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Effects of Electron Beam Irradiation on *Thrips palmi* KARNY and *Thrips tabaci* LINDEMAN (Thysanoptera : Thripidae)

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Abstract : Eggs, second instar larvae and adults of *Thrips palmi* and *T. tabaci* were exposed to electron beams (2.5 MeV) with doses of 0, 100, 200 and 400Gy. The tolerance of the eggs increased with age. Second instar larvae irradiated at 100Gy survived and emerged, however they were completely sterilized. At 200Gy or lower, treated adults kept their fecundities, while at 400Gy they were sterilized.
Key words : radiation, *Thrips palmi*, *Thrips tabaci*, sterility, commodity treatment, cut flower

Introduction

Thrips palmi KARNY, which was distributed in South and Southeast Asia since old days, was found in Japan in 1978 and has become a serious pest of vegetables such as cucumber, eggplant, and sweet pepper in greenhouses and open fields (KAWAI, 1990a ; KAWAI, 1990b). *Thrips tabaci* LINDEMAN, which is distributed in Japan as well as in many countries, also causes economic damage to a wide variety of horticultural plants. These two species are the most terrible pests throughout the year because of their high reproductive rate, and their low sensitivity to many insecticides (KAWAI, 1985 ; MATSUZAKI *et al.*, 1986 ; UMEYA *et al.*, 1988). It is known that both species produce their offsprings by means of parthenogenesis, and that male existance of *T. tabaci* in Japan has not been reported although females and males of *T. palmi* exist in Japan (UMEYA *et al.*, 1988).

Recently, the number of imported cut flowers has increased and amounted to 808 million stalks in 1994. Various kinds of pests were found on the cut flowers, and 34 % of the pests were thrips. These infested cut flowers are subjected to methyl bromide or hydrogen cyanide fumigation treatment. However, the use of methyl bromide will be restricted or limited in the near future, because this chemical was listed as an ozone depleting substance in the Fourth Meeting of Montreal Protcol in November 1992. It is, therefore, extremely urgent to find alternatives to methyl bromide for the disinfestation.

We reported the efficacy of electron beam irradiation as a quarantine treatment against mites, mealybugs and leafminers (DOHINO and TANABE, 1994 ; DOHINO and MASAKI, 1995 ; KUMAGAI and DOHINO, 1995). Our objective is to study the effects of electron beam irradiation on eggs, second instar larvae and adults of *T. palmi* and *T. tabaci*, as there are few studies which have dealt with irradiation of thrips (WIT and van de VRIE, 1985 ; CHIU, 1986).

Materials and Methods

Test insects

T. palmi were obtained from National Research Institute of Vegetable, Ornament Plants and Tea, Ano - cho, Mie. *T. tabaci* were collected from field. The insects were reared with cucumber leaves in a cage (29 × 44 × 30 cm) which was covered with Bemberg® nets (Asahi Chemical Industry Co. Ltd.) at 25 ± 1 ℃ and 60-80% r.h., under a photoperiod of 16L : 8D (Fig. 1.). Under these conditions, the duration of the eggs, larval and pupal stages were 4-5 days, 4-6 days and 4-5 days, respectively. Adults were obtained about 10 days after hatching.

Ten adult females were allowed to oviposit into a cucumber leaf which was put on a filter paper in a polyethylene bag Yunipack® (Seisan Nippon Sha Ltd., 14 × 10 cm, 0.04 mm in thickness) shown in Fig 2. Collection of the eggs of *T. palmi* and *T. tabaci* was performed for 3 days and for 1 day, respectively. The eggs laid in the cucumber leaf in the Yunipack® were held under the rearing conditions until irradiation.

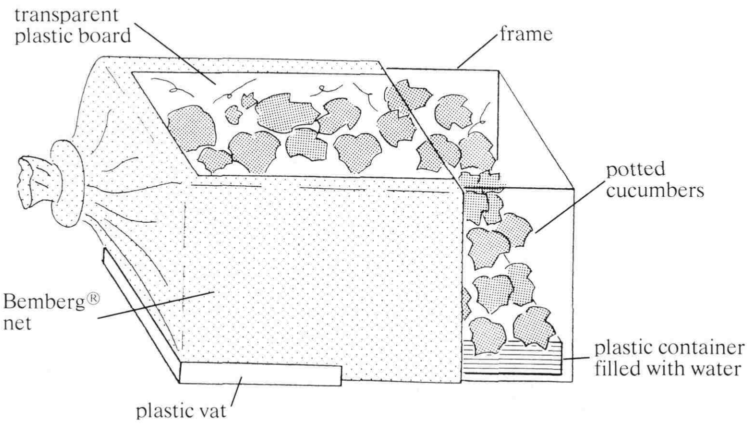

Fig. 1. Rearing cage
Thrips were reared in Bemberg® cages with potted cucumbers.
Potted cucumbers and water were supplied occasionally.

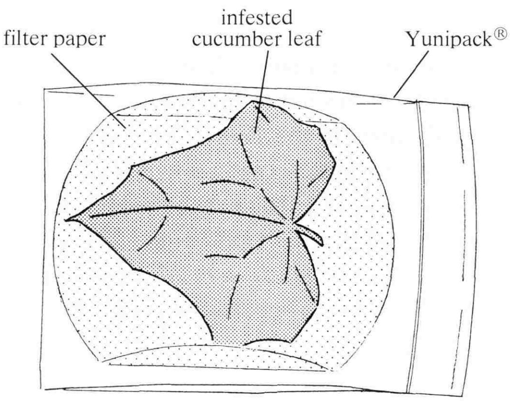

Fig. 2. Test insects for irradiation
A cucumber leaf infested with thrips in Yunipack® was irradiated.

Second instar larvae and adults for irradiation were collected from the colonies in a rearing cage of each species and placed into Yunipack R .

Irradiation

Each stage of eggs, second instar larvae and adults were irradiated with electron beams under conditions of 20 ℃ and 50-60% r.h. in a Van de Graaff electron accelerator (Nissin High Voltage Co. Ltd., 2.5 MeV, 1.5×10^6 Gy/hr) at National Food Research Institute, Kannondai 2 - 1 - 2, Tsukuba, Ibaraki as shown Fig. 2. The absorbed dose was controlled by changing the beam current at a conveyer speed of 3.0m/min. Beam currents were 14.7, 29.4 and 58.8μA for 100, 200 and 400Gy, respectively. Doses were measured with a radiochromic film (RCF) dosimeter (FWT-60-00, Far West Technology Inc.) (HAYASHI *et al.*, 1992).

The eggs (3-5-day-old eggs of *T. palmi*; 1-day-old or 4-day-old eggs of *T. tabaci*) in a cucumber leaf in the Yunipack R were treated. Approximately 20 larvae and 20 adults (in the case of *T. palmi*, about 80 % of tested adult was female, the rest was male) were irradiated on a leaf in the Yunipack R. After irradiation, the adults were transferred to a new cucumber leaf in a Yunipack R. Each irrradiated stage was held under the rearing conditions as mentioned above.

All tests were replicated 5 or 6 times.

Determination of mortality and sterility

After irradiation, the number of survived larvae, pupae and adults were counted. In order to investigate their sterilities, the descendants were counted as well. A new uninfested cucumber leaf was supplied on the old fed leaf in the Yunipack R every 2-3 days.

Results and Discussion

Eggs

The effects of electron beam irradiation on the eggs of *T. palmi* (3-5-day-old) and of *T. tabaci* (1-day-old and 4-day-old) are shown in Table 1. The number of irradiated eggs was estimated by the number

Table 1. Effects of irradiation on *T. palmi* and *T. tabaci* eggs

Dose (Gy)	No. of estimated eggs	No. of hatched larvae	No. of pupae	No. of adults (♂ : ♀)
T. palmi (3-5-day-old eggs)				
0	386	386	336	292 (66:226)
100	386	128	0	—
200	386	122	0	—
400	386	1	0	—
T. tabaci (1-day-old eggs)				
0	137	137	105	103 (0:103)
100	137	11	0	—
200	137	0	—	—
400	137	0	—	—
T. tabaci (4-day-old eggs)				
0	114	114	110	110 (0:110)
100	—	—	—	—
200	114	78	0	—
400	—	—	—	—

1) Total number of irradiated eggs was based on hatched larvae in control in 5 replicates.

of hatched larvae in each control. One-day-old eggs of *T. tabaci* could not hatch at 200Gy or higher of absorbed dose. The 1-day-old eggs of *T. tabaci* were more radiosensitive than the 4-day-old eggs, or than 3-5-day-old eggs of *T. palmi*. It has been reported that younger eggs are more susceptible than older eggs in some arthropod pests (BALOCK *et al.*, 1963 ; BROWER, 1975 ; DOHINO and TANABE, 1993 ; DOHINO and MASAKI, 1995). A similar tendency was confirmed in the eggs of thrips. The survivors of both species could attain to second instar larvae, although they failed in pupation. The dose between 100Gy and 200Gy was enough to inhibit the pupation, although the dose higher than 400Gy will be required to inhibit the hatch of the most tolerant eggs.

Table 2. Effects of irradiation on *T. palmi* and *T. tabaci* second instar larvae

Dose (Gy)	No. of tested larvae[1)]	No. of pupae[2)]	No. of adults[3)]	Sex ratio (♂ : ♀)	Mortality[4)] (%)	No. of descendants[5)]
T. palmi						
0	134	96 (71.6)	82 (61.2)	40:42	36.6	300
100	121	41 (33.9)	9 (7.4)	5: 4	100	0
200	120	13 (10.8)	2 (1.7)	1: 1	100	0
400	126	23 (18.3)	2 (1.6)	1: 1	100	0
T. tabaci						
0	130	94 (72.3)	92 (70.8)	0:92	20.7	680
100	107	11 (10.3)	2 (1.9)	0:2	100	0
200	134	1 (0.7)	0 (0)	—	—	—
400	113	1 (0.9)	0 (0)	—	—	—

1) Total number of larvae in 6 replicates.
2) Value in parentheses is percentage of pupation.
3) Value in parentheses is percentage of adult emergence.
4) Mortality of the adults emerged was calculated 14 days after irradiation.
5) The number of descendants obtained was counted 14 days after irradiation.

Table 3. Effects of irradiation on *T. palmi* and *T. tabaci* adults

Dose (Gy)	No. of tested adults[1)]	Days after irradiation	Mortality[2)] (%)	No. of descendants[3)] Larvae	Pupae	Adults(♂:♀)
T. palmi						
0	103	0- 7	62.1	260	198	51 (45: 6)
		7-14	96.1	12	—	—
100	121	0- 7	46.3	14	33	1 (1: 0)
		7-14	96.7	0	—	—
200	112	0- 7	44.6	0	1	0
		7-14	98.2	0	—	—
400	105	0- 7	54.3	0	0	0
		7-14	96.2	0	—	—
T. tabaci						
0	121	0- 7	82.6	82	305	232 (0:232)
		7- 4	98.3	28	—	—
100	116	0- 7	59.5	12	139	156 (0:156)
		7-14	97.4	0	—	—
200	126	0- 7	65.1	0	12	30 (0: 30)
		7-14	98.4	0	—	—
400	118	0- 7	57.6	0	0	0
		7-14	100	0	—	—

1) Total number of adults in 5 replicates.
2) Mortality of the irradiated adults was calculated.
3) The number of descendants obtained was counted 14 days after irradiation.

Second instar larvae

The adult emergence of *T. tabaci* was inhibited at 200Gy, while the adults of *T. palmi* (a male and a female) appeared from survived larvae even at 400Gy (Table 2). Adults which emereged at 100Gy or higher did not produce their descendants. WIT and van de VRIE (1985) reported that the second instar larvae of *Frankliniella pallida* irradiated with 200Gy of gamma ray were killed before the pupation. Second instar larvae of *T. palmi* and *T. tabaci* were not inhibited in terms of the pupation even at 400Gy. Likewise a dose higher than 100Gy was required to inhibit the adult emergence of *F. pallida* (WIT and van de VRIE, 1985). While higher than 200Gy was required to inhibit the adult emergence of *T. tabaci*, even 400Gy could not inhibit the adult emergence of *T. palmi*. The differences in the irradiation effects on the pupation and the adult emergence rate among these three species of thrips were caused by the growth of the second instar larvae at the time of the irradiation rather than by the irradiation types. The second instar larvae of *F. pallida* or *T. tabaci* irradiated at 200Gy or higher will survive, pupate and emerge after irradiation if they are mature larvae, which are completely sterilized with at least 100Gy irradiation.

Adults

The mortality of unirradiated adults was higher than that of irradiated ones 7 days after irradiation (Table 3). However, almost the same mortality was obtained between the unirradiated and the irradiated adults in 14 days after irradiation. The adults of both species were sterilized at 400Gy, although their descendants were obtained at 200Gy or lower. At 100Gy, the adults of both species still kept their fecundities for about 7 days after irradiation, while at 200Gy they were sterilized within several days. Comparison of the tolerance between *T. palmi* and *T. tabaci* adults by the number of descendants seems to be difficult because of the vague longevities of tested adult females, and the difference of the number of adult females.

Conclusion

These results indicate that the adult stage is the most tolerant to irradiation among the eggs, second instar larvae and adults, but do not show clearly which of *T. palmi* or *T. tabaci* is more tolerant. All stages of *T. palmi* and *T. tabaci* were sterilized or disinfested at 400Gy. No severe injuries were observed on many kinds of cut flowers irradiated at 400Gy (WIT and van de VRIE, 1985 ; TANABE and DOHINO, 1993 ; TANABE and DOHINO, 1995). It is, therefore, considered that the electron beam irradiation is an effective quarantine treatment against thrips on cut flowers.

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和文摘要

ミナミキイロアザミウマ *Thrips palmi* KARNY 及びネギアザミウマ *Thrips tabaci* LINDEMAN に対する電子線照射の効果

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ミナミキイロアザミウマ *Thrips palmi* 及びネギアザミウマ *Thrips tabaci* の卵、第二幼虫及び成虫に 100Gy, 200Gy, 400Gy の電子線(2.5MeV)をそれぞれ照射し、その効果を調べた。

1) 日齢が進んだ卵の方が照射耐性が高かった。しかしながら、照射卵から孵化した個体の蛹化は、100Gy 照射で阻止された。
2) 第二幼虫は 400Gy 照射でも羽化したが、100Gy 以上の照射で完全に不妊化された。
3) 成虫は 200Gy 以下の照射では不妊化されず次世代を残したが、400Gy 照射では完全に不妊化された。