RECENT RESEARCH ACTIVITIES

Discovery of a cadmium transporter for phytoremediation

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Plants chose sessile life style during the evolution since the land plant colonization 500 million years ago. This means that once plants germinate, they complete their entire life duration at the same location where they anchored their roots. Because of the life style, plants have developed a variety of stress response mechanisms to resist and/or tolerate inferior or unfavorable environments. Heavy metal stress is one of them. Because of the economic activities of humans, if particular areas are heavily polluted with heavy metals, such as Pb, or Cd, plants cannot, however, escape from those polluted area, when they started to grow. Thus, plants have developed various heavy metal tolerant mechanisms, and heavy metal transporters are representatives of them.

Transition metal cations play an important role in plant growth and development. For instance, iron (Fe) is an essential element because it acts as a structural and functional component of many biological molecules such as nitrogenase in nodules [1]. In contrast, cadmium (Cd) is a toxic metal that is not required for any physiological functions. Typical cadmium toxicity for plants results in some serious symptoms e.g., chlorosis, growth retardation, and browning of the root tips, which may cause death at a high concentration. Transition metal cations are absorbed with water by root tissues from the soil, and then are circulated in the plant body via vascular tissue and transporter proteins. If the soil contains not only essential metals but also non-essential toxic metals, the uptake of metals may be managed under competition, which is the phenomenon known as inducible deficiency.

We selected a metal accumulater plant, *Crotalaria juncea* (Fabaceae). *C. juncea* has been reported as a plant species to show strong tolerance to Cd, and to accumulate this toxic metal in high concentrations in its leaves (118 mg kg^{-1} DW) in addition to Fe. This is an attractive plant to study metal transporters involved in Cd accumulation because of its high tolerance for Cd and also because of its preference to translocate these metals into the aerial part of the plant. We have isolated a cDNA, belonging to the metal transporter NRAMP family from this plant.

The membrane localization analysis of CjNRAMP1 showed as being the plasma membrane of plant cells. Complementation experiments using yeast strains, in which metal transport systems were impaired, showed that CjNRAMP1 transported both Fe and Cd in an inward direction within the cells. Transgenic Arabidopsis plants overexpressing *CjNRAMP1* gained high tolerance to Cd; notably, the Cd translocation from roots to leaves was dramatically enhanced compared to the wild type plants. The overexpression of *CjNRAMP1* resulted in a higher accumulation of Fe in both the shoots and roots, suggesting that CjNRAMP1 recognizes Fe and Cd as substrates, and that the high Cd tolerance of CjNRAPM1 is due to its strong Fe uptake activity even under the high Cd concentrations in the rhizosphere.

References

[1] Takanashi, K., Yokosho, K., Saeki, K., Sugiyama, A., Sato, S., Tabata, S., Ma, JF., Yazaki, K., "LjMATE1, a citrate transporter responsible for iron supply to nodule infection zone of *Lotus japonicus*" Plant Cell Physiol., 54 (4), 585-594, 2013.

[2] Nakanishi-Masuno, T., Shitan, N., Sugiyama, A., Takanashi, K., Inaba, S., Kaneko, S., Yazaki, K., "The *Crotalaria juncea* metal transporter CjNRAMP1 has a high Fe uptake activity, even in an environment with high Cd contamination" Intl. J. Phytoremed., 20 (14): 1427-1437 (2018).