Title
Analysis of root-to-shoot translocation of Cd in rice cultivars using a positron-emitting tracer imaging system

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Recently, positron-emitting nuclides have been used in plants to study the behavior of metals such as $^{52}$Fe, $^{52}$Mn, and $^{62}$Zn using a positron-emitting tracer imaging system (PETIS) (Watanabe et al., 2001). The tracers of $^{105}$Cd and $^{107}$Cd which are positron-emitting nuclides have been developed and are being applied to plants for visualizing the movement of Cd in real-time (Fujimaki et al., 2006). In the present study, we used PETIS to analyze the real-time translocation of Cd in 6 rice cultivars with different Cd accumulation in upper parts including grains.

We previously selected three rice cultivars ($Oryza sativa$ L., $indica$ type, cvs. Cho-ko-koku, Jarjan, Anjana Dhan) with extremely high Cd concentration in grains and shoots, while three major $japonica$ cultivars in Japan (Nipponbare, Koshihikari, and Sasanishiki) showed a lower Cd concentration in these parts (Uraguchi et al., 2009). Six cultivars were grown in a hydroponic culture for 20 days, and then the seedlings were transplanted to plastic syringes containing $0.5$ mM $CaCl_2$ solution. PETIS analysis was started by adding purified $^{107}$Cd (half-life 6.5h) with $0.1\mu$M Cd as a carrier to $0.5$ mM $CaCl_2$ solution. Time-series images of the $^{107}$Cd distribution were monitored simultaneously in 6 rice cultivars.

The serial images obtained from PETIS revealed that $^{107}$Cd first appeared at the basal portion of the shoot within 2h after $^{107}$Cd exposure. This was similar pattern to $^{52}$Mn and $^{52}$Fe in barley, suggesting that this region may play an important role in heavy metal distribution in graminaceous plants (Tsukamoto et al., 2009). The strength of $^{107}$Cd signal at the basal portion was much greater in $indica$ cultivars than in $japonica$ ones during $^{107}$Cd exposure. $^{107}$Cd accumulated increasingly at the upper portion of the shoot in $indica$ cultivars with time, while the signal of $^{107}$Cd was less in $japonica$ cultivars. Thus, the positron emitter of $^{107}$Cd was very useful isotope for studying the real-time behavior of Cd in rice plants and we first succeeded to visualize the difference in the real-time translocation of Cd among rice cultivars showing different shoot Cd accumulation. Taken together, these results suggest that different pattern of root-to-shoot translocation of Cd is responsible for genotypic variation in the shoot Cd concentration in rice.

References