Effects of heavy-ion-beam irradiation on survival in Eisenia arborea

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Along the coast of Hainan on the west coast of Suruga Bay in Shizuoka prefecture, there once existed a kelp forest of species such as *Eisenia arborea* (Fig. 1). This kelp forest was a good fishing ground for shellfish such as abalone. In addition, *E. arborea* was caught as edible seaweed. However, the kelp forest disappeared, along with shellfish, and fishery suffered serious economic damage. Although measures to restore the kelp forest have been taken subsequently, *E. arborea* has not recovered. Therefore, we investigated survival in *E. arborea* after irradiation with a heavy-ion beam and examined the optimum dose for creating useful properties in *E. arborea* such as high growth and to contribute to the recovery of the kelp forest.

Gametophytes of *E. arborea* were irradiated with an Ar-ion beam (184 keVμm) at a dose range of 0.625–20 Gy and with a C-ion beam (23 keVμm) at a dose range of 5–100 Gy. After the irradiation, batches of 48 female and 48 male gametophytes (approximately 100 μm in length) were incubated at 20°C with 12-h photoperiods and a light intensity of 30 μmol m^{-2} s^{-1}. After 3 weeks of culture, they were measured with a microscope, and gametophytes not growing were deemed to have died. Furthermore, to confirm the survival again, gametophytes visually confirmed to be alive after 8–9 months of culture were regarded as surviving individuals, and the survival rates were obtained.

Sporophytes of *E. arborea* (approximately 3 mm in length) were irradiated with an Ar-ion beam at a dose range of 1.25–10 Gy and with a C-ion beam at a dose range of 10–100 Gy. After the irradiation, batches of 50 sporophytes were incubated at 20°C with 12-h photoperiods and a light intensity of 80 μmol m^{-2} s^{-1}. The survival rates were measured after 4 weeks of culture.

The survival rates after 3 weeks of gametophytes irradiated with the Ar-ion beam showed a tendency to decrease beyond a dose of 10 Gy in both male and female samples (Fig. 2). The survival rates after 3 weeks of gametophytes irradiated with the C-ion beam decreased from 80 Gy in male samples and 100 Gy in female samples (Fig. 3). The survival rates after 8–9 months of culture decreased and abruptly decreased for Ar-ion-beam irradiation at 10 Gy and C-ion-beam irradiation at 80 Gy, respectively (Table 1), which almost agreed with the results after 3 weeks of culture. The survival rates of the sporophytes sharply decreased for Ar-ion-beam irradiation at 7.5 Gy and C-ion-beam irradiation at 20 Gy, respectively (Fig. 2, 3). Susceptibility to heavy-ion beams was higher in sporophytes than in gametophytes.

Based on the above results, the optimum doses were estimated as 2.5 and 5 Gy for gametophytes and sporophytes irradiated with an Ar-ion beam, respectively; 20 and 40 Gy for gametophytes irradiated with a C-ion beam; and 10 and 20 Gy for sporophytes irradiated with C-ion beam. In the future, we will perform mutant screening of the sporophytes in the M_2 generations.

Fig. 1. *Eisenia arborea*.

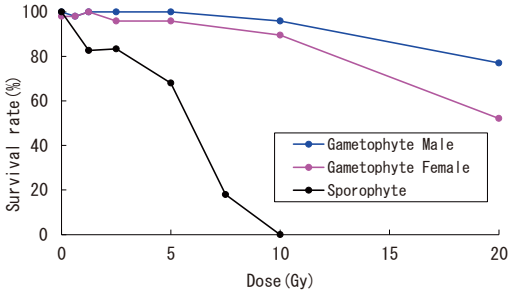

Fig. 2. Survival rates of male and female gametophytes and sporophytes 3 and 4 weeks after irradiation with an Ar-ion beam, respectively.

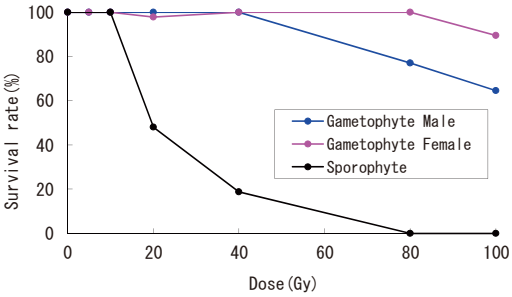

Fig. 3. Survival rates of male and female gametophytes and sporophytes 3 and 4 weeks after irradiation with a C-ion beam, respectively.

Table 1. Survival rates of male and female gametophytes 8–9 months after irradiation with Ar and C-ion beams.

	Ar		C	
	control	10Gy	control	80Gy
Male	100%	71%	100%	17%
Female	50%	29%	94%	8%

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