LET effect of Ar-ion irradiation on the flowering rate of *Arabidopsis thaliana*

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A heavy-ion beam is an effective mutagen with a high linear energy transfer (LET). The lethality rate after ion-beam irradiation was affected by LET in *Arabidopsis thaliana*: Ne or Ar ions with LET values higher than 350 keV/μm were more effective than C ions with an LET value of 113 keV/μm.[1] Further, we previously reported the LET-dependent effect of heavy-ion irradiation in *Arabidopsis*: LET affects both the flowering and mutation rate. Ar ion (290 keV/μm) was more effective than the Fe ion (640 keV/μm) in the decreasing flowering rate.[2] Similar effects were observed when reducing the survival rate for buckwheat[3] and rice,[4] where the survival rates were measured as the number of surviving plants in the field or the number of surviving seedlings per total number of seeds, respectively. Irradiation with LET values such as those of Fe-ion, had a lower effect on survival rate. In this study, we investigated the LET effect to determine the peak effectiveness for the flowering rate decrease in *Arabidopsis*.

The high energy Ar-ion beam (160 MeV/nucleon) delivered by the WACAME beam line was used for this experiment. This beam line enables controlling the LET values in the range of 184–640 keV/μm for the biological samples. The dry seeds of *A. thaliana ecotype* Columbia were vacuum packed in a plastic bag to provide a monolayer of seeds for homogeneous irradiation. They were irradiated with Ar ions at a dose range of 0–160 Gy. The LET was controlled to 184, 300, 400, 500, and 600 keV/μm using a range shifter and an energy adjuster. All LETs were calculated behind the seeds.

In our previous study, the flowering rate showed a similar trend to the survival rate (data not shown), and therefore, we adopted a flowering rate for evaluating the LET effect in *Arabidopsis*. In this study, we improved the method to measure the flowering rate and calculated it as the number of flowering plants per 330 seedlings transplanted randomly.

The effects of Ar-ion irradiation at different LETs on the flowering rate are presented in Fig. 1. There was no difference in the flowering rate between LET values of 300 and 400 keV/μm. The effect on flowering rates at LET values of 500 and 600 keV/μm are less than that for LET values of 300 and 400 keV/μm, especially at higher dose irradiation. This result indicates that the most effective LET value in the decreasing flowering rate is 300–400 keV/μm. The dose is proportional to the product of the LET value multiplied by the number of ion particles. This implies that the higher the LET increase, the smaller is the number of ion particles irradiated at the same dose. The number of ion particles is considered insufficient for achieving high efficiency in the irradiation with higher LET values greater than 500 keV/μm. Consequently, a LET value greater than 500 keV/μm is less effective on the flowering rate or survival rate of the M_1 plant, even though the energy of each ion particle is high.

References
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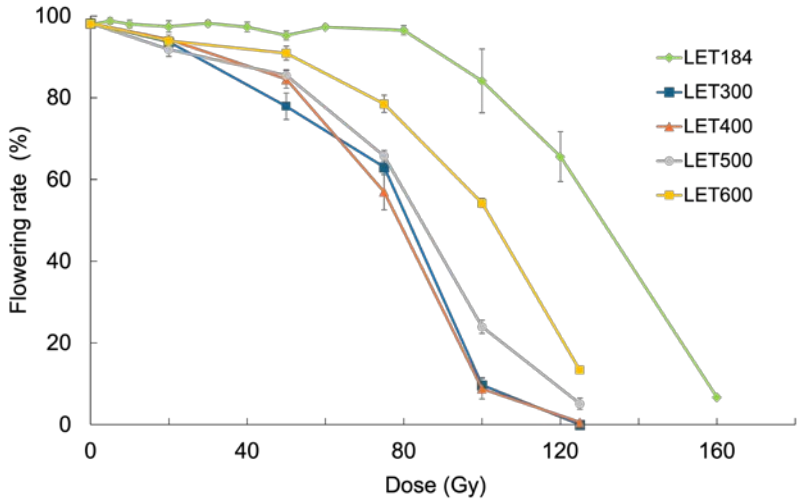

Fig. 1. Flowering rate after Ar-ion irradiation on *Arabidopsis thaliana*.

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DOI:10.34448/RIKEN.APR.58-095