Bio-phytoremediation of organic pollutants in soils from organic farms: current situation in Poland and challenges

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Abstract

Contamination of soils with persistent organic pollutants (POPs), particularly DDT, is very common in the natural environment, and their removal from the soil has become a serious problem. Results of a monitoring program showed that about 80% of the soil samples collected from eight Voivodeships contained DDT residues. We have thus started a research program aiming at: i) assessing the presence of DDT contamination in different Polish soils; ii) evaluate the risk of DDT contamination for different horticultural crops; ii) evaluating the efficacy of different crops for phytoremediation; iii) isolating and selecting soil microbial organisms able to metabolize DDT; iv) assess the efficacy of a bio-rhizoremediation method to reduce the soil contamination with DDT. The consortia utilized in the bioremediation trials showed to favor DDT uptake by the plants and its translocation to above ground organs. Cucurbita pepo L. resulted the most efficient in DDT uptake. A rhizoremediation strategy, using C. pepo plants inoculated with specific microbial strains, seems to better sustain the uptake and accumulation by plants of DDT residues reducing the risk of residue presence in food.

Keywords: DDT, fungal and bacterial degradation, *Cucurbita* spp.

Introduction

Dichloro diphenyl trichloroethane (DDT) was commonly used in Poland as a plant protection product during the ‘50-70s of the last century, but was banned in ‘70s. Even though almost 50 years passed since that moment, soil and some plant products are still found to be contaminated with residues of DDT and its metabolites (Robertson and Alexander 1998). in case of organic production, regulated by EU Regulations 374/2008 and 899/2009, the finding of accidental presence of DDT residues in soil, eventually contaminating organic products, can result in the loss of organic certification. A monitoring was carried out sampling soils of different physico-chemical characteristics and trials applying different remediation strategies were carried out. Some results of the monitoring and of the preliminary tests of remediation are presented.

Materials & Methods

53 sites, in 8 Voivodeships, characterized by organic certified fields and crops were monitored, sampling soil and the growing plants. Soil samples were collected according to the official methodology and residues determination of DDT and its isomers and metabolites (p,p´-DDT, o,p´-DDT, p,p´-DDD, o,p´-DDD, o-p´-DDE, p-p´-DDE) was performed by gas chromatography (Tartanus et al. 2017).

Contaminated soil with DDT or its metabolites was collected from organic plantations and further added of 10 mg of analytical grade p,p.-DDT, which brought the total concentration up to 0.826 mg/kg. The prepared soil was inoculated with selected microorganisms’ consortia when preparing the potting mixture, thoroughly mixed to it. The contaminated soil was used to fill plastic pots used for bio- and rhizoremediation experiments. For the latter,

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seeds of zucchini cv. Soraya were sown in the pots. Samples of soil and plant materials from both trials were collected at the end of the growing season, about 53 days after sowing, and immediately processed for analysis.

Results and Discussion

The monitoring of DDT content in the several soils sampled, which resulted to be mainly Luvisols, showed that more than 80% of the samples (i.e. 43 out of 53 sites monitored) contained DDT or its isomers and metabolites at the level of µg/kg, with only four samples having a higher residues level - from 0.101 to 0.268 mg/kg. This is thus confirming early reports about the time persistence of these compounds (Wania and Mackay 1996).

Despite the detection of DDT in the soil, only 4 samples of the crops grown in these sites (cabbage, carrot, celery and leek) were found to contain traces of DDT, only in the roots; however, for three of them roots are normally not used for human consumption. DDT residues were not found in any edible part of the following crops that were sampled from the 11 contaminated sites: apple, blackberry, carrot, corn, dill, fennel, cucumber, green beans, lentil, mixture of cereals, parsley, parsnip, potato, pumpkin, red and white onion, red beet, rhubarb, sorrel, sour cherries, sweet cherries, tomato, zucchini. Even though early studies showed the possibility of uptake of DDT by plants (Lichtenstein 1959), significant translocation from roots to shoots has been demonstrated only for *C. pepo* (White and Zeeb 2006).

The soil inoculation with consortia of microorganisms induced a reduction of soil DDT residues (about 15-20%) in comparison to the initial level and all the inocula used favoured the uptake of DDT (from 50 to 100%), particularly those containing mycorrhiza fungi, in comparison to plants without inocula. The increase of nutrients uptake in roots colonized by mycorrhizal fungi colonization of roots could allow to hypothesize a similar mechanism for DDT in inoculated plants also considering the synergy with *C. pepo* metabolism (White 2002).

Conclusions

Since only 25% of the plants grown on polluted soils contained DDT residues, and only in root tissues, the risk of contamination of organic fruits is unlikely. To reduce the amount of DDT in soil, inoculation with microbial consortia in association with growing *Cucurbita pepo* plants could be a possible soil remediation strategy.

Acknowledgements

The research was carried out within the framework of the project “Identification of innovative solutions and good practices for the protection of pests and diseases, with particular emphasis on berry crops, including strawberries, raspberries and chokeberry”, funded by the Polish Ministry of Agriculture and Rural Development in 2015-2017.

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Citation of the full publication

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