Ultrastructural Changes of Cell Organelles in Gamma-Ray Irradiated Arabidopsis thaliana L.

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1. Introduction

Low and high doses of ionizing radiation were used to stimulate or inhibit seed germination, plant growth, size and productivity [1-4]. However, Ultrastructure of plant cell is not well known about the effects of irradiation on the plant cell. The morphological changes are attributed to the biological changes of different tissues and cell organelles. The aim of this study is to compare the ultrastructural changes in cellular organelles of stems of *Arabidopsis* after prolonged gamma-ray irradiation from low and high doses.

2. Methods and Results

We used seeds of *Arabidopsis thaliana* L. ecotype Columbia. For irradiation of 4-weeks-old seedling, gamma-ray was irradiated using ^{60}Co gamma-ray source (^{60}Co, ca. 150 TBq of capacity, AECL) of Korea Atomic Energy Research Institute, Korea. The radiation dose which was confirmed by using thermoluminesence dosimeters are ranging from 1, 2, 5, and 50 Gy. For the observation of transmission electron microscopy (TEM), stem segment were transferred to vials containing mixture of 2% glutaraldehyde and paraformaldehyde (in 0.05M sodium cacodylate buffer), and fixed for 4 hours. Then samples were post-fixed in osmium tetroxide, dehydrated in a graded series of acetone, and infiltrated and embedded in Spurr's resin [5]. Ultra-thin sections were cut with diamond knife on an RMC ultramicrotome. Ultra-thin sections were sequentially stained with uranyl acetate and lead citrate and then examined with a JEOL 1010 TEM.

2.1 Plant Growth

Figure 1 showed the height of seedling for 2 weeks after irradiation. Seedlings irradiated with doses to 0-5Gy grew and developed normally. However, the height for seedlings exposed to 50 Gy was significantly inhibited after 12 days.

2.2 Ultrastructure of cell organelles

Cell organelles in cortical cells from control stem (non-irradiation) remained intact (Fig.2). Cortex cells were highly vacuolated with the cytoplasm forming a thin layer between cell wall and vacuole. Cytoplasm contained ER (endoplasmic reticulum), mitochondria and chloroplasts and vacuoles became relatively large. The nuclei are large and irregular shape, containing fairly disperse chromatin and a prominent nucleolus. The intact chloroplast retained the structure of thylakoid membrane.

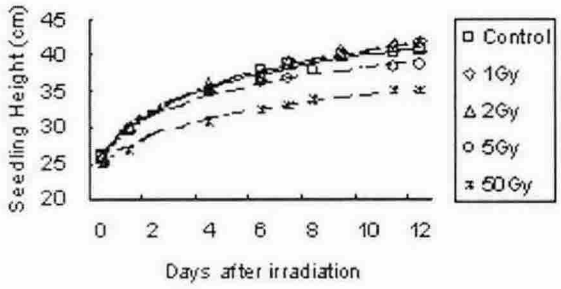

Figure 1. Seedling height through 12 days of cultivation of 4-week-old seedling irradiated by gamma ray.

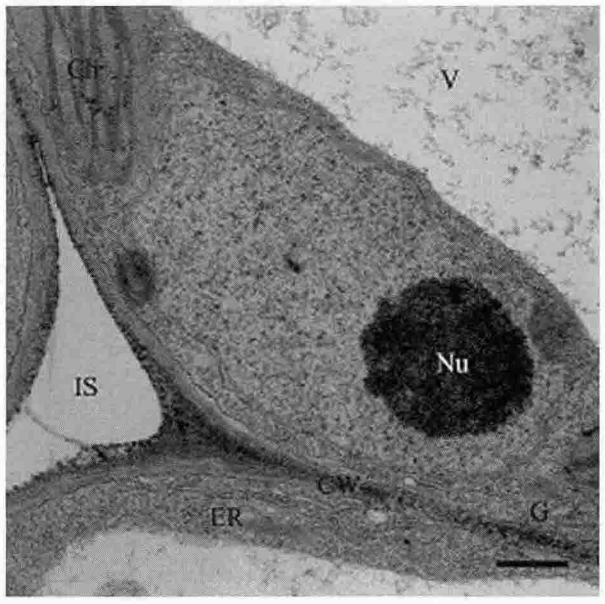

Figure 2. Cell organelles in cortical cell from stems of control plants. Ch; chloroplast, CW; cell wall, ER; endoplasmic reticulum, Nu; nucleolus, G; golgi apparatus, IS; intercellular space, V; vacuole. Bar= 500nm.

After 50 Gy irradiation, however, chloroplast structure in the cortical cell of stem was obviously altered and the thylakoid were considerably swollen and destructed. ER membranes were distended and initiated forming vesicles. Plastoglobuli was also observed in the chloroplasts. (Fig. 3). Cell components were well preserved in xylem cell (Fig. 4). However, mitochondria distorted in shape and plasmalemma was separated from cell wall. Ultrastructure of cell organelle in relatively low doses was similar to that found from the control plant.

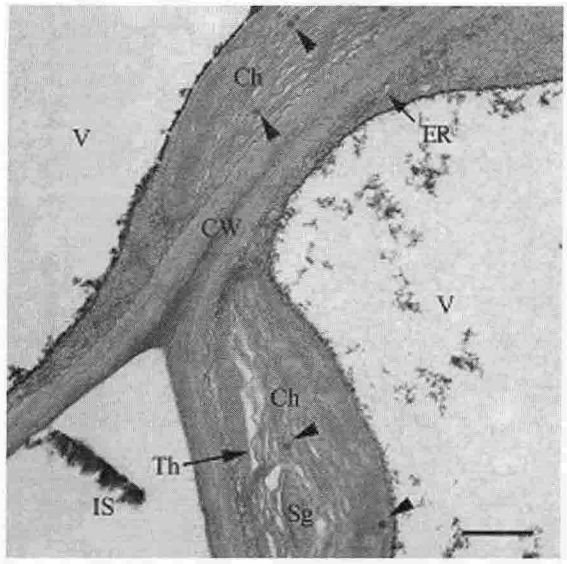

Figure 3. Cell organelles in cortical cell from stems of plants irradiated with 50 Gy. Ch; chloroplast, CW; cell wall, ER; endoplasmic reticulum, G; golgi apparatus, IS; intercellular space, Sg; starch grain, Th; thylakoid, V; vacuole, arrow head; plastoglobuli. Bar= 500nm.

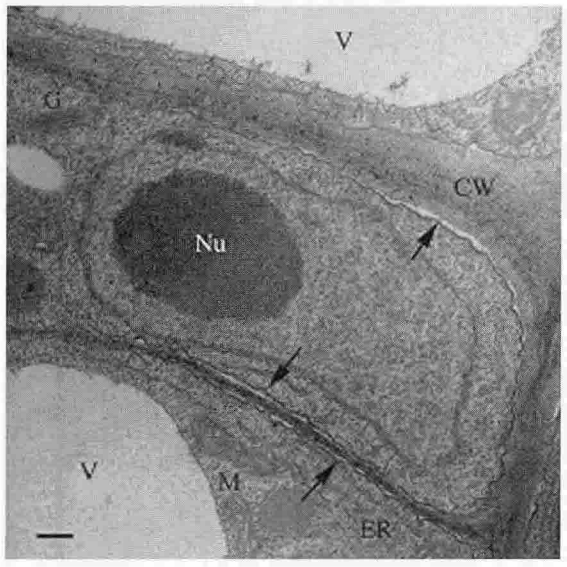

Figure 4. Cell organelles in xylem from stems of plants irradiated with 50 Gy. CW; cell wall, ER; endoplasmic reticulum, Nu; nucleolus, M; mitochondria, G; golgi apparatus. Plasmolysis was detected in xylem cell (arrows). Bar= 200nm.

3. Conclusion

Ultrastructural changes of cell organelles in response to gamma irradiation raging from 0 to 50Gy were examined in stem of *Arabidopsis*. One of the major effects of gamma irradiation was the disruption of membrane structure. Chloroplasts were significantly sensitive to gamma irradiation. Thylakoid membranes were heavily swollen, and some parts of mitochondria and ER were structurally alteration, and the plasmalemma has pulled away from cell wall in place. However, there were no ultrastructural changes in cell organelles at any of the irradiation doses tested from 0 to 5 Gy. The ultrastuctural changes of cell membranes observed in this study are related to growth of *Arabidopsis* caused by gamma-ray irradiation.

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