Characteristics of heavy-ion mutagenesis in cultivated strawberry

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A cultivated strawberry cultivar "Fukuoka S6" has been a popular product in the Japanese strawberry market due to its high quality, which is attributed to desirable characteristics, such as large, deeply red, glossy and tasty fruits. However, this cultivar also has some disadvantages, such as late maturity and a soft fruit pericarp, which causes physical damage to the fruit while transporting. Ion-beam irradiation has attracted much attention as a novel technique for inducing spotted mutagenesis on plant genomes.[1] This study developed mutants of strawberry, which show early flowering and high fruit firmness, by using heavy-ion-beam irradiation.

An experiment was performed in 2014 and 2015. In 2014, strawberry nursery seedlings (5 plants per treatment) propagated in a sterilized condition were exposed to a $^{12}C^{6+}$ ion-beam (1.62 GeV, LET 30 keVμm-1) at the RIKEN Ring Cyclotron at doses of 0 (no treatment), 10, 15, 20, or 30 Gy. In 2015, seedlings were propagated similarly, separated, and filled up in a 50-ml falcon tube (at 7 g per tube). Eight tubes per treatment were exposed to a $^{12}C^{6+}$ ion-beam. Irradiated seedlings were transplanted and cultured on 1/2MS media at 20°C with a 16-h light regime, the weight of seedlings after 2 months from transplanting were measured, and the propagation ratio was calculated in comparison with the initial weight. The effect of each treatment was evaluated by comparing the propagation ratio to that achieved without treatment. Surviving seedlings were potted, acclimated, and transplanted in a greenhouse. The characteristics of mutants were examined using "Fukuoka S6" as a control.

The propagation ratio decreased with an increase in irradiation dose, but the propagation ratio at 30 Gy, which was the highest dosage, was 74% of that achieved without treatment (Fig. 1). Although many previous studies using cultivated strawberry adopted a dosage of approximately 10 Gy, such as 8 to 16 Gy,[2] 10 to 20 Gy,[3] and 0.5 to 2.5 Gy,[4] to obtain mutants in a practical breeding program, the median lethal dose (LD_{50}) has not been detected. The survival ratio at 32 Gy of $^{12}C^{6+}$ ion-beam irradiation was 91%,[2] suggesting that the LD_{50} of strawberry is greater than 30 Gy. Since the genome of strawberry was allo-octoploid ($2n = 8x = 56$), genes on a homoeologous genome might have compensated for the loss of functions of a certain gene. Summarizing those previous studies and this study, the practical and suitable dosage of $^{12}C^{6+}$ heavy-ion-beam irradiation to obtain mutants of cultivated strawberry efficiently should be further investigated.

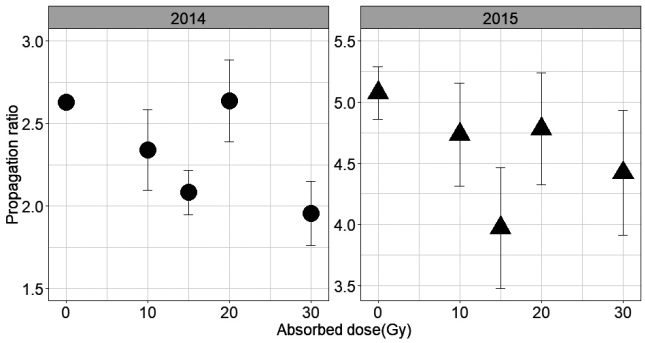

Fig. 1. Propagation ratio of strawberry seedlings mutated by carbon-ion beam irradiation.

Table 1. Characteristics of strawberry seedlings mutated by carbon-ion-beam irradiation.

Trait		Absorbed dose (Gy)				Total
		10	15	20	30	
Fruit color	Darkening	1	2	1	3	7
	Lightening	1	4	0	0	5
Fruit size	Upsizing	0	0	0	0	0
	Downsizing	12	23	10	15	61

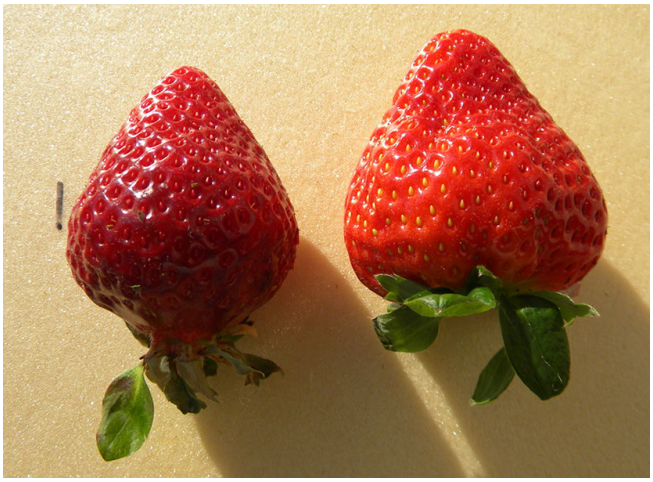

Fig. 2. Fruits of a mutant line developed from 15 Gy heavy-ion-beam irradiation (left) and "Fukuoka S6" (right). Bars = 1 cm.

Some surviving plants indicated characteristics different from "Fukuoka S6" in the forcing culture of the greenhouse (Table 1). The fruit-pericarp pigmentation of mutants varied widely from darker red to lighter red (Fig. 2), but the fruit size only showed downsizing; further, some mutants showed harder fruit firmness than the control.

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