Effects of heavy-ion-beam irradiation on flower-color mutation in chrysanthemum

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Kagoshima Prefecture is a leading spray-mum production region in Japan. Until date, we have developed more than 50 spray-mum cultivars by cross breeding; in addition, we also performed mutation breeding by using heavy-ion-beam irradiation. In this study, we investigated the effects of heavy-ion-beam irradiation on flower-color mutation of spray-mum.

We irradiated cuttings of the spray-mum cultivar 'Southern Chelsea', which was developed in Kagoshima Prefecture, with C-ion (LET 23 keV/μm) at doses of 2–5 Gy, Ne-ion (LET 62 keV/μm) at doses of 2 and 5 Gy, Ar-ion (LET 280 keV/μm) at doses of 2 and 5 Gy, and X-ray at doses of 5–20 Gy. After the irradiation, we planted the cultivars in a greenhouse and investigated the variations in flower-color mutation.

Among 4,741 irradiated branches, we obtained 468 branches with flower-color mutations (Table 1). The mutants from 'Southern Chelsea' with pink flower showed flower colors of white, light pink, deep pink, yellow, light reddish yellow, and deep reddish yellow (Fig. 1).

On the basis of the analysis of flower pigments in the mutants, the relationship between the variations in the amount of the pigments and colors was considered, as shown in Figure 2. The mutants with deep pink flowers had higher anthocyanin content in their flowers than that in 'Southern Chelsea', and the mutants with white, yellow, and light pink flowers had low anthocyanin content. The light reddish yellow, deep reddish yellow, and yellow flowers were because of increased carotenoid content. The flower-color mutation was high in the order of deep reddish yellow, white, and light reddish yellow.

In the irradiations at 5 Gy, the flower-color mutation rate was high in the order of Ne-ion, C-ion, Ar-ion, and X-ray (Table 1), indicating that the heavy-ion-beam irradiations were more effective for the induction of flower-color mutation than that by X-ray irradiation. Since the majority of the shoot tips died after Ar-ion irradiation at 5 Gy, mutant screening should be performed at low-dose irradiations such as 2Gy.

The mutation rate for yellow flowers was 0–0.2% after C-ion, Ne-ion, and X-ray irradiations. On the other hand, the mutation rate after Ar-ion irradiation was 0.9% and was higher than that after the other irradiations (Table 1). In addition, some mutants showed flower-shape and color variations at the tips of the petals, such as to yellow or white (Fig. 1-B). These variations were only observed in the Ar-ion irradiation, suggesting that the Ar-ion beam at a LET of 280 keV/μm might have more different effects on mutation induction than that by the lower LET Ar-ion-beam irradiation.

The results in this study indicated that heavy-ion-beam can induce a broad spectrum of mutant phenotypes in chrysanthemum. Currently, we are screening the mutants derived from Ar-ion irradiation.

Table 1. Flower-color mutation induced by heavy-ion-beam and X-ray irradiations.

Variation source			Flower-color mutation										
									The tip of the petal (The origin of the petal)				
Line class	Dose (Gy)	Number of irradiated plants	Deep reddish yellow	White	Light reddish yellow	Yellow	Deep pink	Light pink	White (pink)	Yellow (Reddish yellow)	Number of mutants	Mutation rate(%)
C	2	84	2		2						4	4.8
	3	540	25	11	9			1			46	8.5
	5	354	25	20	7						52	14.7
Ne	2	348	16	11	7	1					35	10.1
	5	84	9	7	5						21	25.0
Ar	2	434	30	27	12	4	3	1	2	1	80	18.4
	5	21	2								2	9.5
X-ray	5	552	23	9	9		1				42	7.6
	10	1955	73	40	31	3		1			148	7.6
	15	180	6	6	5						17	9.4
	20	189	8	9	4		1				22	11.6
Total		4741	219 (37)	140 (59)	91 (16)	8 (0)	5 (2)	3 (3)	2 (0)	1 (0)	469	9.9

( ): Mutated sector in the flower was defined as the area of the petals with changed color that accounted for more than 50% of the whole petal area in a flower. The total number of irradiated and mutated plants with the number of plants having mutated sectors shown with in parenthesis.

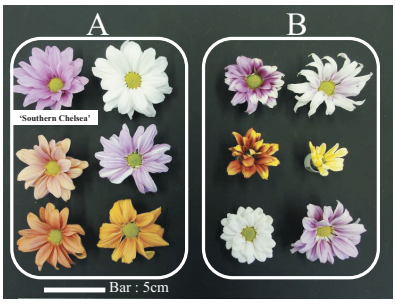

Fig. 1 Spectrum of mutant phenotypes. (A) Flower-color mutations. (B) Color variations at the tips of the petals and variations in the flower shape.

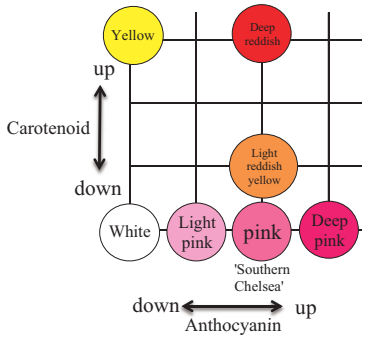

Fig. 2 Relationship between the amount of pigments and color variations in the mutants.

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