POSSIBLE PATHWAYS OF DIOXIN ACCUMULATION TO THE ABOVE-GROUND PORTIONS OF RICE PLANTS GROWN IN CONTAMINATED SOILS

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Introduction

Field experiments and field observations conducted so far to measure dioxin transfer has shown that the uptake of most lipophilic organic pollutants such as dioxins through roots is not a significant pathway of accumulation[1-4]. These results, however, were limited only for the upland crops, and that there was no report on aquatic plants such as rice. Contamination of rice is of special importance for the Asian peoples because of its high consumption compared to other foodstuffs.

Despite the information in the literature on dioxin transfer to upland crops, there are still uncertainties over the accumulation and contamination of dioxins to rice plants from soil and from air. The knowledge of the chemicals accumulation in rice should lead to full understand for intake route of dioxins into humans via rice.

Field studies were conducted in the greenhouse to measure the extent of dioxin transfer into rice plants from soils with different congener profiles and also to assess difference between organs in above-ground portions in the ability to accumulate the dioxins.

Materials and Methods

Soils contaminated with significant proportion of the lower chlorinated congeners, 1,3,6,8-, 1,3,7,9-TeCDDs and OCDD, due to impurities in organochlorine herbicides which have ever been used in Japanese paddy field[5,6], and also soils contaminated with a legacy of congeners due to the emission from waste incinerator were used for the study. A rice variety, Koshihikari, grown in pots with soils were used for the study, and they have been kept in greenhouse until harvest. The sap of the transpiration stream in stem was collected to show direct evidence of the ability of rice to take up dioxin in soil via roots at stages during tillering to just before heading. The above-ground portions of rice plants were harvested when they were in yellow ripe stage, and they were air dried for several days. The husked rice was removed the husk by machine to get rough rice.

Extraction, cleanup and analyses for dioxins (PCDD/Fs and Co-PCBs) in sap of the transpiration stream were carried out by dichloromethane, combination silica gel and activated carbon column chromatography. Samples were analyzed by HRGC/HRMS (HP6890/VG AUTOSPEC ULTIMA) equipped with a SP-2331 (SUPELCO) or DB-5 (J&W SCIENTIFIC). For analyses of dioxins in soils and plants were commissioned to measure by Japan Food Research Analysis (JFRA), Tokyo.

Results and Discussion

Dioxin concentration (I-TEQ/g) of the above-ground portions and the sap of the transpiration stream of rice grown in corresponding soils are shown in Fig.1. The results indicated that the major contamination of the above-ground portions of rice plant is found in leaves and husk, but that of rough

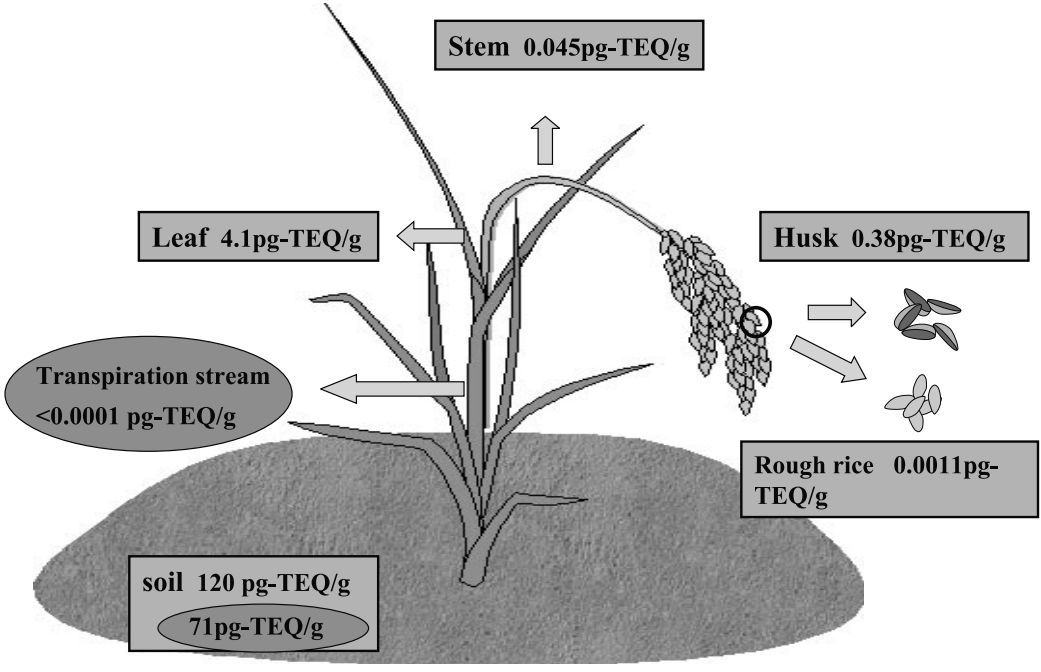

Figure 1. The acumulation and contamination of dioxins to the above-ground portions of rice plants.

rice is very low. The reason for the higher dioxin concentration of husk compared to rough rice is speculated that the grain has not exposed directly to the atmosphere during their growth due to the layer of husk surrounding the grain. It was found that dioxin concentration of all congeners in sap of transpiration stream were below detection limits (less than 0.01 pg/g). It seems to show that rice plants are unable to take up dioxin in soil via roots.

Dioxin concentration and congener profile of the above-ground portions of rice plants and dioxin homologue pattern of leaves grown in corresponding soils contaminated with different concentration and congener profile of dioxins are shown in Figs. 2 and 3, respectively. The above-ground portions of rice plants not only show similar concentration but also show similar congener profiles. The congener profiles of the portions are characterized by dominance of Co-PCBs, despite the very low concentration in corresponding soils. There are no difference in concentration and homologue profile of the leaves of rice plants grown in corresponding soils. In leaf samples, the homologue distribution pattern commonly show an decrease in the concentration from lower chlorinated to high chlorinated dioxins.

In the experiments, uptake of volatilized dioxins from contaminated soils seems of little relevance, if any, in accounting for the contamination of rice plants, as volatilization should be disturbed by water filled in pots during their growth. It is considered from results obtained above that dioxins are neither transfer through transpiration stream to above-ground portions of rice plants nor directly accumulated to rice grain from the atmosphere. It seems to show that the lower concentration of dioxins in grain compared to husk should account for the layers of husk surrounding the grain.

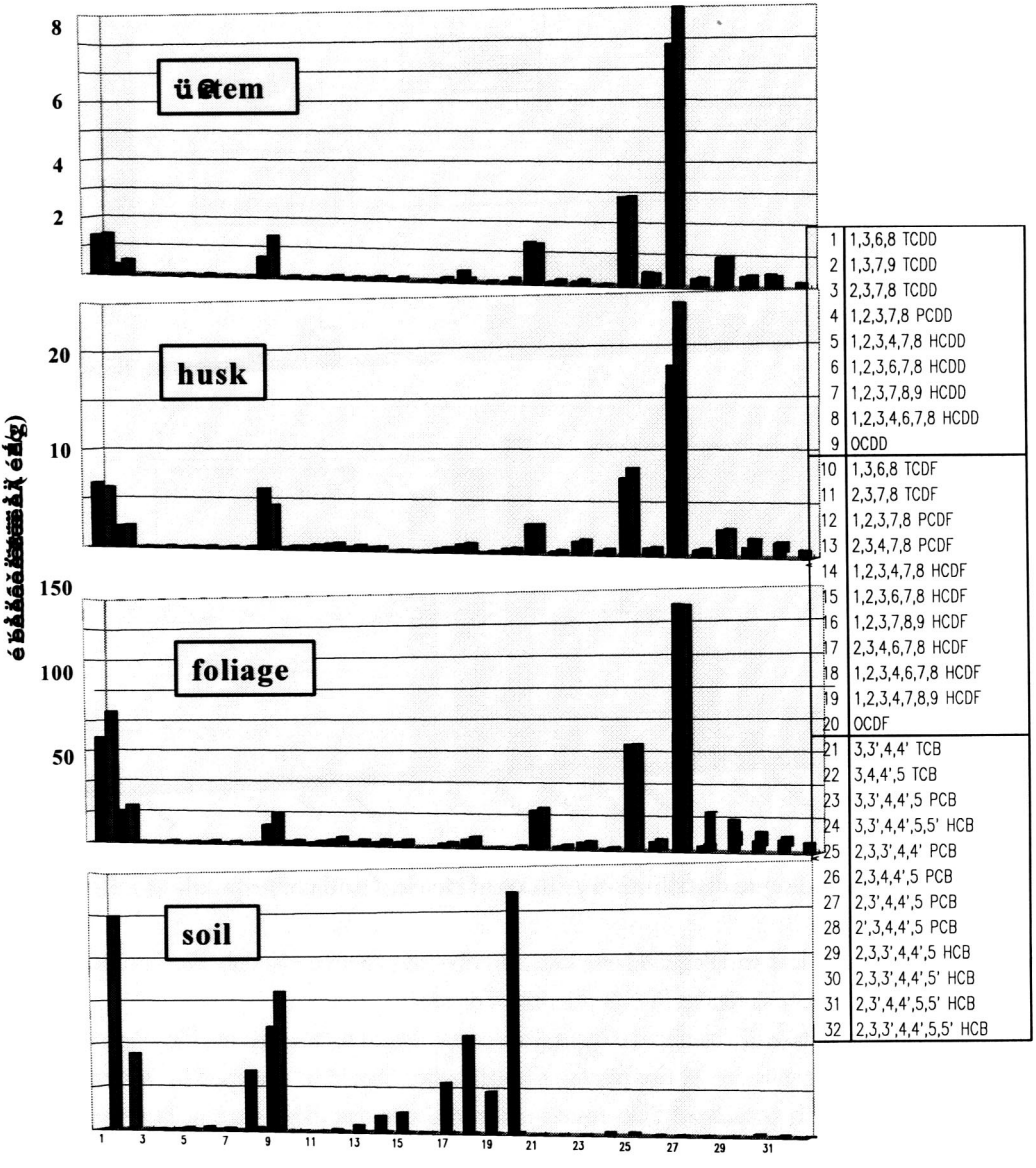

Figure 2. Congener profile for dioxins of soils and the above-ground portions of rice plants

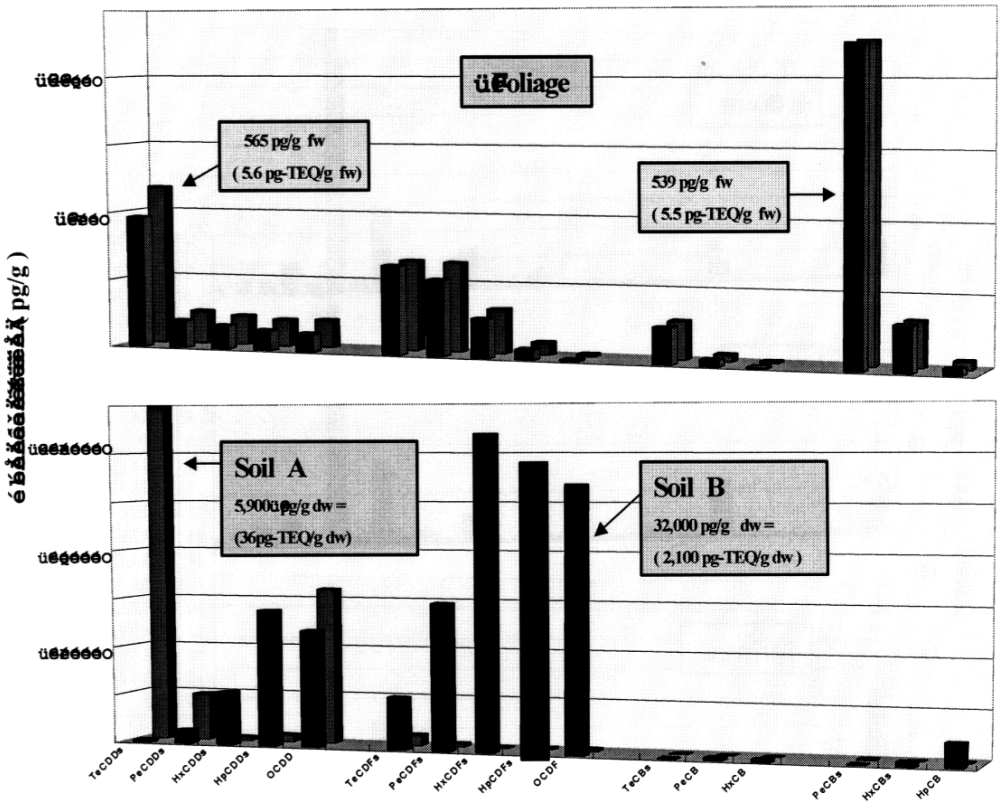

Figure 3. Dioxin homologue distribution pattern of rice leaf and corresponding soils

References

1. Briggs G.G., Briomilow R.H. and Evans A.A. (1982) Pesti. Sci., 13:495-504
2. Bacci,E. and Gaggi C. (1985) Bull. Environ. Contami. Toxicol. 35:673-681
3. Reishl A., Reissinger M., Thoma M. and Hutzinger O. (1989) Chemoshpere 19:467-474
4. McCrady J.K.,McFarlane C. and Gander L.K. (1990) Chemosphere 21:359-376
5. Yamagishi T., Miyazaki T., Akiyama K., Morita M., Nakagawa J., Horii S. and Kaneko S.(1981) Chemosphere 10:1137-1144