



POST HARVEST CONTROLLING OF ORCHID THRIPS ON CUT FLOWERS BY IRRADIATION

K. BANSIDDHI, S. SIRIPHONTANGMUN

Division of Entomology and Zoology,
Department of Agriculture,
Jatuchack, Bangkok, Thailand

Abstract

Post-harvest controlling of orchid thrips, *Thrips palmi* Karny on cut flowers by irradiation was conducted during October 1992 to September 1997 at the Thai Irradiation Centre (TIC) and Division of Entomology and Zoology, Department of Agriculture, Thailand. The studies were carried out by conducting experiments on irradiation of cut flowers for controlling thrips with doses ranging from 0.1 to 1 kGy. The vase life of radiated cut flowers was evaluated. Colonies of thrips were established in the laboratory in order to determine radiation sensitivity of various development stages of thrips and also to assess the occurrence of natural infestations by examining commercial market quality flowers from growers where management practices can be identified. Results from five years of research on post harvest control of thrips on orchids and cut flowers by irradiation showed that despite intensive investigation, difficulty in permanent establishment of a laboratory colony of *Thrips palmi* Karny for bioassays continued. The snap bean rearing method for rearing large number of thrips has been developed, although it is less satisfactory than desirable. It has given sufficient numbers for testing in the 6th experiment. The maximum dose tolerated by *Dendrobium* orchid flowers at ambient temperature (25 - 30 °C) was below 0.5 kGy, but at a pre-and post irradiation temperature 15 - 18 °C, the maximum dose tolerated approached 0.75 - 0.8 kGy. The effective dose for control *Thrips palmi* Karny, however, was higher than 0.75 kGy.

1. INTRODUCTION

Thrips are important agricultural pests not only because of the mechanical injury caused by their feeding, but they also are vectors for bacterial, fungal and viral disease organisms. They are abundant in vegetation and live mainly in flowers without any noticeable damage. Among the pests of ornamental crops in Thailand, the orchid thrips *Thrips palmi* Karny and *Dichromothrips corbetti* Prisner are considered to be the most destructive sucking insect in both the high land and low land areas. Severe damage causes silvery or whitish patches that gradually become light brown to brown, and finally the flowers fall off. The few research reports on thrips in Thailand deal mainly with which chemical control method can be used, but sensitivity to a number of commercially available insecticides is low. Eggs are deposited in plant tissues where the larvae feed. They pupate in the soil. These properties make it difficult to control thrips with chemicals unless they are sprayed many times. The major problems from orchid thrips in Thailand is not only the severe damage on cut flowers, especially orchid and chrysanthemum, but also the presence of thrips found in export products, and then necessitating a quarantine treatment. In order to avoid or reduce the use of pesticides, radiation of orchid cut flowers is an alternative that needs intensive study. The orchid flowers irradiated and studied in this report were obtained and packed both from growers and exporting companies in Bangkok, Thailand.

2. MATERIALS AND METHODS

2.1. Assessing the occurrence of natural infestation

Monthly investigations, explorations, and recordings were made from 1992-1997 in five locations of commercial and local market quality from growers. The result showed that the infestation of thrips in cut flowers for exportation from October 1992 to December 1995 was low and averaged 4.48% - 5.7% (Tables I, II). Infestation increased to 8.44 - 12.91 % in 1996-1997 (Table III).

Possibly the attractive cost of cut flowers during 1992 to 1997 may have induced growers to use more pesticide to control thrips. Without control, thrips caused 100% infestation of plants and damaged plants in many ways, such as producing galls, causing patching or white spot on flowers, and feeding on the sap of living plant cells. If the flower surface is fed on extensively, silvery, whitish, or colorless patches are formed. These patches or spots gradually become light brown to brown, and finally the flowers fall off.

2.2. Mass rearing of thrips

Mass rearing of thrips is very difficult, because of the lack of proven mass rearing techniques. Thrips were collected from areas where high usage of pesticides has occurred, and lack of a susceptible strain made evaluation of resistant and susceptible tests difficult. Rearing studies were divided into two parts: first, the use of natural diets, and second, the use of artificial diets.

2.2.1. The use of natural substrate

Live thrips were collected from orchid growing areas and reared on 6 different plant flowers (as a natural diet) including orchid (*Vanda spp.*), okra (*Abelmoschus esculentus*), chrysanthemum (*Chrysanthemum hortorum*), egg plant (*Solanum melongena*), cucumber (*Cucumis spp.*), and watermelon (*Citrullus lanatus*). The result showed that thrips appeared to only survive tested crop flowers, and populations of *Thrips palmi* Karny did not increase enough for testing.

TABLE I. ORCHIDS INFESTED BY THE THRIPS *Thrips palmi* Karny IN 1992-1993.

Month 1992	No. of orchid flowers Examined Infested			% infestation	Month 1993	No. of orchid flowers Examined Infested			% infestation
JAN	200	10		5	JAN	250	11		4.4
FEB	250	14		5.6	FEB	200	13		6.5
MAR	370	29		7.83	MAR	380	39		10.26
APR	150	13		8.66	APR	200	26		13
MAY	100	8		8	MAY	150	14		9.33
JUN	250	11		4.4	JUN	250	11		4.4
JUL	200	3		1.5	JUL	300	8		2.66
AUG	170	6		3.52	AUG	200	9		4.5
SEP	350	8		2.28	SEP	400	15		3.75
OCT	400	5		1.25	OCT	320	9		2.81
NOV	300	7		2.33	NOV	300	7		2.33
DEC	350	12		3.42	DEC	190	4		2.1
Total	3,090	126		53.79	Total	3,140	166		66.04
Average	2,575	105		4.48	Average	261.66	13.83		5.5
Max	400	29		8.66	Max	400	39		13
Min	100	3		1.25	Min	150	4		2.1

TABLE II. ORCHIDS INFESTED BY THE THRIPS *Thrips palmi* Karny IN 1994-1995.

Month 1994	No. of orchid flowers Examined Infested		% infestation	Month 1995	No. of orchid flowers Examined Infested		% infestation
JAN	180	9	5	JAN	190	9	4.73
FEB	220	16	7.27	FEB	210	9	4.28
MAR	300	22	7.33	MAR	350	39	11.14
APR	160	14	8.75	APR	180	21	11.66
MAY	140	9	6.42	MAY	160	17	10.62
JUN	180	7	3.88	JUN	220	13	5.9
JUL	190	6	3.15	JUL	200	17	8.5
AUG	150	7	4.66	AUG	170	9	5.29
SEP	230	5	2.17	SEP	-	-	-
OCT	300	7	2.33	OCT	210	7	3.33
NOV	280	3	1.07	NOV	300	4	1.33
DEC	340	11	3.23	DEC	290	5	1.72
Total	2,670	116	55.26	Total	2,480	150	68.5
Average	223	9.66	4.6	Average	206.66	12.5	5.7
Max	340	11	8.75	Max	350	39	11.66
Min	140	3	1.07	Min	150	4	1.72

2.2.2. Mass rearing by the snap bean method

This thrips rearing method was learned from Dr. Ron Mau, University of Hawaii, and Dr. Diane Ullman and Dr. Wayne Hunter, University of Davis. Young to mature pods of snap bean, *Phaseolus vulgaris*, were selected as the test plant part. The studies were conducted at the Entomology and Zoology laboratory, Bangkok, under temperature and humidity controlled conditions. Beans were covered completely with 2% Clorox bleach for 10 minutes, then given a quick water rinse and allowed to drain. The bean pods were placed on tissue papers to dry, and when dry, the ends were trimmed off in order to reduce mold. The beans were then ready to use for mass rearing of the thrips in plastic cups.

At least 15-20 cups and about 5 beans per cup were used, and live adult thrips (collected from farmer's plots) were released into each cup. For adult egg laying, a small amount of diluted honey was placed in the groove of a bean, but the entire bean was not covered. Tapping on the top of containers knocked adults to the bottom of the cup. Also opening the lid slightly and blowing one's breath on the thrips caused them to jump to the bottom of the cup. A small brush was used to remove any adults on beans that were to be moved to new cups. Moisture was provided and controlled by placing pieces of filter paper in the bottom of cup to help absorb excess moisture. This rearing procedure provided eggs, larvae, pupae, and adults.

TABLE III. ORCHIDS INFESTED BY THE THRIPS *Thrips palmi* Karny IN 1996-1997.

Month 1996	No. of orchid flowers Examined Infested		% infestation	Month 1997	No. of orchid flowers Examined Infested		% infestation
JAN	214	5	2.42	JAN	236	16	6.77
FEB	231	20	9.65	FEB	224	19	8.48
MAR	210	20	9.52	MAR	228	26	11.40
APR	172	18	10.46	APR	218	41	18.80
MAY	224	34	15.17	MAY	176	19	10.79
JUN	204	25	12.26	JUN	178	32	17.97
JUL	241	32	13.27	JUL	126	23	18.25
AUG	141	13	9.21	AUG	176	27	15.34
SEP	270	19	7.03	SEP	201	17	8.45
OCT	269	21	7.80	OCT	-	-	-
NOV	272	8	2.94	NOV	-	-	-
DEC	201	3	1.56	DEC	-	-	-
Total	2649	218	101.29	Total	1,763	220	116.25
Average	220.75	18.16	8.44	Average	195.88	24.44	12.91
Max	272	34	15.17	Max	236	41	18.80
Min	141	3	1.56	Min	126	16	6.77

3. RESULTS AND DISCUSSION

3.1. The egg stage

Eggs were collected from adults at two-day intervals; for more precise staging, eggs should be collected at 24-hr intervals. In practice, eggs cups were made every two days and about 15-20 cups for egg collection were maintained. It was not possible to synchronize development of the thrips and to have all individuals in the same stage at one time.

3.2. The larval stage

The first instars of thrips prefer the youngest beans. After beans with eggs are removed from cups, they should be put in a clean cup, with a filter paper in the bottom. It was also practical to combine different cups together (usually 2 egg cup beans into one cup). Fresh beans were added to the previous egg cups for collection of more eggs. Larvae can hide in the wrinkles of older beans, so they must be inspected carefully. After first instars are observed on fresh beans, the old beans can be removed. Additional beans were added as needed on the second day, and again 2 days later. Only 2-3 beans were needed to maintain a food source. It is important to observe the quality of the beans in the cups, and touching them aids in determining if they are too dry, and need replacing.

3.3. The adult stage

The emergence of new adults should be recorded to determine the developmental time; adults were produced in 10-15 days at 28 °C, but the time can be as long as 18-24 days at 20 °C. The first

addition of beans to new adults was plain beans. Streaked beans can be used, but it takes a few days for females to mature and then lay more eggs on the 2nd changing of beans. If only larvae are needed and adults of a specific age are not needed, then one can put two cups of adults into one cup of beans for higher egg production. Developing and learning to use the snap bean rearing method was started in 1996-1997, and larval thrips obtained increased enough for testing. However, it was not possible to get large numbers of the same instar of larval thrips at the same time. Therefore, development of and confirmatory rearing studies of thrips on snap beans or other substrates, and improved alternative rearing techniques under laboratory conditions needs continued study.

3.4. Experiments on irradiation of cut flowers for controlling thrips

Six experiments were performed. The first experiment was conducted at ambient room temperature 27 - 30 °C and 70 - 75% RH (no control of temperature and moisture), but experiments 2-6 were conducted under temperature and humidity controlled conditions in which the orchid flowers were transported by an air conditioned bus from growers to the irradiation center and stored in the laboratory at 12 - 18 °C and 70 - 75% RH. Doses of 0, 0.1, 0.3, 0.5, 0.8, and 1.0 kGy (also 1.5 kGy in experiments 5 and 6) from a cobalt-60 source were used to treat cut flowers of *Dendrobium* Pompadour. Before irradiation, 625 inflorescences of orchid flowers were prepared and packed in 25 cardboard boxes (size 24 x 63.5 x 6.6 cm). A Randomized Complete Block design was used with 5 replications and 6 treatments. After irradiation the treated flowers were kept under controlled conditions at 20±2 °C and 80-90% RH, and were put in vases that contained 100 ml of distilled water.

Observations were made on vase life and damage symptoms 24 hours after treatment and for 12 days post treatment. Observations of the number of thrips (live and dead) and % mortality was done under a microscope 24 hours after irradiation, and continued for 12 days post treatment. For evaluation, five inflorescences were randomly removed from 25 of each treatment. In general, shelf life or vase life was determined both in opened and unopened flowers. Export standards require acceptable vase life for 7 days or more.

Vase life effects of irradiation were divided into 6 grades as follows:

- 1 = Fresh, no damage (no difference in quality between treated and untreated).
- 2 = Slight damage symptoms, 5-10% of treated flowers (opened and unopened) show symptoms of wilting and beginning to yellow. This is considered to be commercially acceptable damage that will be acceptable to consumers.
- 3 = Moderate damage symptoms with 10 - 15% wilted; this is considered acceptable to consumers.
- 4-6 = Severe damage, more than 25 -50% wilted, flowers or buds completely dropped over, and unacceptable to consumers.

4. RESULTS AND DISCUSSION

4.1. Effects on cut flowers

Effect of irradiation varied according to flower quality and cultivar. In many cases the vase life and quality of treated flowers were comparable to the untreated. A longer vase life occurred after treatment with Co-60 at the rate of 0.3 and 0.5 kGy. In a number of cases the effects were partly influenced by physiological state of the flowers. Indications were found in 3 reactions, as follows:

(1) When there was no temperature control during transportation before and after irradiated, damage was more severe and vase life was shorter.

(2) Damage in low quality (local grade) of orchid flowers was more severe than in exporting grade (high quality).

TABLE IV. EFFECT OF IRRADIATION ON OPENED ORCHID FLOWERS AND VASE LIFE IN EXPERIMENT 1, 19 JAN.-2 FEB. 1994 AT 27-30 °C, 70-75% RH. MEAN RATING GIVEN TO OPENED FLOWERS AT INDICATED DOSE AND DAYS AFTER TREATMENT (DAT).

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	9 DAT	11 DAT
Untreated	1.00	1.75 b	2.16 d	2.79 d	2.99 d	3.54 c
0.1	1.00	1.66 b	2.37 c	2.58 d	2.93 d	3.43 c
0.3	1.00	1.77 b	2.83 b	3.22 c	3.41 c	3.83 bc
0.5	1.00	1.95 a	2.92 b	3.57 b	3.77 b	4.10 ab
0.8	1.00	1.97 a	2.49 a	4.05 a	4.47 a	4.40 a
CV%	NS	7.20	5.42	7.56	4.52	7.52

TABLE V. EFFECT OF IRRADIATION ON UNOPENED ORCHID FLOWERS AND VASE LIFE IN EXPERIMENT 1, 19 JAN.-2 FEB. 1994 AT 27-30 °C, 70-75% RH. MEAN RATING GIVEN TO UNOPENED FLOWERS AT INDICATED DOSE AND DAYS AFTER TREATMENT (DAT).

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	9 DAT	11 DAT
Untreated	1.00	1.03	1.11 c	1.28 c	1.56 c	1.99 c
0.1	1.00	1.04	1.14 bc	1.24 c	1.53 c	1.87 c
0.3	1.00	1.04	1.18 bc	1.27 c	1.51 c	1.84 c
0.5	1.00	1.04	1.27 b	1.53 b	2.04 b	2.56 b
0.8	1.00	1.06	1.46 a	2.07 a	2.98 a	3.42 a
CV%	NS	NS	7.53	12.13	15.52	13.17

Note : Level 1 - 3 is acceptable to consumers.
Level 4 - 6 is unacceptable.

TABLE VI. EFFECT OF IRRADIATION TREATMENT ON OPENED ORCHID FLOWERS, EXPERIMENT 2, 7-18 JUNE, 1995 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 18 °C, 70-75% RH. MEAN RATING GIVEN TO OPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	9 DAT	11 DAT
Untreated	1.00	1.11 b	2.00	2.87 b	3.32 b	3.49 c
0.1	1.00	1.10 b	2.25	3.16 b	3.75 b	4.1 bc
0.3	1.00	1.10 b	2.16	3.24 b	3.75 b	3.93 bc
0.5	1.00	1.45 a	3.26	3.81 a	4.58 a	4.81 a
0.8	1.00	1.2 b	2.39	3.34 ab	3.90 b	4.24 ab
CV%	NS	12.82	NS	11.29	12.42	11.81

TABLE VII. EFFECT OF IRRADIATION TREATMENT ON UNOPENED ORCHID FLOWERS, EXPERIMENT 2, 7-18 JUNE, 1995 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 18 ° C, 70-75% RH. MEAN RATING GIVEN TO UNOPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	9 DAT	11 DAT
Untreated	1.00	1.00	1.03 c	1.05 b	1.10 c	1.29 c
0.1	1.00	1.00	1.07 bc	1.22 b	1.55 bc	1.71 bc
0.3	1.00	1.05	1.25 abc	1.59 ab	1.95 ab	1.93 b
0.5	1.00	1.00	1.40 ab	2.01 a	2.39 a	2.58 a
0.8	1.00	1.01	1.44 a	1.79 a	2.17 a	2.30 ab
CV%	NS	NS	19.22	25.42	20.51	22.44

Note : Level 1 - 3 is acceptable to consumers.
Level 4 - 6 is unacceptable.

(3) On average, the lower flowers of each inflorescence had a shorter vase life, more severe damage, turned yellow, and dropped down within 5-7 day after being irradiated at 0.5, 0.8, and 1 kGy when there was no temperature control. With temperature controlled conditions, similar damage occurred only at 0.8 and 1 kGy.

Therefore, the effects of irradiation on cut flowers trend to depend on flowers quality and cultivar. Negative effects of higher doses of radiation occurred in a number of cut flowers. For the five doses studied, the percentages of flowers that showing no damage or acceptable damage were 87.85% at 0.1 kGy, 86.80% at 0.5 kGy, and 86.10% at 0.8 kGy 7 days after treatment (DAT).

5. THRIPS CONTROL

5.1. Mortality of orchid thrips caused by Co-60 radiation

The effect of irradiation on the second instar (larvae stage) was studied in six experiments with Co-60 radiation at doses of 0, 0.1, 0.3, 0.5, 0.75, 1.0, and 1.5 kGy. Experiments 1-4 were done with an unknown number of thrips, but in experiments 5 and 6, the original number of thrips 2nd instars was known. A Complete Randomized Block (CRD) was designed with six treatments and five replications. Observations were made at 1, 3, 5, 7, 10, and 12 days after treatment by recording the number of live and dead thrips in each replications in order to calculate percent mortality from irradiation with Co-60. For evaluation, five inflorescences were taken randomly from 25 flowers in each treatment. Results are tabulated separately for experiments in which the original number of thrips was unknown and for those experiments in which the original number was known. In the tables that follow values in a column followed by the same letter are not significantly different.

6. RESULTS AND DISCUSSION

6.1. Unknown number of thrips in the test

Experiments 2-4 (when the mass rearing method is not applicable) were done with an unknown number of thrips. In experiments 3-4, when immediate death was the criterion evaluated, the results presented in detail in Tables XIV-XVI, showed that 0.5 kGy gave 50% mortality at 3 DAT, 0.8 kGy gave 85.71% in experiment 3, and 85% and 90% mortality in experiment 4.

TABLE VIII. EFFECT OF IRRADIATION TREATMENT ON OPENED ORCHID FLOWERS, EXPERIMENT 4, 25 APR.- 4 MAY, 1996 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 12 - 15 ° C, 70-75% RH. MEAN RATING GIVEN TO OPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	12 DAT
Untreated	1.00	1.00	1.99	2.48 b	2.93 cd	3.14 c
0.1	1.00	1.00	2.03	2.43 b	2.79 d	3.66 b
0.3	1.00	1.00	2.00	2.70 b	3.17 bc	3.96 d
0.5	1.00	1.06	2.05	2.64 d	3.19 bc	3.80 d
0.8	1.00	1.00	2.00	2.78 ab	3.40 b	3.89 b
1.0	1.00	1.00	2.00	3.07 a	4.00 a	4.78 a
CV%	NS	NS	NS	8.19	5.67	4.83

TABLE IX. EFFECT OF IRRADIATION TREATMENT ON UNOPENED ORCHID FLOWERS, EXPERIMENT 4, 25 APR.- 4 MAY, 1996 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 12 - 15 ° C, 70-75% RH. MEAN RATING GIVEN TO UNOPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	12 DAT
Untreated	1.00	1.00	1.58 b	1.42 d	1.85 ab	2.05 b
0.1	1.00	1.00	1.58 b	1.52 cd	1.75 b	2.11 b
0.3	1.00	1.00	1.57 b	1.60 bcd	2.11 a	2.14 ab
0.5	1.00	1.16	1.67 ab	1.63 bc	1.88 ab	2.11 b
0.8	1.00	1.00	1.77 a	1.75 ab	2.09 a	2.27 a
1.0	1.00	1.00	1.75 a	1.88 a	2.07 a	2.28 a
CV%	NS	NS	4.51	7.68	8.82	4.43

TABLE X. EFFECT OF IRRADIATION TREATMENT ON OPENED ORCHID FLOWERS, EXPERIMENT 5, 12 - 24 JUNE 1997 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 18 - 26 ° C, 72-76% RH. MEAN RATING GIVEN TO OPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	12 DAT
Untreated	1.59 b	2.22 c	2.49	2.95 bc	3.32 ab	3.65 ab
0.3	1.08 a	1.33 a	2.28	2.67 ab	3.34 ab	3.68 ab
0.5	1.04 a	1.62 ab	2.28	2.39 a	2.97 a	3.32 a
0.75	1.26 ab	1.83 bc	2.69	3.36 c	4.10 c	4.76 c
1.0	1.10 a	1.69 ab	2.52	2.96 bc	3.62 bc	3.91 b
1.5	1.22 a	1.92 bc	2.54	3.93 d	5.51 d	5.90 d
CV%	15.9	18.1	NS	11.8	9.6	8.2

TABLE XI. EFFECT OF IRRADIATION TREATMENT ON UNOPENED ORCHID FLOWERS, EXPERIMENT 5, 12 - 24 JUNE 1997 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 18 - 26 ° C, 72-76% RH. MEAN RATING GIVEN TO UNOPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	12 DAT
Untreated	1.02	1.07	1.34	1.67 ab	1.84 ab	2.03 b
0.3	1.00	1.08	1.28	1.42 a	1.52 a	1.56 a
0.5	1.00	1.07	1.29	1.47 ab	1.86 ab	2.07 b
0.75	1.00	1.12	1.54	1.79 b	2.11 b	2.38 b
1.0	1.00	1.13	1.54	1.69 b	2.09 b	2.18 b
1.5	1.00	1.01	1.43	2.12 c	2.59 c	2.78 c
CV%	NS	NS	NS	13.3	14.9	12.4

TABLE XII. EFFECT OF IRRADIATION TREATMENT ON OPENED ORCHID FLOWERS, EXPERIMENT 6, 17 - 30 JULY 1997 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 20 - 21 ° C, 70-82% RH. MEAN RATING GIVEN TO OPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	12 DAT
Untreated	1.00	1.05	1.47 a	3.18 a	3.31 a	3.75 a
0.3	1.00	1.07	2.53 de	3.12 a	3.60 a	3.87 a
0.5	1.00	1.07	2.12 c	3.21 a	4.18 b	4.37 b
0.75	1.02	1.06	2.34 cd	3.55 b	4.48 b	4.91 c
1.0	1.00	1.03	1.79 b	3.22 ab	4.61 b	5.23 c
1.5	1.00	1.03	2.71 e	4.73 c	5.85 c	5.96 d
CV%	NS	NS	10.8	6.3	6.0	6.2

TABLE XIII. EFFECT OF IRRADIATION TREATMENT ON UNOPENED ORCHID FLOWERS, EXPERIMENT 5, 17 - 30 JULY 1997 WITH TEMPERATURE AND RELATIVE HUMIDITY CONTROLLED AT 20 - 21 ° C, 70-82% RH. MEAN RATING GIVEN TO UNOPENED ORCHIDS TREATED WITH THE DOSE INDICATED AND AT DAYS AFTER TREATMENT (DAT)

Dose (kGy)	1 DAT	3 DAT	5 DAT	7 DAT	10 DAT	12 DAT
Untreated	1.00	1.04	1.18 a	1.41 a	1.51 a	1.62 a
0.3	1.00	1.03	1.48 bc	1.63 ab	1.82 bc	1.90 ab
0.5	1.00	1.10	1.55 bc	1.81 b	1.99 bc	2.00 b
0.75	1.00	1.02	1.38 ab	1.85 b	2.10 c	2.13 b
1.0	1.00	1.04	1.16 a	1.60 ab	1.80 b	1.83 ab
1.5	1.00	1.03	1.66 c	2.13 c	2.63 d	2.85 c
CV%	NS	NS	10.7	10.3	10.5	10.7

Note : Level 1-3 is acceptable to consumers.

Level 4-6 is unacceptable.

TABLE XIV. PERCENTAGE MORTALITY OF THRIPS AFTER IRRADIATION IN EXPERIMENTS 3 AND 4 WHEN THE ORIGINAL INFESTATION NUMBER OF THRIPS WAS NOT KNOWN

Dose (kGy)	EXP 3 MARCH 1996				EXP 4 APRIL-MAY 1996			
	1 DAT	3 DAT	5 DAT	7 DAT	1 DAT	3 DAT	5 DAT	7 DAT
Untreated	0	0	0	0	0	0	0	0
0.1	10.00	12.50	0	0	81.42	20.00	0	0
0.3	0	0	0	0	87.49	66.66	0	0
0.5	0	50.00	0	0	85.00	42.85	0	0
0.8	82.60	85.71	0	0	90.00	54.54	0	0
1.0	-	-	-	-	100	90.00	0	0

TABLE XV. EFFECT OF COBALT -60 IRRADIATION ON *Thrips palmi* Karny DAYS AFTER TREATMENT IN EXPERIMENTS 3 AND 4

Dose (kGy)	EXP 3 MAR 1996						EXP 4 MAY 1996					
	0	0.1	0.3	0.5	0.8	1.0	0	0.1	0.3	0.5	0.8	1.0
Number of thrips studied	7	8	4	4	7	-	11	10	9	7	11	10
No. live thrips after treatment	7	7	0	2	1	-	11	8	3	4	5	1
No. dead thrips after treatment	0	1	0	2	6	-	0	2	6	3	6	9
% mortality	0	12.5	0	60	85.71	-	0	20	66.66	42.25	54.54	90

TABLE XVI. EFFECT OF COBALT - 60 IRRADIATION ON *Thrips palmi* Karny SEVEN DAYS AFTER TREATMENT IN EXPERIMENTS 3 AND 4

Dose (kGy)	EXP 3 MAR 1996						EXP 4 MAY 1996					
	0	0.1	0.3	0.5	0.8	1.0	0	0.1	0.3	0.5	0.8	1.0
Number of thrips studied	7	3	2	2	2	-	3	2	5	1	8	8
No. live thrips after treatment	0	0	0	0	0	-	3	2	5	1	8	1
No. dead thrips after treatment	0	0	0	0	0	-	0	0	0	0	0	1
% mortality	0	0	0	0	0	-	0	0	0	0	0	12.5

TABLE XVII. PERCENTAGE MORTALITY OF THRIPS AFTER IRRADIATION WHEN A KNOWN NUMBER OF THRIPS WAS RELEASED ON ORCHID FLOWERS IN EXPERIMENTS 5 AND 6

Dose (kGy)	EXPERIMENT 5 JUNE 1997						EXPERIMENT 6 JULY 1997					
	1	3	5	7	10	12	1	3	5	7	10	12
	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT
Untreated	0	0	0	0	0	0	0	0	0	0	0	0
0.3	-	-	-	-	-	-	13.79	18.49	21.21	41.58	64.70	100
0.5	11.42	15.15	21.21	39.13	46.15	76.47	11.66	13.95	37.25	57.57	87.50	100
0.75	11.76	13.15	20.00	46.15	62.50	71.42	26.00	34.64	47.05	61.38	100	-
1.0	25.00	40.54	62.00	71.42	100	-	28.94	33.33	78.78	95.95	100	-
1.5	33.33	81.69	100	-	-	-	81.69	92.94	100	-	-	-

TABLE XVIII. EFFECT OF COBALT- 60 IRRADIATION ON *Thrips palmi* Karny FIVE DAYS AFTER TREATMENT IN EXPERIMENT 5 ON 17 JUNE 1997 AND EXPERIMENT ON 22 JULY 1997

Dose (kGy)	EXP 5						EXP 6					
	0	0.3	0.5	0.75	1.0	1.5	0	0.3	0.5	0.75	1.0	1.5
Number of thrips studied (released)	100	-	100	100	100	100	100	100	100	100	100	100
No. live thrips after treatment	133	-	78	80	38	0	105	78	64	54	20	0
No. dead thrips after treatment	0	-	21	20	62	99	0	21	38	48	79	99
% mortality	0	-	21.21	20	62	100	0	21.21	37.25	47.05	78.78	100

TABLE XIX. EFFECT OF COBALT -60 IRRADIATION ON *Thrips palmi* Karny SEVEN DAYS AFTER TREATMENT IN EXPERIMENT 5 ON 19 JUNE 1997 AND IN EXPERIMENT 6 ON 24 JULY 1997

Dose (kGy)	EXP 5						EXP 6					
	0	0.3	0.5	0.75	1.0	1.5	0	0.3	0.5	0.75	1.0	1.5
Number of thrips studied (released)	100	-	100	100	100	100	100	100	100	100	100	100
No. live thrips after treatment	135	-	70	70	28	0	103	59	42	39	4	0
No. dead thrips after treatment	0	-	45	60	70	126	0	42	57	62	95	95
% mortality	0	-	39.13	46.15	71.42	100	0	41.58	57.57	61.38	95.95	100

TABLE XX. PERCENTAGE MORTALITY OF THRIPS IRRADIATED AND HELD IN TEST TUBES AFTER IRRADIATION WHEN THE NUMBER OF THRIPS IN THE TEST WAS KNOWN

Dose (kGy)	EXPERIMENT 5 JUNE 1997						EXPERIMENT 6 JULY 1997					
	1	3	5	7	10	12	1	3	5	7	10	12
	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT	DAT
Untreated	0	0	0	0	0	0	0	0	0	0	0	0
0.3	-	-	-	-	-	-	2	19	51	90	100	-
0.5	9	16	42	68	-	-	8	22	53	91	100	-
0.75	12	18	58	98	-	-	16	41	75	100	-	-
1.0	15	25	96	-	-	-	10	53	90	100	-	-
1.5	12	49	100	-	-	-	26	87	100	-	-	-

TABLE XXI. EFFECT OF COBALT - 60 IRRADIATION ON *Thrips palmi* Karny FIVE DAYS AFTER TREATMENT IN EXPERIMENTS 5 AND 6

Dose (kGy)	EXP 5 17 JUNE 1997						EXP 6 22 JULY 1997					
	0	0.3	0.5	0.75	1.0	1.5	0	0.3	0.5	0.75	1.0	1.5
Number of thrips studied (released)	100	-	100	100	100	100	100	100	100	100	100	100
No. live thrips after treatment	114	-	58	42	4	0	131	49	47	25	10	0
No. dead thrips after treatment	0	-	42	58	96	118	0	51	53	75	90	131
% mortality	0	-	42	58	96	100	0	51	53	75	90	100

TABLE XXII. EFFECT OF COBALT - 60 IRRADIATION ON *Thrips palmi* Karny SEVEN DAYS AFTER TREATMENT IN EXPERIMENTS 5 AND 6

Dose (kGy)	EXP 5 19 JUNE 1997						EXP 6 24 JULY 1997					
	0	0.3	0.5	0.75	1.0	1.5	0	0.3	0.5	0.75	1.0	1.5
Number of thrips studied (released)	100	-	100	100	100	100	100	100	100	100	100	100
No. live thrips after treatment	136	-	32	2	0	0	135	10	9	0	0	0
No. dead thrips after treatment	0	-	68	98	100	118	0	90	91	114	131	131
% mortality	0	-	68	98	100	100	0	90	91	100	100	100

TABLE XXIII. WORKING PROGRAM AND ENVIRONMENTAL CONDITIONS FOR THE VARIOUS EXPERIMENTS

	1st Experiment	2nd Experiment	3rd Experiment	4th Experiment	5th, 6th Experiment
1. Duration of studies	19-29JAN94	7-18JUN95	25MAR-4APR96	22APR-1MAY96	12JUN-SEP97
2. Vaselife studied	—/	—/	—/	—/	—/
3. Mortality studied	X	—/	—/	—/	—/
4. Harvesting and packaging	Temp.(°C) 27-35 %RH 80	27-35 80	27-30 80	28-35 80	28-35 80
5. Transportation	Temp.(°C) 23-25 %RH 70-75	15 90	15 90	15 90	20±2 72-75
6. At TIC* or before irradiation	Temp.(°C) 27-35 %RH 93-95	12-18 90-95	12-18 90-95	12-18 90-95	27±2 90
7. After irradiation	Temp.(°C) 23-25 %RH 70-75	15 90	15 90	15 90	25 70
8. Laboratory or stored room	Temp.(°C) 19-27 %RH 70-75	20-35 70-75	19-22 80-90	19-22 80-90	20±2 80-90

* TIC = Thai Irradiation Center

6.2. Known original number of thrips (Tables XVII-XXIII)

When the snap bean rearing method had been developed, it was possible to release 100 thrips 2nd instars in each replication of experiments 5 and 6. The experiments were separated according to studies in test tube with thrips on tested plants (flowers).

In the test tube method, thrips were released in test tubes and directly exposed to Co-60 at the tested doses. The results noted 5 DAT, shown in Table 20, are that in experiment 5 0.5 kGy gave 42% mortality, 0.75 kGy gave 58%, 1.0 kGy gave 96%, and 1.5 kGy gave 100% mortality. At 7 DAT 0.75 kGy gave 98% mortality. In experiment 6, 5 days after treatment, 0.5 kGy gave 53% mortality, 0.75 kGy gave 75%, 1.0 kGy gave 90%, and 1.5 kGy gave 100% mortality. At 7 DAT 0.3 kGy gave more than 90% mortality.

In the tests with thrips on the tested plants (flowers), with 100 2nd instars on orchid inflorescences in each replications, the results are shown in Table I7. In experiment 5 at 5 DAT, 1.0 kGy gave 62%, and 1.5 kGy gave 100% mortality, and 1.0 kGy gave 71.42% mortality at 7 DAT. In experiment 6 at 5 DAT, 1.0 kGy gave 78.78% while 1.5 kGy gave 100% mortality. At 7 DAT 0.75 kGy gave 61.38%, and 1.0 kGy gave 95.95% mortality.

In conclusion, results from tests with thrips in test tubes and on tested orchid flowers showed that the effective dose for death of the thrips should be higher than 0.75 kGy at 7 DAT. The use of Co-60 radiation to control thrips in cut flowers depends on acceptance of irradiation as a quarantine treatment. When applied at the rate of 0.1, 0.3, 0.5, 0.8, and 1 kGY (also 1.5 kGY) with unknown and known of original number of thrips in each treatment, live larvae of thrips were found in each treatment, and the population gradually increased starting from two days after radiated. Because Co - 60 radiation does not directly kill all thrips at the doses used, other criteria than insect mortality need to be established to describe treatment efficacy. When the rearing technique for thrips is more successfully established, and large numbers of the same instar can be obtained, it should be possible

to determine radiation sensitivity and to compare tolerance of life stages of *Thrips palmi* Karny. This should allow determination of the most tolerant and sensitive stages, and enable prediction of dose needed to meet quarantine requirements of markets.

ACKNOWLEDGEMENTS

The authors thank Mr. Tipakorn Sanguthai, Managing Director of Excel Orchid Co. Ltd and his staff for providing orchid flowers for testing; Dr. Ampai Ungsunantwiwat and Dr. Kovit Nuchpramol, Thai Irradiation Centre for their advice and cooperation in irradiation treatment; and Mrs. Nuchanart Tangchitsomkid, Mr. Surasak Kasa, Miss Wimol Kamnengsak, and Mrs. Runtom Kongprom for their help with the work and manuscript. We also express our sincere thanks to FAO/IAEA, and to Dr. Paisan Loaharanu for financial support and encouragement.

BIBLIOGRAPHY

J. MITSUHASHI, Artificial rearing and aseptic rearing of leafhopper vectors application in Virus and MLO Research. Leafhopper vectors and plant disease 10 (1979) 369-411.

INTERNATIONAL ATOMIC ENERGY AGENCY, 1982. Basic safety Standards for Radiation Protection 1982 Edition No.9, Vienna (1982).

WIT, A.K.H., VRIE, M.V.D., Possibilities for radiation to control insects and mites in cut flowers after harvest. Netherland, (1986).

KAWAI, A., Life cycle and population dynamics of *Thrips palmi* Karny. JARQ 24(1) (1990) 282-288.

TALWKAE, N.S., Thrips in Southeast Asia. Proceeding of a Regional Consultation Workshop, Bangkok, Thailand, 13 March 1991, AVRDC Publication no. 91-342, (1991) 74 pp.