UPTAKE OF PCBs IN HORDEUM VULGARE (BARLEY) AND LYCOPERSICON ESCULENTUM (TOMATO)

R.K. Puri, S. Kapila, W.R. Lower and A.F. Yanders

Environmental Trace Substances Research Center
University of Missouri
Columbia, Missouri

ABSTRACT

The uptake of PCBs by Hordeum vulgare (barley) and Lycopersicon esculentum (tomato) was investigated by growing these two species on soil contaminated with Aroclor mixtures 1221, 1242 & 1260 at 500 ppm levels.

INTRODUCTION

Polychlorinated biphenyls (PCBs), a group of chlorinated hydrocarbons, have been extensively used in a number of industrial products. The discovery of their widespread environmental occurrence and apparent link to carcinogenesis led to increased public concern which resulted in discontinuation of their use in open systems and cessation of their manufacture after 1976. Although no longer manufactured, the prior use and improper disposal of PCBs have resulted in their widespread presence in the environment, particularly in sediments, rivers, and various dump sites, and this continues to be a source for their entry into the food chain.

Investigations of PCB uptake by plants are few and mostly limited to individual chlorinated biphenyl isomers or a single PCB preparation added to growth medium (1 - 9). Some of the studies are also contradictory. Moreover, many isomers, especially the highly chlorinated PCBs, have not been studied with respect to their uptake and metabolism in plants (6). It is still a controversial issue as to whether or not PCBs enter the transportation channels of the plants.

In view of the above contradictory findings, it was considered desirable to undertake a systematic study in our laboratory to delineate plant uptake of PCBs from soil.

EXPERIMENTAL

Solvents, chemicals and plant material:

The organic solvents, anhydrous sodium sulfate, silica gel, Florisil and GPC used were specially prepared for analysis of residual organic pesticides. The Aroclors used (1221, 1242 & 1260) were generously provided by the Department of Agricultural Chemistry, Oregon State University, Corvallis, Oregon.

The p, p'-DDE and octachloronaphthalene were purchased from Ultra Scientific, North Kingstown, RI 02852. PCB standards of established identity were procured from National Research Council, Halifax, N.S., Canada.

Hordeum vulgare (barley) seeds were obtained from F & T Seed Service, Woodstock, IL 60098, and Lycopersicon esculentum (tomato) from A. L. Castle, Inc., Morgan Hill, CA 95037.

Preparation of Soil:

A soil mixture of 50% Bradford Farm clay loam soil, 25% sand and 25% promix was used throughout the study.

Preparation of Soil Contaminated With PCBs For Growing Plants:

Preparation of Clean Sand

The sand was obtained from the Department of Horticulture, University of Missouri, Columbia, MO. The sand was passed through sieve #40, washed with water, dried at room temperature and then extracted with n-hexane for 12 h in a large Soxhlet apparatus to remove any detectable organochlorine compounds. This treated clean sand was analyzed by GC/ECD and did not show the presence of PCBs.

Preparation of PCB-Contaminated Sand

PCB-contaminated sand was prepared in stainless steel vessels by adding a hexane solution of Aroclor mixtures 1221, 1242, 1260 (90 gm/300 ml) to the clean sand (4.50 kg) prepared earlier. The solution of the Aroclor mixtures was added drop by drop and thoroughly mixed. The sand was kept at room temperature overnight in a hood to remove the solvent.

Preparation of Soil Spiked with PCBs

The total amount of soil (180 kg) was divided into three parts. Each part (60 kg) of the uncontaminated soil was taken and put in the tumbler mixer and mixed thoroughly for 5 minutes. The contaminated sand (1.5 kg) was added and mixed thoroughly with soil for 10 minutes in the mixer. After mixing, the soil was immediately put into pots.

Preparation of Pots For Plant Growth

Ceramic glazed pots with 18 cm diameter and 14 cm height were used for the barley crop (H. vulgare L.). Bigger pots with 19 cm diameter and 17 cm height were used for tomato (L. esculentum L.). On the bottom of each pot, a 2 cm layer of clean gravel was placed, followed by contaminated soil. The soil in each pot was moistened with distilled water, and covered with a 3 cm layer of moist vermiculite.

Sampling Procedure:

The various parts of the plants growing above the soil were cut 5 cm above the soil level, washed with water and transferred to separate cleaned glass containers. The samples were transferred to a freezer and kept at -40°C.

PCBs Extraction and Purification From Plants and Soil:

50 gms of the fresh plant material was blended with 250 gms of anhydrous sodium sulfate and spiked with p,p' DDE surrogate and kept at room temperature for 2 hours. The material was extracted with cyclohexane in a Soxhlet apparatus for 14 hours. The extract was reduced to 1 ml and resolved by multiple column chromatography using Florisil, gel permeation and silica gel for cleanup to remove lipids and macromolecules such as chlorophyll pigments and other extraneous plant constituents.

PCB Analysis:

The quantitative determinations for PCB residues were carried out with a gas chromatograph equipped with an electron capture detector.

The GC analysis was carried out with a 60 m fused silica capillary with a "bonded" methyl (95%) / phenyl (5%) polysiloxane stationary phase. Columns with 0.32 mm i.d. were found to give optimum performance. A multi-ramp temperature program was used. The initial column temperature was kept at 80° and then ramped rapidly at 10°/min to 170°, after which the ramp rate was cut down to 3°/min to 250°. Separation of PCB congeners was achieved with dual column systems (10). Co-eluting congeners were transferred to a previously cooled, low mass cryogenic trap at preselected intervals. Trapped components were heat desorbed into the second column for further separation. A 30m x 0.25 (i.d.) fused silica tubing with bonded cyanopropyl siloxane was used as the second column. Two independently controlled electron capture detectors interfaced with the Laboratory Information Management System computer are used for monitoring effluents from column 1 and column 2.

The calibration curves are run at the start of the analysis set and cover a concentration range from 2 x to 40 x. All standard solutions in the laboratory were made by dissolving an Aroclor mixture ranging from 50 pg - 1 ng.

Various parts of the plants were analyzed at different stages of growth and the concentrations of PCB congeners were determined.

RESULTS AND DISCUSSION

The results of these studies on the uptake of PCBs by Hordeum vulgare (barley) and Lycopersicon esculentum (tomato) grown in PCB contaminated soil with the three Araclor mixtures (1221, 1242 & 1260) will be presented, and their bearing on the entrance of PCBs into the food chain will be discussed.

REFERENCES

1. Fries, G.F. and G.S. Marrow, Chlorobiphenyl movement from soil to soybean plants, J. Agric. Food Chem., 29, 757-759 (1981).

2. Buckley, E.H., PCBs in the atmosphere and their accumulation in foliage and crops, in Recent Advances Phytochem., 21, "Phytochemical Effects of Environmental Compounds", James A. Saunders, Lynn Kosak-Channing and Eric E. Conn, Eds., Plenum Publishing Corporation, 1987.

3. Iwata, U. and F.A. Gunther, Translocation of the polychlorinated biphenyl Aroclor 1254 from soil into carrots under field conditions, Arch. Environ. Contam. Toxicol., 4, 44-59 (1976).

4. Lawrence, J. and H.M. Iosine, Polychlorinated biphenyl concentration in sewage and sludge of some waste treatments plants in southern Ontario, Bull. Environ. Contam. Toxicol., 17, 49 (1977).

5. Moza, P., I. Weisgerber, W. Klein, Fate of 2,2'Dichlorophenyl 14C in carrots, sugar beets and soil under outdoor conditions, J. Agric. Food Chem., 24, 881 (1976).

6. Pal, D, J.B. Weber, and M.R. Overcash, Fate of polychlorinated biphenyls (PCBs) in soil plant systems, Residue Rev., 74, 45 (1980).

7. Sawhney, B.L. and L. Hankin, Plant contamination by PCBs from amended soils, J. Food Prot., 47(3), 232 (1984).

8. Walsh, G.E. T.A. Hollister and J. Forester, Translocation of four organochlorine compounds by red mangrove (Rhizophora mangel, L.) seedlings, Bull. Environ. Contam., 12, 129 (1974).

9. Suzuki, M., N. Aizawa, G. Okano, and T. Takahashi, Translocation of polychlorobiphenyls in soil into plants: A study by a method of culture of soybean sprouts. Arch. Environ. contam. Toxicol., 5, 343 (1977).

10. Duebelbeis, D.O., A Dual Column Reaction Gas Chromatographic System for the Structural Confirmation of Chlorinated Organics, Ph.D. Dissertation, University of Missouri, Columbia, 1988.