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Phytoremediation potential of Indica rice to clean cadmium polluted paddy fields

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Cadmium (Cd) is one of the key problem elements regarding the production of safe rice, i.e. rice that meets food quality standards of WHO or national governments. Due to the relatively high transfer of Cd from soil into the rice plants and eventually rice grains, Cd levels in rice frequently exceed current food quality standards of 0.2 mg kg-1 (WHO) or even 0.4 mg kg-1 (Japan, Taiwan). Recent research results indicate that even at relatively low Cd levels in soil (0.5 to 1.0 mg kg-1) Cd levels in grain exceed these standards (Römkens et al., 2010). Especially in highly industrialized areas like Taiwan and other parts of Asia, such levels in soils are easily reached or exceeded due to the use of contaminated irrigation water. The vicinity of especially electronic industries has resulted in a substantial emission of Cd and other metals to the surface water which subsequently was used for irrigation purposes.

In order to produce safe rice, i.e. rice that meets quality standards set by local or (inter)national governments, soil management is needed to ensure that Cd levels in rice are lowered. Traditionally soil cleanup was the main instrument through which a reduction of soil Cd levels has been achieved. Methods employed in Taiwan include ex-situ soil washing with strong acids followed by liming of the acid soil or deep ploughing which resulted in a lowering of the top soil Cd content. Obviously both methods have disadvantages which are hard to overcome. Acid washing of soil results in a serious degradation of soil quality (nutrient status) and structure although the latter aspect is less relevant in paddy soils. Also the presence of small amounts of acid remaining in soil aggregates results in a potential release of Cd after the treatment has been completed. Soil mixing (deep-ploughing) results in a rapid translocation of Cd to lower soil horizons and thereby a potential release to ground- or surface water systems.

Ideally soil treatment strategies should both minimize the impact on soil and at the same time minimize the impact on the farming activities of the farmer. One of the options to achieve these goals is to use rice plants themselves to act as phytoextraction crops. Rice has various advantages which favours the application as a phytoextraction crop: i. a high biomass, ii. the potential of 2 to 3 crops each year depending on local climatic conditions and water supply of course, iii. a high uptake rate in stems and leaves.

However, at present little information on a field scale level is available to assess the potential of rice for phytoextraction. In order to successfully apply phytoextraction reliable estimates are needed of the time frame required to achieve the desired reduction of soil Cd levels. Up till now, such estimates are mainly based on limited data. To improve the accuracy of predictions of the time frame, a model was developed based on a large number of field data. A transfer model that is able to predict the levels of rice in various parts of the plant (including roots, stems, leaves, husk and grain) was developed using up to 3000 paired data samples from soil and rice. The dataset contains information on 12 different cultivars which is essential since uptake of Cd from soil varies greatly among cultivars.

The presentation focuses on the model structure which allows to distinguish between different soils by considering soil pH, texture and soil organic matter. The model subsequently will be used to assess under which conditions and levels of Cd in soil phytoextraction is a realistic alternative to standard techniques used to remediate soils.