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Effects of Electron Beam Irradiation on Sterility of Comstock Mealybug, *Pseudococcus comstocki* (KUWANA) (Homoptera: Pseudococcidae)

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Abstract: Twelve-day-old eggs and third-instar nymphs (including 77.5% preovipositional adult females) were irradiated with electron beams in order to determine their radiosensitivities. Survivors from the 12-day-old eggs irradiated at 400 Gy or higher died in the 1st-instar nymphs; however, at 200 Gy, survivors grew up to adult females slowly. Cross test indicated that they were sterilized. Third-instar larvae were sterilized at 200 Gy or higher, so they yielded unviable eggs.
Key words: radiation, Pseudococcidae, *Pseudococcus comstocki*, sterility, cut flower, commodity treatment

Introduction

Data on the disinfestation with electron beam irradiation have been accumulated in order to develop a quarantine treatment of infested cut flowers alternative to methyl bromide fumigation. There are few studies which have dealt with irradiation of mealybugs or scales (ANGERILLI and FITZGIBBON, 1990; WIENDL *et al.*, 1994).

In our previous study, we irradiated eggs, 1st-instar nymphs and mature adult females of Comstock mealybug, *Pseudococcus comstocki* at 200, 400 and 600 Gy, and found that 12-day-old eggs were the most tolerant to the irradiation among the other egg stages (0-5-day-old, 6-10-day-old and 11-day-old); 1st-instar nymphs were killed at 200 Gy or higher; mature adult females were sterilized at 400 Gy or higher (DOHINO and MASAKI, 1995). However, a few problems still should be solved. "How do the survivors from the irradiated 12-day-old eggs develop?" or "Do they attain to adult stage and keep their fecundities?" The decrease in larval/nymphal radiosensitivity in developing larval/nymphal instar has been reported in various arthropod pests (BURDITT and HUNGATE, 1989; ELBADRY *et al.*, 1972; HARWALKAR and NAIR, 1968). "How are the radiosensitivities of the nymphs older than 1st-instar nymphs?" The authors investigated the effects of electron beam irradiation on 12-day-old eggs and 3rd-instar nymphs of *P. comstocki* to answer the above questions.

Materials and Methods

1. Test insects

Test insects were obtained from a laboratory colony of Comstock mealybug, which were reared on pumpkin, *Cucurbita moschata* (DUCHESNE) (DUCHESNE ex POIR) in polyethylene containers (14 cm in height, 18 cm in diameter) at 23±1°C and 70% r.h., under a photoperiod of 24D. The developmental duration of the eggs was 12 days under these rearing conditions. Adult males emerged in about 30 days

and adult females laid eggs in about 50 days after hatching.

Five adult females were allowed to oviposit for 24 hours in a petri dish. Egging and preparation of 12-day-old eggs were conducted under the rearing conditions.

Fifty 3rd-instar nymphs including 77.5% preovipositional adult females, which were obtained 28–30 days after hatching and already coupled with males, were collected from the infested pumpkin and placed in a petri dish.

2. Irradiation

The 12-day-old eggs or the 3rd-instar nymphs in a petri dish were irradiated with electron beams according to the previous study (DOHINO and MASAKI, 1995).

3. Evaluation of development and fecundity

The irradiated 12-day-old eggs or the irradiated 3rd-instar nymphs were inoculated on an uninfested pumpkin in a polyethylene container and held under the rearing conditions to investigate their subsequent development, mortality and fecundity.

In the irradiated 12-day-old eggs, the number of survivors and dead nymphs were counted 5 weeks after irradiation. The number of females and adult females which oviposited were counted 7 weeks after irradiation, and the yielded eggs were transferred into a petri dish. Nine weeks after irradiation, the hatchability was calculated.

In the 3rd-instar nymphs, the number of dead insects and adult females which oviposited were counted 2 weeks after irradiation, and the yielded eggs were transferred into a petri dish. The hatchability was calculated 4 weeks after irradiation to investigate the fecundity of the irradiated 3rd-instar nymphs.

Results and Discussion

1. Twelve-day-old eggs

When 12-day-old eggs, which were the most tolerant eggs, were irradiated with electron beams, the survivors from the eggs treated at 400 Gy and at 600 Gy were blackened and died in 1st-instar nymphs (Table 1). Differentiations between male and female appeared on the control in 5 weeks after irradiation, whereas 288 nymphs without the differentiation existed at 200 Gy. Likewise, adult females which were obtained from the control oviposited within 7 weeks after irradiation, whereas survivors

Table 1. Effects of electron beam irradiation on 12-day-old eggs of *P. comstocki*

Dose (Gy)	No. of[1] tested eggs	5 weeks after irradiation			7 weeks after irradiation		9 weeks after irradiation	
		No. of dead nymphs	No. of adult males	No. of adult females	No. of adult females	No. of ovipositing females	No. of[2] eggs	Hatchability (%)
0	1,545	28	412	1,105	1,092	85	7,118	92.2
200	1,545	150	nymphs 288		nymphs 26	–	–	–
400	1,545	142	–	–	–	–	–	–
600	1,545	53	–	–	–	–	–	–

1) Total number of eggs in 3 replications and the number of tested eggs in each dose were estimated by the number of hatched individuals in control.
2) Number of eggs which were obtained from the ovipositing females in 7 weeks after irradiation.

Table 2. Effects of electron beam irradiation on 3rd-instar nymphs of *P. comstocki*

Dose (Gy)	No. of[1] tested insects	2 weeks after irradiation		4 weeks after irradiation	
		No. of dead insects	No. of ovipositing females	No. of[2] eggs	Hatchability (%)
0	150	6	37	2,751	80.5
200	150	1	23	1,439	0
400	150	10	17	671	0
600	150	10	4	45	0

1) Third-instar nymphs including 77.5% preovipositional adult females were irradiated and the total number of insects in 3 replications.
2) Number of eggs which were obtained from the ovipositing females in 2 weeks after irradiation.

from at 200 Gy developed slowly and were still nymphal stage at this time. The survivors attained to adult stage 3 months after irradiation and they were all females. These females were crossed with unirradiated males in order to investigate their fecundities. The cross test indicated that these females were sterilized by 200 Gy irradiation and yielded unviable eggs.

2. Third-instar nymphs

Both the number of adult females which oviposited and the number of eggs yielded were in inverse proportion to the rise in dosage, although at the maximum dosage in our test, 600 Gy irradiation could not prevent them ovipositing (Table 2). However, the eggs which were laid by the females irradiated at 200 Gy or higher did not hatch. It is, therefore, considered that 3rd-instar nymphs and preovipositional adult females were sterilized by 200 Gy irradiation.

Based on the results of our previous study and this paper, it is clear that the most tolerant stage to irradiation is mature adult female among the tested stages (eggs, 1st-instar nymphs, 3rd-instar nymphs and preovipositional adult females, and mature adult females). It is concluded that 400 Gy is needed to disinfest flowers contaminated with any stage of *P.comstocki*.

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和 文 摘 要

クワコナカイガラムシ *Pseudococcus comstocki* (KUWANA) (Homoptera: Pseudococcidae) の不妊化における電子線照射の効果

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前回の報告（DOHINO and MASAKI, 1995）に引続きクワコナカイガラムシ*Pseudococcus comstocki*の12日齢卵及び3齢幼虫(産卵前期間の雌成虫を77.5%含む)に200，400，600Gyの電子線（2.5MeV）をそれぞれ照射し，その影響を調べた。

1） 卵の中で照射最耐性である12日齢卵を照射したとき，400Gy及び600Gyでは得られた孵化幼虫は2齢まで達しなかった。200Gyでは成虫まで達したが，これらはすべて雌であり，妊性調査（対照区の雄成虫との交配試験）から不妊化されていることが判明した。

2） 3齢幼虫（産卵前期間の雌成虫を77.5%含む）を照射したとき，600Gyでも産卵したが，線量増加に伴い産卵個体数及び産卵数は減少した。また，これらの産下卵は200Gy以上で孵化しなかったため3齢幼虫及び産卵前期間の雌成虫は200Gy以上で不妊化されたことが判明した。

3） したがって，前回報告の結果と合わせると，クワコナカイガラムシにおいては，雌成虫が照射最耐性ステージであり，全てのステージを殺虫・不妊化するためには400Gy以上の電子線照射が必要と考える。