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Short Communication

Effects of Electron Beam Irradiation on Ethylene Production and Senescence of Cut Flowers

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Abstract: Cut flowers of carnation cv. 'Francisco®' harvested at different flowering stages were irradiated in an electron accelerator at the dose range of 200 Gy~700 Gy. For all flowering stages, obvious injuries did not appear on carnations irradiated upto 700 Gy. Although irradiation caused carnations to reduce their ethylene production, the reduction did not lead to severe injuries. Irradiation inhibited flowering of rose cv. 'Rote Rose®' and cv. 'Tineke®' harvested at an early morphological stage, and remarkably reduced ethylene production in androecium.
Key words: commodity treatment, radiation, ethylene, Dianthus, Rosa

Introduction

Irradiation is the cause of short vase-life and wilting in some species of cut flowers. Sympton of the injuries gradually appears after irradiation and is scarcely differentiated from physiological injuries by stress other than irradiation (TANABE and DOHINO, 1993). Although action of irradiation to cut flowers is in most cases negative, detrimental or variable (HALEVY and MAYAK, 1981), we found extended vase-life in several flowers irradiated at low doses in previous studies (TANABE and KATO, 1992 ; TANABE and DOHINO, 1993). The extended vase-life is a result of delayed flowering and wilting, which could be a mild injury caused by the suppressive effect of irradiation on metabolism of plant. Ethylene production by cut flowers themselves is a determinative factor resulting in their senescence (ABELES, *et al.*, 1992). In the present study, we evaluated effects of electron beam irradiation on senescence and ethylene production in cut flowers of tolerant carnation and sensitive rose.

Materials and methods

Cut flowers

Cut flowers of carnation cv. 'Francisco®', rose cv. 'Rote Rose®' and rose cv. 'Tineke®' were examined. Carnations were standard type, cultured by commercial growers in Chiba prefecture, and harvested at the stage of 30%, 50% and 80% flowering, which corresponds to flower diameters of 60 mm, 70 mm and 80 mm, respectively. Roses cultured by commercial growers in Aichi prefecture were harvested at morphological stage zero (Fig. 4)

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(KUIPER, *et al.*, 1991).

Irradiation

Cut flowers were irradiated in Dynamitron® accelerator at Electron Beam Service and Application Research Center, Sumitomo Heavy Industries, Ltd. according to our previous studies (TANABE and KATO, 1992 ; TANABE and DOHINO, 1993). After irradiation, 5 cm of stem end was cut off plants. Plants were stood in vases and stored at 15°C±1°C and 50 ~70% r.h.

Measurement of ethylene

Stems of carnation were recut to a length of 5 cm. Four flowers were weighed and enclosed in 1.5 *l* gas-tight glass container with rubber ceptum for 2 hours at 20°C under the dark, after that, 50 μl of the headspace gas was sampled and the ethylene concentration was determined by gas chromatography (BRANDT and WOODSON, 1992). Gas chromatograph (Model GC-8A, Shimadzu) with flame ionization detector was used under the following conditions ; 110°C of injection temperature, 50°C of oven temperature, silicone SE-30/chromosorb WAW DMCS column (30 m), nitrogen gas as carrier gas. Measurement was replicated 3 times and data represents the average of 3 replications. Five androecia of rose were weighed 8 days after irradiation, and enclosed in 42 m*l* glass bial with rubber ceptum for 4 hours at 20°C under the dark, after that, the ethylene concentration was determined by gas chromatograhy.

Results and discussion

Flowering of carnation at different stages was not affected by electron beam irradiation at 200 Gy, 350 Gy and 520 Gy (data were not shown). Also, there was no difference between non- and irradiated flowers in vase-life, which of 30%, 50% and 80% flowering stage were 22, 17 and 10 days, respectively. At the dose of 700 Gy, however, flowers showed different responses within various stages. In the case of the 30% flowering stage, maximum flower diameter of irradiated flowers was maintained until petals withered. On the contrary, wilting and in-rolling of petals in non-irradiated flowers were visible during the last 7 days and their quality was lower than the irradiated one (Fig. 1-A). At the 50% flowering stage, flowering was slightly inhibited by irradiation (Fig. 1-B), although the inhibition was not significant and injuries were not observed during flowering. At the 80% flowering stage, flowers did not exhibit any obvious effects by irradiation (Fig. 1-C). However, at all stages, elongation of columns was inhibited by irradiation (Fig. 2). Irradiation inhibited ethylene production at all flowering stages (Fig. 3). In both non- and irradiated flowers, ethylene production was higher in earlier stages and decreased with time, except to non-irradiated flowers at the 30% flowering stage, which showed increase in ethylene production prior to petal senescence (Fig. 3-A) although the increase seems to be different from the typical climacteric increase reported on carnation cv. 'White Sim®' (BRANDT and WOODSON, 1992).

Responses of roses to irradiation at 170 Gy, 410 Gy, 570 Gy and 780 Gy were variable

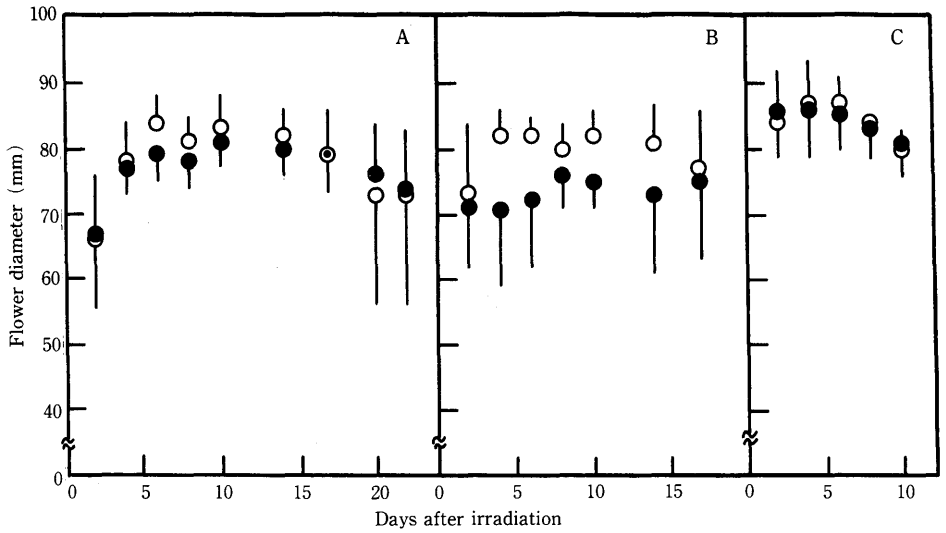

Fig. 1. Flower diameter of carnation cv. 'Francisco®' irradiated at different flowering stages. Data are average±S.D. (n=10).
A ; 30% flowering stage
B ; 50% flowering stage
C ; 80% flowering stage
○ ; 0 Gy, ● ; 700 Gy

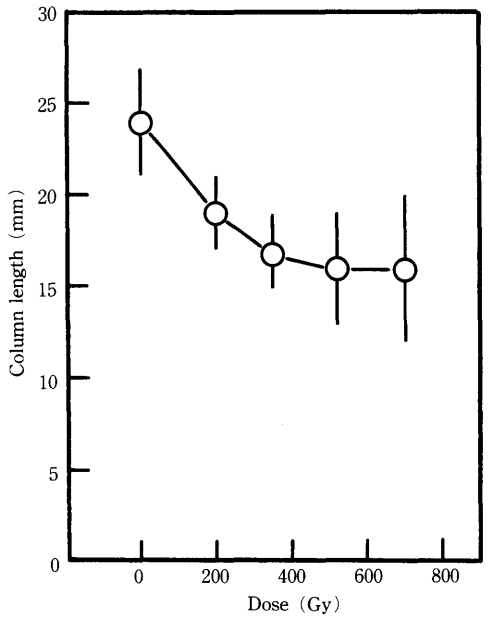

Fig. 2. Colum development of carnation cv. 'Flancisco®' irradiated at 50% flowering stage.
Column length was measured 20 days after irradiation. Data are average±S.D. (n=10).

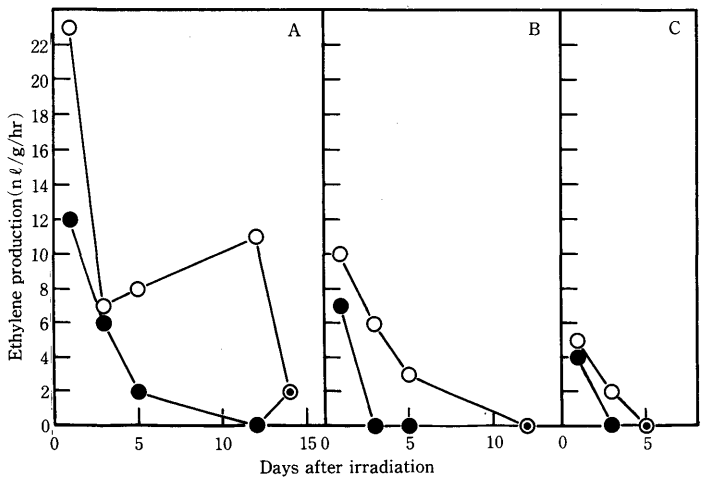

Fig. 3. Ethylene production of carnation cv. 'Francisco®' irradiated at different flowering stages.
Data are average of three measurements for four flowers, of which stems were recut to a length of 5 cm.
A ; 30% flowering stage
B ; 50% flowering stage
C ; 80% flowering stage
○ ; 0 Gy, ● ; 700 Gy

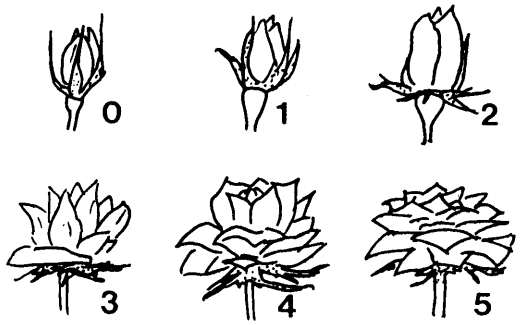

Fig. 4. Morphological Stages of rose cv. 'Rote Rose®' and 'Tineke®' during flower bud opening.
At stage 0, sepals enfold the petals. At stage 5, flowers fully open but anthers are not visible.

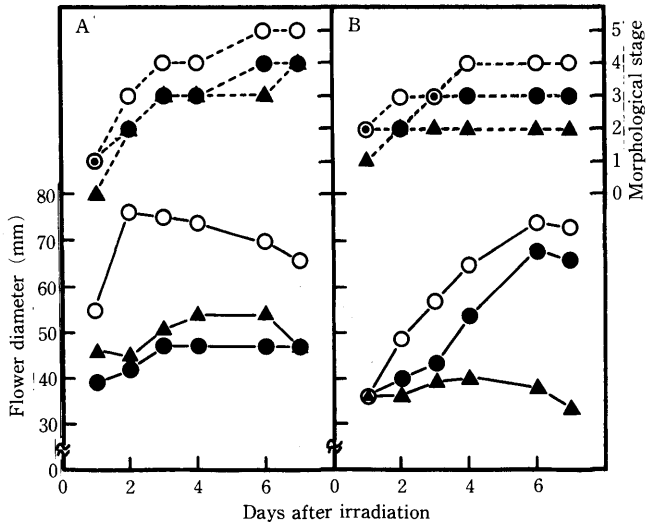

Fig. 5. Effects of irradiation on flowering of rose Data are average of 20 samples.
A ; cv. 'Rote Rose®', B ; cv. 'Tineke®'
○ ; 0 Gy, ● ; 170 Gy, ▲ ; 780 Gy

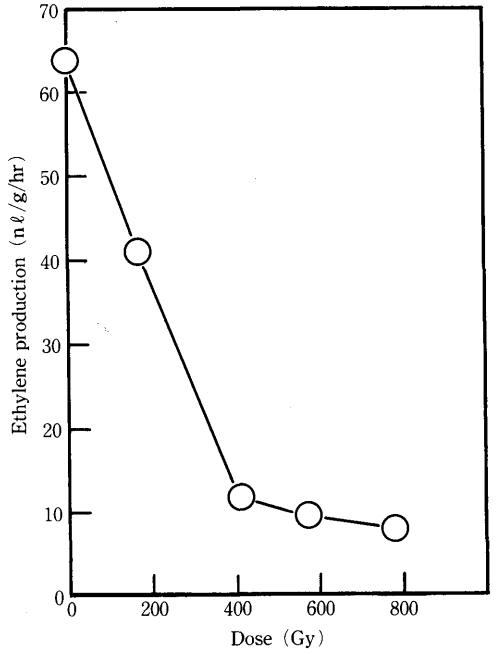

Fig. 6. Ethylene production of androecium of irradiated rose cv. 'Rote Rose®'
Five androecia were used for ethylene measurement 8 days after irradiation.

with different cultivars. In cv. 'Rote Rose®', the morphological stage progressed at all doses, although flower diameter was smaller than that of non-irradiated ones (Fig. 4 and Fig. 5-A). Vase-life of non-irradiated roses was 8 days and at which time petals were rapidly withered, while that of irradiated roses was not clear because of inhibited flowering and delayed wilting. In cv. 'Tineke®', vase-life after irradiation at 0~410 Gy, 570 Gy and 780 Gy was 8, 7 and 6 days, respectively. Progress of morphological stage and elongation of petals was inversely dependent on absorbed dose (Fig. 5-B). At higher doses, opening of flowers was perfectly prevented, and abscission of petals and leaves were rapidly stimulated at end of vase-life. Ethylene production of androecia of cv. 'Rote Rose®' irradiated at 410 Gy and more, was reduced in one sixth of non-irradiated plants (Fig. 6). Ethylene and other mobile wilting factors are translocated within plant (WOLTERING, *et al.*, 1991). In the present study, since petal ethylene was not detected until 5 days after irradiation, androecium must have initially promoted ethylene production in other floral organs. Irradiation may indirectly influence flowering through inhibition of ethylene production enhancing growth and senescence of floral organs (ABELES, *et al.*, 1992). Ethylene production was higher in the earlier stages as in carnation. For example that of non-irradiated rose 6, 8 and 9 days after irradiation was 74.5, 64.0 and 47.9 n*l*/g/hr, respectively. However, roses irradiated at 780 Gy slightly increased ethylene production with time; 0.2, 7.9 and 10.8 n*l*/g/hr in 6, 8 and 9 days after irradiation, respectively. The increase may be caused by the stress ethylene resulting in short vase-life and wilting at higher doses (ABELES, *et al.*, 1992). The difference between carnations and roses in responses to irradiation is likely to concern susceptibility of the ethylene production system to irradiation.

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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
II. 照射による切花のエチレン生成の阻害

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'Rote Rose ®' 種および 'Tineke ®' 種バラ切花，切り前3分咲き，5分咲きおよび8分咲きの 'Francisco ®' 種のカーネーション切花に5MeV電子線を照射して，その影響を調べた。

(1) カーネーションは，照射によってエチレン生成がやや低下したが，顕著な障害は見られなかった。また，切り前の違いによる反応の差も有意ではなかった。

(2) バラは照射によって開花が阻害され，雄しべ群のエチレン生成が低下した。

(3) 切花の収穫後の開花に対する照射の影響は，切花のエチレン生成系の照射に対する感受性を反映しているものと思われる。