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Short Communication

Comparison of Lethal Effects of Electron Beams and Gamma Rays on Eggs of Two Spotted Spider Mite, *Tetranychus urticae* KOCH (Acari : Tetranychidae)

Toshiyuki DOHINO, Kazuo TANABE
and Toru HAYASHI*

Physical Control Laboratory, Research Division, Yokohama Plant Protection Station, Kitanaka-dori 6-64, Naka-ku, Yokohama 231, Japan
* National Food Research Institute, Kannondai 2-1-2, Tsukuba, Ibaraki 305, Japan

Abstract: Irradiation with electron beams or with gamma rays reduced hatchability of younger eggs (3-day-old eggs) of *Tetranychus urticae* to a greater degree than that of older eggs (4-day-old eggs). There was no significant difference in the lethal effects between electron beams and gamma rays.
Key words: Arachnida, *Tetranychus urticae*, radiation, hatchability

Introduction

Reactions caused by electron beams from an accelerator and by gamma rays are regarded as the same in principle, although the two type irradiations have large differences in dose rate and penetration capacity (the dose rate of electron beams is much higher than gamma rays, however the opposite is true for the penetration capacity).

In comparison of the biological effects of two irradiations, some reports showed dominancy of gamma ray in suppressing emergence of the grain weevil *Sitophilus* spp. pupae (ADEM, *et al.*, 1978), in sensitivity of fungi (OHKI, *et al.*, 1991) and in inactivating microorganisms in dehydrated blood plasma (HAYASHI, *et al.*, 1991), whereas TABEI, *et al.* (1984) reported that electron beams more effectively sterilized polypropylene surgical sutures than did gamma rays. Others showed that two type irradiation effects were equivalent in suppressing emergence of *Sitophilus* spp. eggs and larvae (ADEM, *et al.*, 1978) and adult emergence of *S. granarius* (BULL and CORNWELL, 1966), in bactericidal effect (GOLDBLITH, *et al.*, 1953) and in sensitivities of endospores from some *Bacillus* species (FURUTA, *et al.*, 1987 ; OHKI, *et al.*, 1990).

Few data comparing the two type irradiation effects on organism, especially insect pests are available in the present situation. In the present study, the hatchabilities of two spotted spider mite, *Tetranychus urticae* eggs irradiated either with electron beams or gamma rays were investigated for the purpose of demonstrating efficacy of electron beam irradiation as a quarantine treatment.

Materials and methods

1. Rearing

T. urticae was obtained from Faculty of Horticulture, Chiba University. Mites were reared with kidney bean leaves at 22°C±1°C and 70% r.h. under a photoperiod of 16L : 8D. Under these conditions, the duration of eggs was 4～7 days.

2. Eggs

Fifteen females and 3 males were allowed to oviposit on a bean leaf which was put on 0.6% agar medium including 20 ppm crystal violet (DOHINO and TANABE, 1993). After 8 hours these adults were removed and the number of eggs laid on the leaf was recorded. Eggs were held under rearing conditions until irradiation.

3. Irradiation

Eggs were treated with electron beams or gamma rays at National Food Research Institute. The absorbed dose of both irradiations was determined with RCF dosimeter (FWT-60-00, Far West Technology Inc.) (HAYASHI, *et al.*, 1992).

Electron beam irradiation was carried out with a Van de Graaff electron accelerator (Nissin High Voltage Co. Ltd., 2.5 MeV, 1.5×10^6 Gy/hr). The absorbed dose was controlled by changing the beam current at a conveyer speed of 3.0 m/min. Beam currents were 7.4 μA, 14.7 μA, 22.1 μA, 29.4 μA, 58.8 μA, 88.2 μA, 117.6 μA and 147.0 μA for 50 Gy, 100 Gy, 150 Gy, 200 Gy, 400 Gy, 600 Gy, 800 Gy and 1000 Gy, respectively.

Gamma irradiation was carried out with a Gamma-cell 220 (AECL, 2.1×10^2 TBq of ^{60}Co, 5.9×10^3 Gy/hr). The absorbed dose was controlled by changing the irradiation period for the Gamma-cell. Irradiation periods were 0.75 min, 1.50 min, 2.25 min, 3.00 min, 6.00 min, 9.00 min, 12.00 min and 15.00 min for 50 Gy, 100 Gy, 150 Gy, 200 Gy, 400 Gy, 600 Gy, 800 Gy and 1000 Gy, respectively.

Both irradiation units were operated at 20°C and 50～60% r.h. Eggs were held under rearing conditions, and hatchability was recorded until 8 days after irradiation (11～12 days after oviposition).

All tests were replicated five times.

Results and discussion

Cumulative hatchabilities of 3-day-old eggs (68～76 hr after oviposition) and 4-day-old eggs (92～100 hr after oviposition) at 1, 3, 6 and 8 days after irradiation showed that the dose-hatchability relationship was entirely the same in electron beams and gamma rays (Fig. 1). Final hatchabilities of 3- and 4-day-old eggs are shown in Table 1. Susceptibility was higher in 3-day-old eggs, which agreed with our previous study using 1～5-day-old eggs (DOHINO and TANABE, 1993), in that a higher susceptibility in younger eggs was observed, although hatchabilities in the present study were higher since slightly high temperature in transit before and after irradiation stimulated embryonic development.

BULL and CORNWELL (1966) and ADEM, *et al.* (1978) reported that adult grain weevils

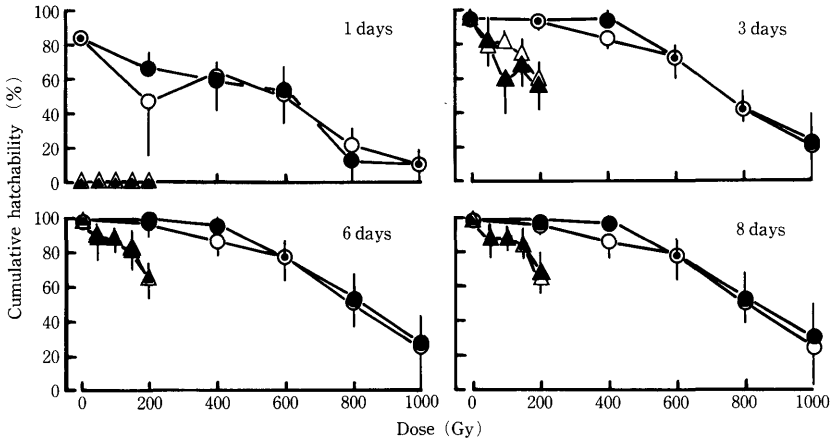

Fig. 1. Cumulative hatchability of *T. urticae* eggs at intervals after irradiation. Three-day-old eggs were irradiated by gamma ray (△) or electron beam (▲). Four-day-old eggs were irradiated by gamma ray (○) or electron beam (●).

Table 1. Comparison of gamma rays and electron beams in inhibition of hatch of *T. urticae* eggs[1]

Egg Age (day)	Dose (Gy)	Hatchability (%)[2]	
		Gamma Rays	Electron Beams
3	50	88.3±11.2 (161)	90.4± 6.3 (161)
	100	88.6± 6.7 (152)	89.4± 6.8 (161)
	150	82.8± 7.8 (155)	84.1±11.8 (166)
	200	65.4± 7.8 (153)	69.6±12.8 (151)
4	200	95.7± 4.8 (172)	97.7± 3.8 (180)
	400	84.7± 7.8 (173)	96.0± 4.3 (176)
	600	76.8±13.3 (175)	77.5± 9.4 (164)
	800	50.7±13.9 (158)	52.6±16.7 (159)
	1000	23.4±22.2 (168)	29.7±20.2 (164)

1 : Eggs were irradiated in May 18, 1993.
2 : Value in parenthesis is a sum of tested eggs in five replications. Hatchability of non-irradiated control was 99.5±1.1% (n=179).

irradiated with electron beams or gamma rays showed different reduction in survival rate with time, *i.e.* no difference appeared in the survival rate between the both irradiations until 12~14 days after treatment, but thereafter gamma rays provided higher mortality rather than electron beams. Although dissimilar materials do not allow direct comparison between their results with adult grain weevils and our result with *T. urticae* eggs, some differences of irradiation effects found in their results seem to be caused by the following two reasons. First, the penetration capacity of electron beam and gamma ray should be considered since the grain weevil adults in maize or corn medium were irradiated, while

naked eggs of mite were irradiated. Secondly, it is doubtful whether the dosimetry technique for electron beams was accurate or not.

GOODWIN and WELLHAM (1990) reported that gamma irradiation was an effective quarantine treatment for *T. urticae* eggs, and our study showed both irradiations were equivalent in lethal effects on mite eggs. The electron beam irradiation is considered to be an effective quarantine treatment. Electron beam irradiation with an electron accelerator has many advantages in comparison with gamma irradiation, *e.g.* more safety, lower (good) cost performance, ability to treat more in less time and little damage to the environment (FURUTA, *et al.*, 1987; TANABE and DOHINO, 1993). Electron beam irradiation is an effective quarantine treatment for cut flowers which are valued for their freshness and which have been imported more recently.

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和 文 摘 要

ナミハダニ *Tetranychus urticae* KOCH (Acari : Tetranychidae) 卵の孵化に対する電子線とガンマ線の照射効果の比較について

土肥野 利 幸・田 辺 和 男
林 徹*
横浜植物防疫所調査研究部
食品総合研究所流通保全部*

1) 日齢の異なるナミハダニ卵を電子線またはガンマ線で照射したとき，若い卵ほど孵化が阻止された。

2) 電子線とガンマ線における孵化阻止効果は，両者の間で有意差は認められず，同等の効果があった。