was shortened except at 40 krad in *A. ovatus* and 15 krad in *R. echinopus*. In those two cases egg-laying was prolonged but only a few eggs were laid.

When deutonymphs were irradiated, the pattern of fecundity was, in general, similar for both species, but the effect of irradiation was much stronger than when adult mites were treated. The oviposition period was shortened at all doses in *R. echinopus* but only at the highest doses in *A. ovatus*.

Longevity of females of both species, irradiated as adults, was similar. Doses 5 - 40 krad increased the survival. Survival of non-irradiated and irradiated females with high doses (60 krad) also was comparable but their life span was shortened when irradiated with 80 krad. The effect of irradiation on *R. echinopus* also was stimulatory, at least at doses of 15 and 20 krad.

Table 3. Fecundity of irradiated *R. echinopus* females. (mean # eggs/♀/week).

Week of life	0 krad		5 krad		10 krad		15 krad		20 krad		40 krad		60 krad		80 krad	
	$\bar{x}$	± SE	$\bar{x}$	± SE	$\bar{x}$	± SE	$\bar{x}$	± SE	$\bar{x}$	± SE	$\bar{x}$	± SE	$\bar{x}$	± SE	$\bar{x}$	± SE
1	52.2	4.47	22.8	2.28	16.3	1.81	3.7	0.92	0.0	0.00	20.8	2.10	4.9	0.81	0.0	0.00
2	35.1	2.93	12.8	1.72	17.3	2.26	8.3	0.87	0.7	0.27	10.1	1.25	1.8	0.58	0.5	0.27
3	11.3	1.47	15.3	1.72	14.6	2.37	6.2	0.76	3.3	0.91	4.1	0.96	0.5	0.25	0.1	0.07
4	5.4	0.65	7.5	0.67	8.9	1.05	2.9	0.87	15.1	3.00	1.8	0.51	0.0	0.00	0.1	0.07
5	5.9	0.60	2.6	0.54	5.0	0.78	2.2	0.72	7.5	1.74	0.0	0.04	0.0	0.00	0.0	0.00
6	4.5	0.71	2.9	0.89	4.0	1.12	2.0	0.85	1.4	0.67	0.0	0.00	0.0	0.00	0.0	0.00
7	0.8	0.29	3.0	0.67	1.1	0.43	1.2	0.36	0.1	0.67	0.0	0.00	0.1	0.07	0.0	0.00
8	0.4	0.29	2.7	0.81	1.7	0.83	0.7	0.29	0.3	0.11	0.0	0.00	0.0	0.00	0.0	0.00
9	0.2	0.11	3.6	0.83	3.3	1.10	1.4	0.58	0.2	0.31	0.0	0.00	0.0	0.00	0.0	0.00
10	0.1	0.11	0.4	0.20	0.3	0.11	9.6	3.42	0.6	0.16	0.0	0.00	0.1	0.04	0.0	0.00
11	0.7	0.34	0.0	0.00	0.0	0.00	1.7	1.19	0.0	0.51	0.0	0.00	0.0	0.00	0.0	0.00
12	3.7	1.50	0.2	0.09	0.0	0.00	1.7	1.63	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00
13	12.6	2.73	0.0	0.00	0.0	0.00	0.6	0.58	0.0	0.00	0.0	0.00	0.0	0.00	–	–
14	9.7	2.39	0.0	0.00	0.0	0.00	0.5	0.49	0.0	0.00	0.0	0.00	0.0	0.00		
15	10.6	2.44	5.0	1.59	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00		
16	6.7	2.39	19.5	6.17	0.0	0.00	0.0	0.00	0.0	0.00	–	–	–	–		
17	8.4	1.74	13.5	4.27	0.0	0.00	0.1	0.07	0.0	0.00						
18	7.5	1.79	4.0	1.28	0.5	0.16	0.3	0.22	0.0	0.00						
19	4.3	1.16	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00						
20	4.2	1.23	0.0	0.00	0.0	0.00	0.1	0.07	0.0	0.00						
21	2.8	1.41	0.0	0.00	–	–	0.0	0.00	0.0	0.00						
22	1.4	0.58	–	–			0.0	0.00	0.0	–						
Total	188		116		73		43		29		37		7		0.7	

Table 4. Fecundity of *A. ovatus* in consecutive weeks of life after irradiated as adults (# eggs/♀/week).

Week of life	0 krad $\bar{x}$ ± SE		5 krad $\bar{x}$ ± SE		10 krad $\bar{x}$ ± SE		15 krad $\bar{x}$ ± SE		20 krad $\bar{x}$ ± SE		40 krad $\bar{x}$ ± SE		60 krad $\bar{x}$ ± SE		80 krad $\bar{x}$ ± SE	
1	188.1	17.94	32.5	3.76	9.2	1.39	37.7	4.09	4.1	1.19	5.9	1.21	7.7	1.66	0.0	0.00
2	220.1	19.51	52.0	5.26	20.8	2.19	51.1	5.95	7.0	1.03	4.5	1.19	1.0	0.47	0.5	0.20
3	146.6	15.50	41.6	5.19	18.8	2.66	45.4	5.17	29.7	4.14	7.2	1.74	1.2	0.94	0.1	0.11
4	18.3	2.91	24.2	1.88	19.4	3.47	22.8	2.73	13.7	1.57	6.5	1.86	5.1	2.21	0.0	0.00
5	17.2	3.80	31.3	4.21	38.2	4.36	14.7	2.33	26.6	3.06	6.1	2.17	3.5	1.86	0.0	0.00
6	10.8	3.94	19.6	5.06	13.4	1.95	11.7	3.11	19.8	3.60	3.0	1.57	3.0	1.39	0.0	0.00
7	14.9	3.02	7.8	2.33	12.5	2.44	8.4	2.51	12.1	2.26	0.6	0.38	0.8	0.60	0.0	0.00
8	7.2	1.52	3.5	1.23	14.9	2.01	4.7	1.57	5.7	1.39	1.1	0.76	0.5	0.36	0.0	0.00
9	5.4	1.66	3.5	1.63	20.7	2.46	2.0	0.76	1.6	0.54	0.5	0.34	0.1	0.07	0.0	0.00
10	4.5	1.21	10.2	4.77	9.4	1.50	2.2	0.87	0.0	0.00	0.3	0.11	0.0	0.00	–	–
11	1.0	0.00	3.3	1.48	6.9	1.36	3.8	1.54	0.0	0.00	0.1	0.07	0.0	0.00		
12	0.0	0.00	4.3	1.92	4.7	0.96	0.8	0.34	0.0	0.00	0.2	0.09	0.0	0.00		
13	0.0	0.00	0.7	0.29	6.5	2.60	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00		
14	0.0	0.00	0.8	0.45	1.4	0.43	0.0	0.00	0.0	0.00	0.1	0.07	0.0	0.00		
15	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00		
16	–	–	0.0	0.00	0.0	0.00	0.0	0.00	0.0	0.00	0.00	0.00	0.00	0.00		
Total	632		235		197		205		120		36		23		0.6	

The effect of irradiation of inert deutonymphs on subsequent female longevity was, again, alike for both species. Non-irradiated and irradiated (5 - 60 krad) *R. echinopus* females had similar life-spans. Non-irradiated females of *A. ovatus* had a shorter life-span than those irradiated with 5 - 60 krad. Irradiation with 5 - 60 krad caused a prolongation of life in *A. ovatus* while only doses of 15 and 40 krad produced the same effect in *R. echinopus*. Only an 80 krad dose caused a strong shortening of the life span of both species.

The effect of gamma radiation on 1-d-old eggs is presented in Table 5. It appears that eggs of *R. echinopus* were more sensitive than those of *A. ovatus*. For example, the lowest dose, 5 krad, caused a decrease in the survival of all developmental stages; whereas, in *A. ovatus* doses of 5 and 10 krad did not show any deleterious effect on the number of adults that resulted from irradiated eggs. Doses of $\geq$ 20 krad adversely affected the survival of both species.

Table 5. Survival of irradiated eggs of *A. ovatus* and *R. echinopus* (% of adults emerged from 200 eggs/species/dose).

Dose krad	*Rhizoglyphus echinopus*	*Aleuroglyphus ovatus*
0	62.0	57.0
5	20.0	57.0
10	6.0	59.0
15	17.0	34.0
20	1.0	9.0
40	10.0	1.0
60	0.0	0.0
80	0.0	0.0

These data indicate a differentiated effect of gamma radiation on various life stages of the two mite species. Doses of 40 krad or higher would be necessary to control these species but doses as low as 5 krad decrease their fecundity by at least 50%. It would appear that such information for these and other species would be desirable if not essential for any program involving gamma radiation as a potential control measure.

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