RES. BULL. PL. PROT. JAPAN No. 29: 1～9 (1993)

Effects of Electron Beam Irradiation on Cut Flowers

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Abstract: Four species of cut flowers were irradiated in 5MeV Dynamitron® accelerator. Tulips were tolerant to irradiation up to 0.6kGy, but red petal of cv. 'Malta' and cv. 'Merry Widow' showed lackluster color at 0.8～1.1kGy. In gladiolus cv. 'Traveler' and prairie gentian cv. 'King of Blue Picotee', higher doses dalyed flowering of upper and smaller florets or flower buds. Large flowered chrysanthemum showed severe injuries at even 0.2kGy. Inflorescence core of cv. 'Shuho no Chikara' showed browning and its flowering was remakably inhibited by irradiation.
Key words: commodity treatment, radiation, Chrysanthemum, Dianthus, Tulipa, Gladiolus

Introduction

Cut flowers imported into Japan in 1991 amounted to 435 millions, and 22.1% of them were infested with pests which cause possible economic damage to Japanese horticulture. Present use of fumigants, especially methyl bromide, is likely to be restricted or prohibited because of environmental reasons. Preliminary researches indicated that irradiation could be applied to disinfestation as a quaratine procedure (CHIU, 1986; GOODWIN and WELLHAM, 1990; KÖLLNER, 1977; TANABE and KATO, 1992; WIT and VRIE, 1985). Further data are needed to establish irradiation treatment as a quarantine procedure for cut flowers against mites, thrips and insects other than fruit flies. It is also urgently needed to evaluate quality (shelf-life or vase-life) and injuries of cut flowers irradiated at or beyond the dose required for quarantine purposes. In the present study, we evaluated effects of irradiation up to 1kGy on cut flowers exposed to 5MeV electron beam in commercial scale accelerator.

Materials and methods

Cut flowers were obtained at flower market 2 days before irradiation. Plants were irradiated in Dynamitron® accelerator at Electron Beam Service and Application Research Center, Sumitomo Heavy Industries, Ltd. according to our previous report (TANABE and KATO, 1992). After irradiation, 5cm of stem end was cut off plants, and plants were soaked in tapped water without preservatives. Irradiation conditions and storage conditions after irradiation were discribed in results of the studies.

Results and discussion

Vase-life of tulip cut flowers was not influenced by irradiation at less than 0.6kGy (Table 1). Quality of plants irradiated at less than 0.4kGy was equivalent to control or even better than control. Injury symptons were observed in plants irradiated at higher doses which gradually appeared around the half period of vase-life (6 or 7 days after irradiation) and became more conspicuous toward the end of the vase-life. Two types

Table 1. Effects of irradiation on tulip cut flowers*

Cultivar	Dose** (kGy)	Symptons	Vase-life*** (days)
'Angelique'	Control	—	11
	0.2	Better than control	12
	0.4	Slightly withered flower and lighter color of flower	10
	0.6	Ditto	9
	0.8	Ditto	8
	1.1	Withered and smaller flower, and slight chlorosis leaves	7
'Malta'	Control	—	12
	0.2	Better than control	13
	0.4	Non-significant difference	11
	0.6	Slightly lackluster flower	10
	0.8	Lackluster flower	9
	1.1	Dark and smaller flower, and slightly withered leaves	8
'Merry Widow'	Control	—	12
	0.2	Better than control	13
	0.4	Slightly lackluster color in petal center	12
	0.6	Ditto	12
	0.8	Ditto	12
	1.1	Lackluster color of petal center, in-rolling of petal, and smaller flower	10
'Purissima'	Control	—	13
	0.2	Non-significant difference	13
	0.4	Ditto	13
	0.6	Ditto	13
	0.8	Smaller flower	12
	1.1	Ditto	12
'Spring Green'	Control	—	12
	0.2	Better than control	13
	0.4	Slightly withered flower	11
	0.6	Ditto	11
	0.8	Ditto	11
	1.1	Withered flower and slight chlorosis of leaves	10

*; Plants produced in Fukaya, Saitama prefecture were irradiated immediately before flowering on February 26th 1992. Irradiated plants were stored at 13℃±1℃ and 60~80%r. h.

**; Beam current was 0.27mA for 0.2~0.8kGy and 0.54mA for 1.1kGy.

***; Days after irradiation until quality deteriolated.

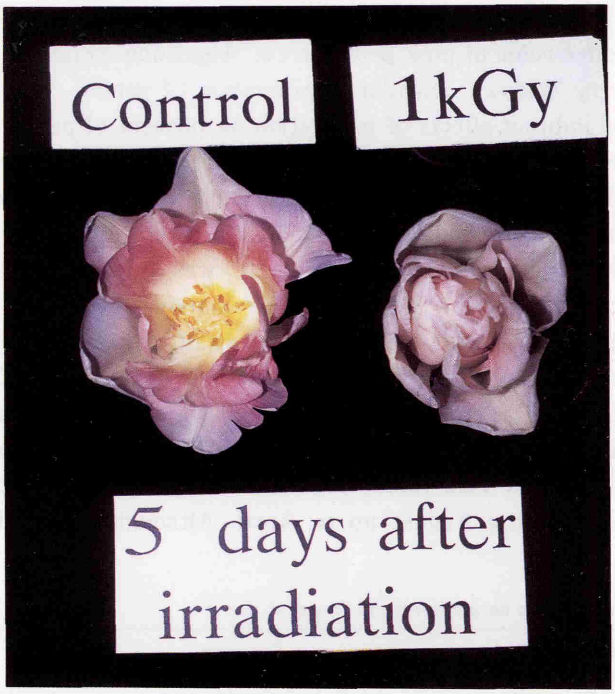

Plate 1. Discoloration of petals in tulip cv. 'Angelique'

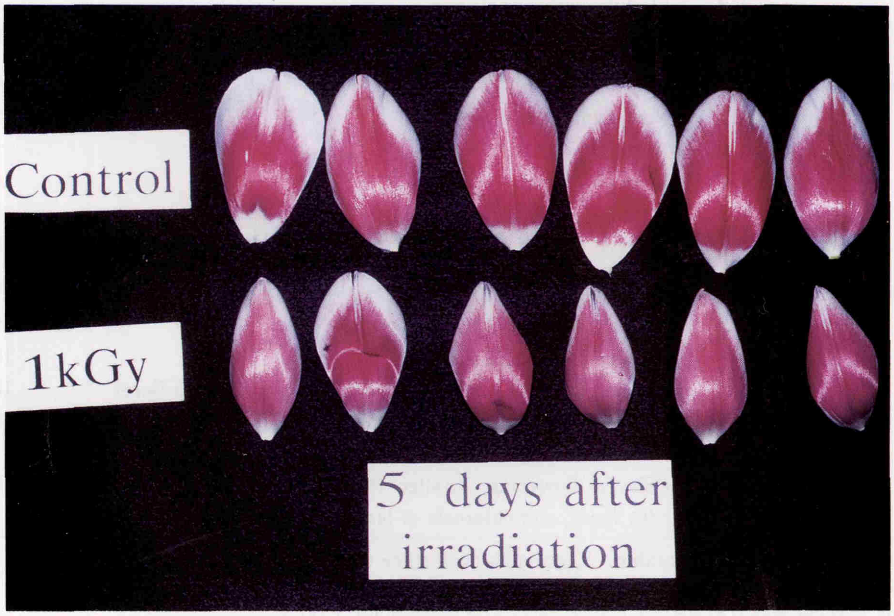

Plate 2. Effect of irradiation on petal size of tulip cv. 'Merry Widow'

of injury could be distinguished ; one was the cultivar-specific and the other was the common one. The former type was lackluster color of red petals in cv. 'Malta' and cv. 'Merry Widow', lighter color of pink petals in cv. 'Angelique' (Plate 1) and in-rolling of petals in cv. 'Merry Widow'. Similar discoloration of petals, which is presumably caused by direct or indirect effects of irradiation on pigment of petals, was observed in carnation irradiated at 4.1kGy (TANABE and KATO, 1992). The latter type was short vase-life, delayed flowering, withered flower and slight chrolosis of leaves. Short vase-life and delayed flowering caused smaller flower size. In the case of cv. 'Angelique', flower diameter (55 ± 1mm, n = 20) was significantly smaller ($P < 0.05$) than control (87 ± 1mm, n = 45) 5 days after irradiation at 1.1kGy. Also, petal size of cv. 'Merry Widow' irradiated at 1.1kGy was smaller than control (Plate 2), and average weight of petal (543.2 ± 41.8mg) was one half of control (952.2 ± 99.5mmg) 5 days after irradiation. Flower of cv. 'Angelique', which has thin petals, withered at higher doses, while other cultivars showed susceptibility to mechanical shocks in stead of visible wilting. WIT and VRIE (1985) reported that Tulipa showed damage at 0.5kGy of gamma irradiation during August up to April. Although they did not give a full

Table 2. Effects of irradiation on gladiolus cut flowers*

Cultivar	Dose** (kGy)	Symptons	Vase-life*** (days)
'Firebrand'	Control	—	8
	0.2	Non-significant difference	8
	0.4	Ditto	8
	0.7	Ditto	8
	0.9	Slightly withered flower	8
	1.1	Ditto	8
'Fuji no Yuki'	Control	—	9
	0.2	Non-significant difference	9
	0.4	Ditto	9
	0.7	Ditto	8
	0.9	Ditto	8
	1.1	Delayed flowering	8
'Traveler'	Control	—	9
	0.2	Better than control	10
	0.4	Slightly delayed flowering	10
	0.7	Delayed flowering and failure of flowering in > 7th floret	10
	0.9	Delayed flowering, failure of flowering in > 5th floret, and chlorosis of leaves	8
	1.1	Delayed flowering, smaller flower, failure of flowering in > 3th floret, and chlorosis of leaves	6

* ; Plants produced in Okinoerabu, Kagoshima prefecture were irradiated immediately before flowering on March 25th 1992, and then stored at 14℃ ±1℃ and 60~90% r. h.
** ; Beam current was 0.27mA for 0.2~0.9kGy and 0.54mA for 1.1kGy.
*** ; Days after irradiation until first floret withered up.

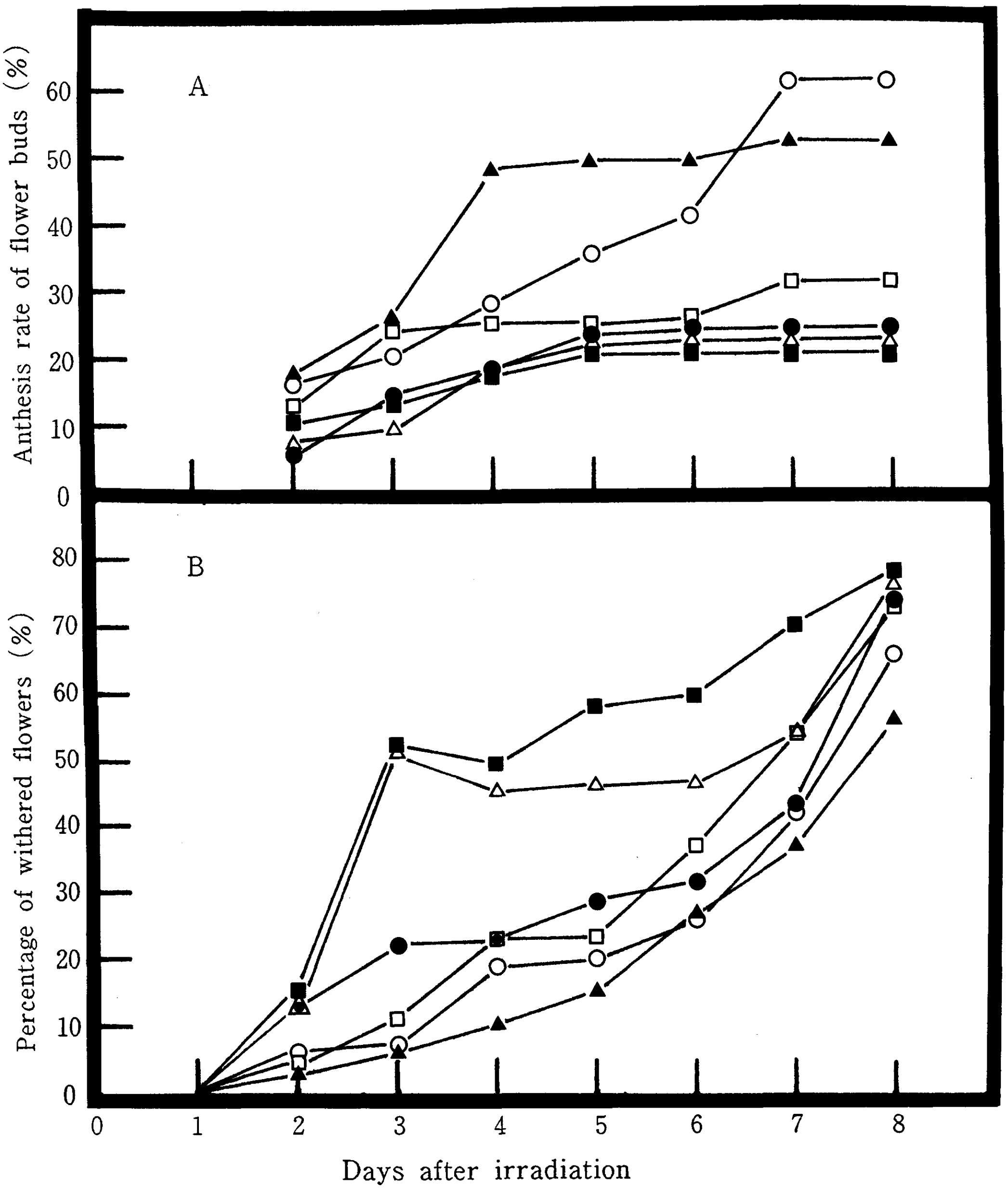

Fig. 1 Effects of electron beam irradiation on petals and flower buds of cut flowers of prairie gentian, *Eustoma russellinum* GRISEB. cv. 'King of Bule Picoty'

Plants produced in Tateyama, Chiba prefecture were irradiated on July 14th 1992. Ten plants were used for each dose. Beam current was 0.27mA for 0.2kGy to 0.8kGy and 0.54mA for 1.0kGy. After irradiation plants were stored in vase at 22℃ and 85% r. h.

A ; Anthesis rate of flower buds, B ; Percentage of withered flowers = $x/y \times 100$, where x is the number of withered flowers and y is the amount of flowers that have opened by given day.

○ ; 0kGy, ▲ ; 0.2kGy, □ ; 0.4kGy, ● ; 0.6kGy, △ ; 0.8kGy, ■ ; 1.0kGy account of their experiments, the damage seems to be not a serious one in the light of our present studies.

Vase-life of gladiolus cut flowers was not influenced by irradiation at lower doses and quality was maintained as the same as control, except that flowering of upper florets in cv. 'Traveler' were inhibited depending on the received doses (Table 2, Plate 3).

In prairie gentian *Eustoma russellium* GRISEB cv. 'King of Bule Picotee', which has small flower buds as many as 60~70% of the total florets, flower buds were inhibited to open by the irradiation at the doses higher than 0.4kGy (Fig. 1-A). However, flowering of larger florets immediately before opening were not influenced by irradiation. At the doses less than 0.6kGy, length of vase-life and increase of withered florets were similar to control (Fig. 1-B). Difference in anthesis rate between control and irradiated plants was due to a higher susceptibility of smaller flower buds to irradiation (Fig. 1-A). When irradiation is applied to the plant with florets having extremely variable tolerance, deleterious effects on quality should well be considered since tolerance of florets seems to be determined by degree of its development.

Large flowered chrysanthemum were susceptible (Table 3). In cv. 'Shuho no Chikara', flower was affected at even 0.2kGy and showed severe inhibition in

Table 3. Effects of irradiation on chrysanthemum cut flowers*

Cultivar	Dose** (kGy)	Symptons	Vase-life*** (days)
'Kurenaikeshiki'	Control	–	19
	0.2	Non-significant difference	19
	0.4	Chlorosis leaves	15
	0.5	Chlorosis and withered leaves	14
	0.7	Severe chlorosis and withered leaves	13
	0.9	Ditto	13
'Shuho no Chikara' (white)	Control	–	22
	0.2	Delayed flowering	19
	0.4	Delayed flowering, smaller flower, and browing in inflorescence core	13
	0.5	Ditto	12
	0.7	Ditto	10
	0.9	Ditto	10
'Shuho no Chikara' (yellow)	Control	–	24
	0.2	Delayed flowering and smaller flower	20
	0.4	Failure of flowering	14
	0.5	Ditto	12
	0.7	Ditto	10
	0.9	Ditto	9

*; Plants produced in Atsumicho, Aichi prefecture were irradiated immediately before flowering on February 12th 1992. After irradiation, plants were stored for 10 days at 5.0℃ ±0.5℃ and 98%r. h. and then at 13℃ ±1℃ and 50~80% r. h.

**; Beam current was 0.25mA.

***; Days after irradiation until quality deteriolated.

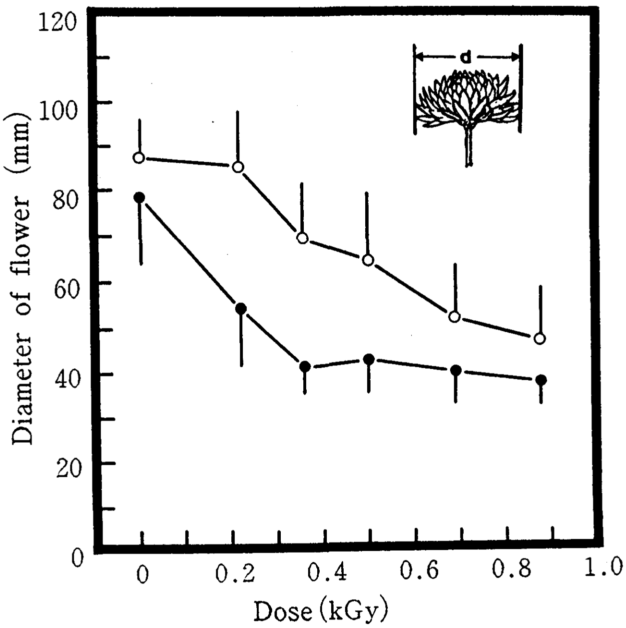

Fig. 2 Effect of electron beam irradiation on flowering of *Chrysanthemum morifolium* cv. 'Shuho no Chikara'
After irradiation, plants were stored at 5℃ and 98% r. h. for 10 days, and then at 13℃ and 60% r. h. for 2 days.
○ ; white type
● ; yellow type

flowering. Relationship between dose and flower diameter in two type of cv. 'Shuho no Chikara' was shown in Fig. 2. Flower diameter of white type showed a certain dose-dependence ($y = 90.0688 - 50.4512x$, $r = -0.7825$), while yellow type was more susceptible and flower diameter remained constant at the doses higher than 0.4kGy, because of failure in flowering. Delayed flowering in chrysanthemum irradiated at higher doses was noticed at an early stage in cold storage. Inflorescence core of white type cultivar showed browning and wilt (Plate 4). Injury of inflorescence core caused smaller flowers and delayed flowering of irradiated chrysanthemum. In both types of cv. 'Shuho no Chikara', leaves were not affected by irradiation. On the contrary, cv. 'Kurenaikeshiki' showed severe chlorosis followed by shriveling after cold storage at the doses higher than 0.4kGy.

CHIU (1986) suggested that use of preservatives including $AgNO_3$ before and after irradiation was effective to prevent chlorosis and wilt of chrysanthemum leaves which was caused by the inhibition of water absorption and its transfer. Withered flower and shorter vase-life were observed on every plant tested in the present study. These symptons seem to be related to the senescence of plants with stress ethylene which is induced by irradiation (ABELES, et al., 1992: LARRIGAUDIÈRE, *et al.*, 1991). Further studies in the effects of irradiation on stress ethylene production and senescence of plants may give a clue to the control of severe injury such as the one observed on chrysanthemum cut flowers.

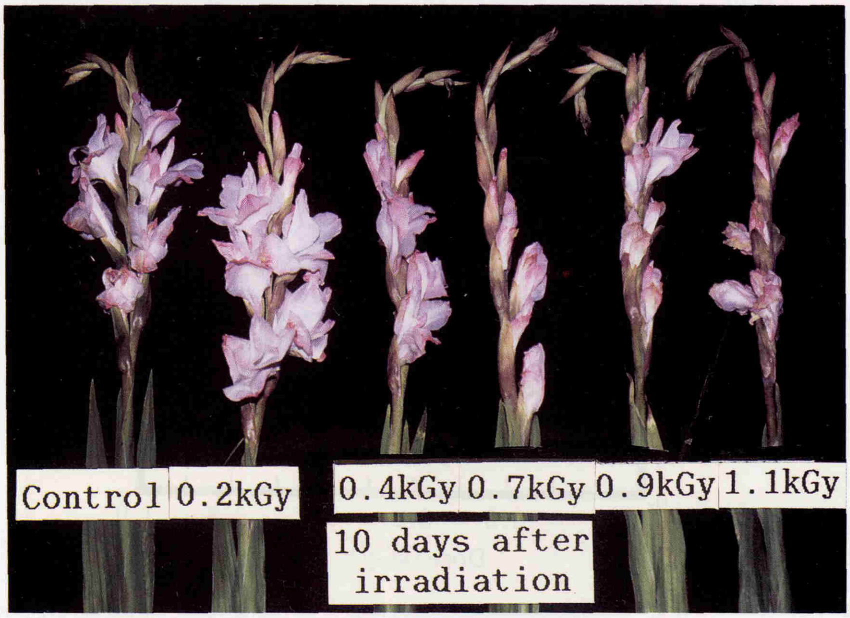

Plate 3. Inhibition of flowering in gladiolus cv. 'Traveler'

Plate 4. Bowning of inflorescence core in white type of chrysanthemum cv. 'Shoho no Chikara'

Acknowledgments

The authers thank the stuffs of Electron Beam Service and Application Research Center, Sumitomo Heavy Industries Ltd. for their cooperation in irradiation of cut flowers. We are also grateful to Mr. Takushi OBATA, Japan Plant Quarantine Association, for critical reading of the manuscript.

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和 文 摘 要

電子線照射が切花に与える影響について

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5 MeV の電子加速器® ダイナミトロンを用いて切花を電子線照射し，照射後の影響を調べた。
(1) チューリップ（'アンジェリケ'，'マルタ'，'メリー・ウイドウ'，'プリシマ'，'スプリング・グリーン'）の日持ち日数は対照と差がなかったが，0.8kGy 以上で，開花遅延，花弁の萎凋・色のくすみ・in-rolling を呈した。これらの障害は照射後 6 ～ 7 日後から徐々に現れて，日持ち限界の直前に顕著になった。
(2) グラジオラス（'ファイアー・ブランド'，'富士の雪'，'トラベラー'）の日持ち日数は対照と差がなかった。しかし，'トラベラー' は0.7kGy 以上で開花遅延および上部小花の開花不全を示した。
(3) トルコギキョウ（'キング・オブ・ブルー・ピコティ'）は開花直前の小花は影響を受けなかったが，蕾は0.4kGy 以上で開花不全を示した。開花した小花のうち萎凋するものの割合は0.6kGy 以下では対照と大きな差はなかった。
(4) キク（'紅景色'，'秀芳の力'）は耐性が低く，日持ち日数は全ての線量で短縮した。'紅景色' は花に障害は認められなかったが，0.4kGy 以上で葉に重度の黄化が発生した。'秀芳の力'（白）は開花が遅延し，花序中心部は褐変・萎凋して，花径が線量に依存して小さくなった。'秀芳の力'（黄）は 0.4kGy 以上で開花不全を呈した。