NONINVASIVE IMAGING OF ZINC MOVEMENT IN AN INTACT PLANT USING ^{65}Zn.

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Introduction

Zinc is an essential element for all living organisms. Zinc deficiency of crops is one of the most serious problems in food production in the world. On the other hand, high-dose of zinc is toxic to human, making acute intoxication or interfering with the uptake of copper. Therefore, it is important to understand how plants regulate zinc uptake and exclusion in the various environments.

In attempt to elucidate the mechanism of dynamics of heavy metals in the plant body, noninvasive imaging of movement of heavy metal has been a powerful tool. In the past decade, we have employed a positron-emitting tracer imaging system (PETIS), which provides serial time-course images of the two-dimensional distribution of various positron-emitting radionuclides (e.g. ^{64}Cu, ^{62}Zn, ^{107}Cd) in an intact plant without contact (Fujimaki, 2007; Kawachi et al., 2006; Ishii et al., 2009; Watanabe et al., 2009; Suzuki et al., 2008; Fujimaki et al., 2010). Because most of positron-emitting radionuclides have short half-life (e.g. the half-life of ^{62}Zn is only 9.2 hours), we have to produce positron-emitting radionuclides by ourselves using cyclotron (a type of ion accelerator) in order to conduct the PETIS experiment.

One of zinc radionuclides, ^{65}Zn (half-life: 244 days) is commercially available and frequently used as a zinc tracer in the field of plant science. ^{65}Zn is a positron-emitting radionuclide but its emitting ratio is only 1.4 %. Therefore, ^{65}Zn was thought to be an unsuitable radionuclide for positron imaging. However, there has been no detailed verification of the possibility of positron imaging using ^{65}Zn. Thus, in this study, we examined whether positron imaging of ^{65}Zn is possible by PETIS.

Methods

Rice plants (*Oryza sativa* L.) were cultured hydroponically for 4 weeks. The roots of the four rice plants were inserted into plastic syringes and the shoots were fixed on an acrylic board. The acrylic board with the plants and the syringes was set in the field of view of the PETIS detector. Then, the hydroponic solution containing 400 kBq ^{65}Zn was fed to each syringe and the movements of ^{65}Zn in the intact rice plants were monitored by PETIS every 1 min for 48 hours continuously.

Results

We obtained the fine serial images by using ^{65}Zn and PETIS (Fig. 1). ^{65}Zn signal spread in the region of the syringe during the first 1 hour and gradually gathered in the shape of the root after 2 hours. Furthermore, the strong ^{65}Zn signal was accumulated in the region of the shoot base after 12 hours. Finally, little ^{65}Zn signal was found in the root region after 48 hours. These results indicated that we succeeded in visualization of the process of zinc uptake from the root and translocation to the shoot in the intact plant by using ^{65}Zn and PETIS.

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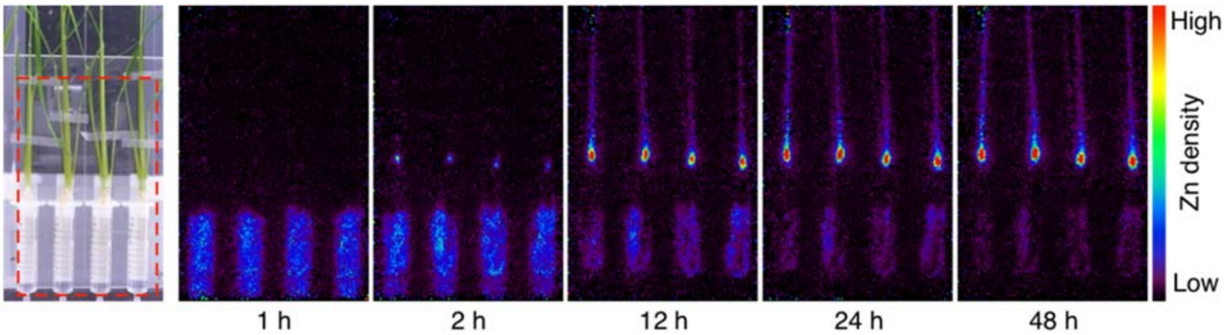

Figure 1. Serial PETIS images of ^{65}Zn distribution in intact rice plants. The red dot line in the photograph shows the field view of PETIS. Each PETIS image is integration of 60 original frames, corresponding to 1 hour.

Conclusion

We conclude that ^{65}Zn is a suitable radionuclide for noninvasive imaging of zinc movement in intact plants. By taking advantage of the long half-life of ^{65}Zn, zinc movement can be visualized all through the life of plants. Furthermore, the commercial availability of ^{65}Zn and PETIS detector (Hamamatsu Photonics, Japan) makes it possible to conduct noninvasive imaging of zinc movement in facilities without cyclotron and accelerates the researches about the mechanism of zinc dynamics in the plant body.

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