

Change in rice gene expression profile dependent on linear energy transfer after heavy-ion beam irradiation†

K. Ishii,^{*1} Y. Kazama,^{*1} R. Morita,^{*1} T. Hirano,^{*1,*2} T. Ikeda,^{*1} S. Usuda,^{*1} Y. Hayashi,^{*1} S. Ohbu,^{*1} R. Motoyama,^{*3} Y. Nagamura,^{*3} and T. Abe^{*1}

LET is an important factor affecting several aspects of the irradiation effect, such as cell survival and mutation frequency.¹⁾ The effect of LET on deletion induction increases up to an LET value of approximately 100 keV/μm²⁾ while the mutation frequency increases abruptly and peaks at a particular LET value.¹⁾ The mechanism between LET and the corresponding mutation frequency is still unknown. In this study, we focused on the effect of LET on gene expression profiles.

Oryza sativa L. cv. ‘Nipponbare’ seeds were imbibed for 3 days. The seeds were irradiated with 22.5 or 50 keV/μm C ions or with 63 or 80 keV/μm Ne ions at a dose of 15 Gy. Embryos were sampled 2 h after irradiation. Gene expression profiles were generated using a rice 4×44K microarray RAP-DB (Agilent Technologies, Tokyo, Japan).

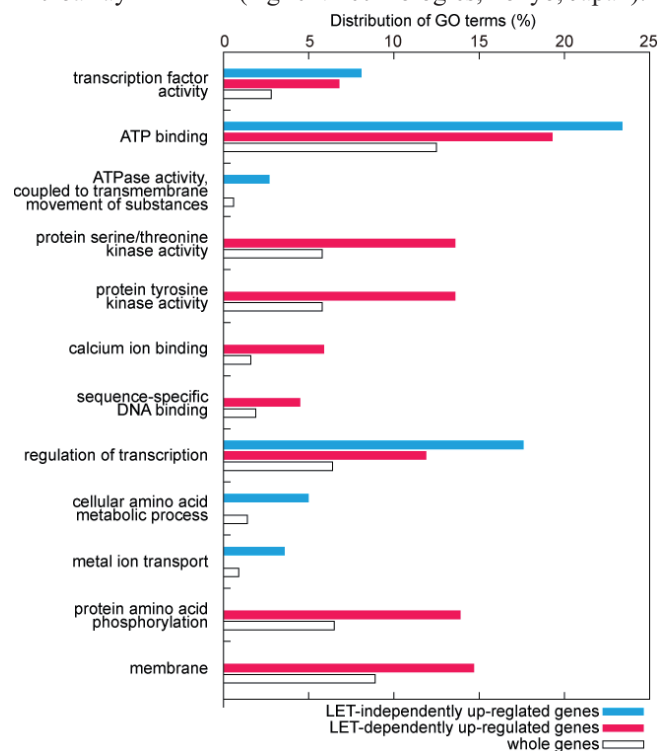


Fig 1. SEA analysis. The horizontal axis shows the distribution of the GO term, which is a percentage of genes having each GO term in the analyzed gene set. Blue, red, and white boxes indicate the distribution of LET-independent up-regulated genes, LET-dependent up-regulated genes, and whole genes (rice TIGR locus).

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^{*1} RIKEN Nishina Center

^{*2} Faculty of Agriculture, University of Miyazaki

^{*3} Agrogenomics Research Center, National Institute of Agrobiological Sciences

We defined 379 genes showing a significant change in expression level (FC > 2, and p < 0.05) at all four LETs as “LET-independent up-regulated genes” and 628 genes showing a significant change in expression level at an LET of 80 keV/μm, but not at 22.5 keV/μm, as “LET-dependent up-regulated genes”. A singular enrichment analysis (SEA) using a gene ontology (GO) analysis toolkit agriGO revealed that GO terms significantly (p ≤ 0.01) enriched were different in LET-dependent up-regulated genes and LET-independent up-regulated genes (Fig. 1), which implies that some specific genetic pathway is induced depending on the complexity of DNA damage.

Additionally, *OsPCNA* and *OsPARP3* were found to be LET-dependent up-regulated genes (Fig 2). Although molecular functions of rice PARP family genes are largely unknown, some of them are involved in Ku-independent non homologous end joining (A-NHEJ) with *Xrcc1* and *DNA ligase III* in animals³⁾ and plants.⁴⁾ *OsPCNA* forms a complex with *OsXRCC1* in vivo.⁵⁾ We assume that the high expression of *OsPARP3* and *OsPCNA* is needed to repair the high-LET induced DNA lesions via Ku-independent NHEJ.

In this study, we found an LET-dependent change of gene expression profile, which is a clue to the clarification of the relationship between LET and mutation frequency.

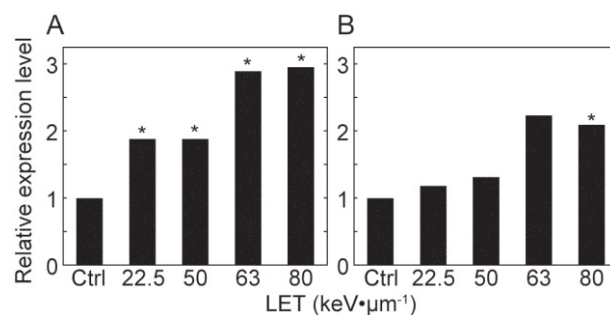


Fig 2. Response of *OsPCNA* and *OsPARP3* gene expressions to heavy-ion beam irradiation. Fold changes in expression level of *OsPCNA* (A) and *OsPARP3* (B) compared to the unirradiated control are shown. *: p < 0.05 (Student’s t-test).

References

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