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THE FATE OF DIOXINS IN SILAGE CORN LEAVES: RELATIONSHIP BETWEEN DIOXINS CONCENTRATIONS AND BIOMASS OF SILAGE CORN LEAVES

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Introduction

There is growing concern over foods prepared from farm animals contaminated with polychlorinated dibenzo-*p*-dioxins (PCDDs), polychlorinated dibenzofurans (PCDFs), and coplanar PCBs (Co-PCBs) (these chemicals are collectively called dioxins in this paper). To reduce the intake of these chemicals contaminating human food, we must minimize the original contamination in animal feeds.

Silage corn (*Zea Mays L.*) is a major forage crop. We have been studying the dynamics of dioxins accumulation in corn and found that dioxins concentrations and profiles changed during the growth of corn plants. We reported[1,2] that in early growth stages, dioxins uptake by corn was affected both the cultivated soil and the atmosphere, after a few weeks dioxins uptake by corn was affected only the atmosphere. There seem to be 3 main sources for dioxins uptake: the soil adhered to corn, atmospheric particulate deposition, and gaseous in the atmosphere. There also appear to be 3 main ways by which the dioxins concentration in corn plants decreases: dilution by the plant growth, falling off the leaf surface, and gas exchange between the plant and the atmosphere.

We also reported[1,2] that dioxins concentrations and the profiles changed during plant growth and estimated the dilution caused by plant growth, or fall out of soil. But we could not determine the total amount of dioxins in the whole plant, because the total biomass was not measured.

In this paper, we clarified the relationship between the amounts of dioxins and the total biomass of contaminated plants.

Materials and Methods

Plant Management

The ‘Dea’ variety of silage corn (Pioneer Hi-Bred Japan Co. Ltd., Tokyo, Japan) was used. Corn seed was

sown on May 15, 2001, in an experimental field in Ibaraki, Japan. Fertilizer was applied as usual, and no pesticide was used. Corn leaves were harvested 14 times: on May 25, June 5, June 12, June 11, June 19, June 25, July 3, July 9, July 17, July 23, July 30, August 6, August 13, and August 20. The leaves from each three individuals plants were chopped and mixed thoroughly and then analyzed for dioxins.

Dioxins Analysis

Each of the plant leaf samples (100 g fresh weight) was crushed in contact with dry ice, extracted with hexane/acetone (150 mL/150 mL), and filtered through a glass fiber filter. The filtrate was treated with sulfuric acid, and the organic layer was evaporated, purified by silica gel column chromatography, and fractionated by activated carbon column chromatography. All samples were analyzed with a HRGC/HRMS system (HP6890/VG Autospec ULTIMA, Micromass Ltd., Manchester, UK) equipped with an SP-2331 column (Supelco) and a DB-5MS capillary column (J&W Scientific).

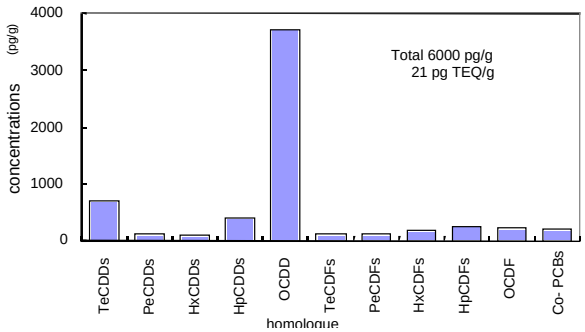

Figure1. Dioxin Concentrations of Soil Used to Grow Silage

Results and Discussion

The corn grew steadily, the heading stage occurred about July 3, and the yellow-ripe stage began about August 6. After that, the leaves changed rapidly to dark brown. Dioxins concentrations and the isomers in the cultivated soil and atmosphere are shown in Figs. 1 and 2. PCDDs, especially OCDD, dominated in the soil. In the atmosphere, high amounts of Co-PCBs were detected in the gas phase, whereas, that in the particle phase were negligible. Changes in leaf fresh weight and surface area were clearly distinguished into three stages: vegetative growth (May 15–July 3), reproductive growth (July

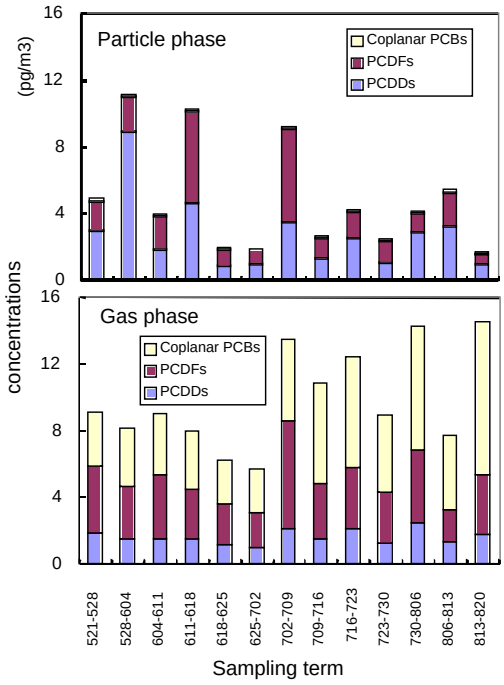

Figure2. Dioxin Concentrations in Atmosphere

3–August 6), and senescence (after August 6) stages (Fig. 3). Both the weight and surface area of the corn leaves increased during vegetative growth stage, did not change during reproductive growth stage, and decreased during senescence stage.

Our earlier work showed the relationship between corn growth stage and dioxins concentration. But it wasn't clear that the cause of the changes were biomass increasing or other factors.

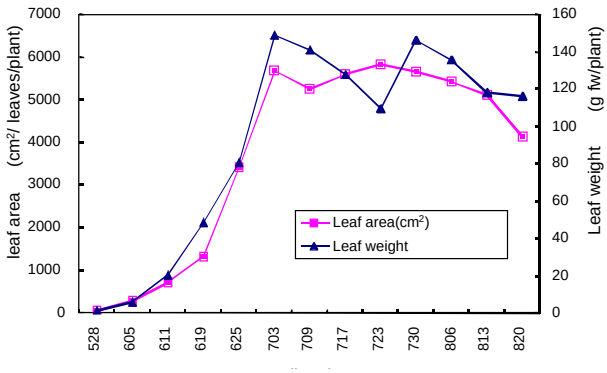

Figure 3. Increases in Corn Leaf Area and Fresh Weight with Plant Growth

The amounts of dioxins per unit area of the corn leaves differed in each stage of the growth (Fig. 4). The amounts of dioxins, all homologue, per unit leaf area generally decreased during vegetative growth stage, probably due to their dilution by the increasing biomass. In the reproductive growth stage, the amounts of dioxins increased, perhaps because the plants were subject to continued exposure to gaseous dioxins in the atmosphere. We thought the cause, which as for both differences was, changes the biomass. After senescence began, our observation is that concentrations first increased, then decreased, possibly due to gas-exchange between the leaves and atmosphere, washing from the plants by rain fall, and photo degradation in strong summer sunlight.

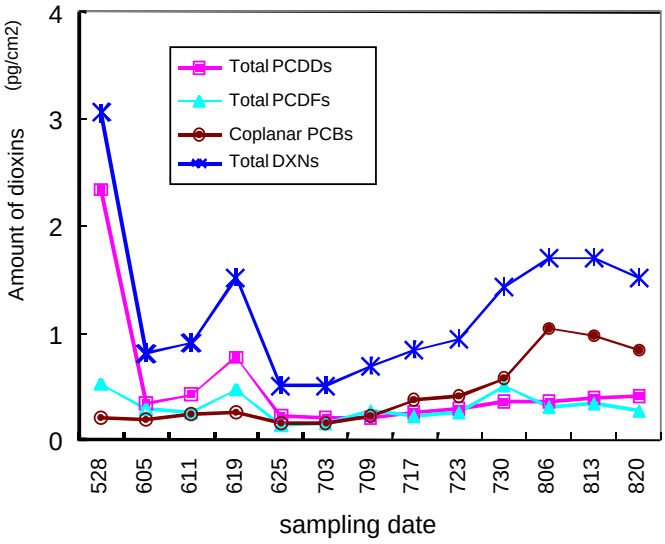

Figure 4. Amounts of Dioxins per Unit Area of Corn Leaves

The amounts of dioxins per total fresh leaf weight per plant increased roughly linearly with time until August 6 (Fig. 5). This result shows that dioxins accumulated during every stage without biomass dilution effect. After senescence, the amounts of dioxins decreased, perhaps due to vaporization from the leaves, felled with the leaves or photo degradation.

From these results, we suggest that the changes in dioxins concentrations per fresh weight during the growth of corn were mainly due to changes in biomass. We thought important phenomenon that changes dioxins amounts per unit leaf area in the vegetative growth stage and the reproductive growth stage were different, but total amount of corn leaves were little different. We thought there were minor factors, too. We are continuing to study these problems.

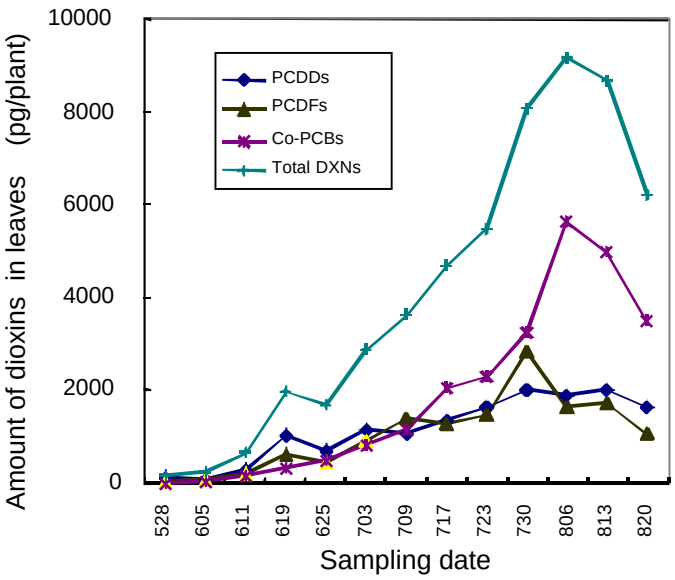

Figure 5. Amounts of Dioxins in total fresh leaves

References

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2. Uegaki R., Kurokawa S., Yoshimura Y., Cai Y., Fujita Y., Eun H., Seike N., Kuwahara M. and Ueji M. (2002) Organohalogen Compounds 57, 81–84.