ВЛИЯНИЕ НА ОРГАНИЧНИТЕ ДОБАВКИ ВЪРХУ УСВОЯВАНЕТО НА ТЕЖКИТЕ МЕТАЛИ ОТ ЕЧЕМИК (HORDEUM VULGARE L.)

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THE EFFECT OF ORGANIC AMENDMENTS ON UPTAKE OF HEAVY METALS IN BARLEY (HORDEUM VULGARE L)

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Abstract

Pot experiments were carried out to evaluate effects of organic soil amendments (peat, compost and vermicompost) on uptake of heavy metals (Pb, Cd and Zn) in barley (*Hordeum vulgare* L.). Soils used in this experiment were sampled from the vicinity of the Non-Ferrous-Metal Works near Plovdiv, Bulgaria. The soils were amended or not with 5, 7.5, 10 or 15% of peat, compost and vermicompost.

Peat, compost and vermicompost application led to effective immobilization of Pb, Zn and Cd phytoaccessible forms in soils. There was correlation found between the quantity of the mobile forms and the uptake of Pb, Zn, and Cd by the barley.

Organic amendments significantly reduced heavy metals concentration in barley grain, but the effect differed among them. Also, there was a dose effect for amendments. The peat treatments had only slight effects on the uptake of heavy metals. Thus, there was little benefit of peat treatments for phytoremediation purposes at these sites.

The compost and vermicompost treatments had significant effects on the uptake of heavy metals. The 7.5% compost and vermicompost treatments led to the maximal reduction of Cd, Zn and Pb in barley grain (64%, 53% and 47%, respectively).

Key words: Heavy metals, Organic amendments, Barley, Phytoremediation

INTRODUCTION

Phytoremediation can be defined as the combined use of plants, soil amendments and agronomic practices to remove pollutants from the environment or to decrease their toxicity (Salt et al., 1998). This technique has many advantages compared with other remediation procedures – low economic costs and the possibility of being applied to soils, causing a minimum environmental impact.

Addition of organic matter amendments, such as compost, fertilizers and wastes, is a common practice for immobilization of heavy metals and soil amelioration of contaminated soils (Clemente et al., 2005). The effect of organic matter amendments on heavy metal bioavailability depends on the nature of the organic matter, their microbial degradability, salt content and effects on soil pH and redox potential, as well as on the particular soil type and metals concerned (Walker et al., 2003, 2004).

The aim of the study was the determine the effect of organic additives on accumulation of heavy metals by the barley and to estimate the effect of the introduction of additives on the phytoremediation of contaminated with heavy metals soils.

MATERIAL AND METHODS

The soils used in this experiment were sampled from the vicinity of the area contaminated by the Non-Ferrous-Metal Works near Plovdiv, Bulgaria. It is characterized by acid reaction (pH 6.0), loamy texture and a moderate content of organic matter (2.0%). The total content of Zn, Pb and Cd is high (1481 mg/kg Zn, 767 mg/kg Pb and 29 mg/kg Cd, respectively) and exceeds the maximum permissible concentrations (200 mg/kg Zn, 70 mg/kg Pb, 1.5 mg/kg Cd).

The pot experiment was conducted on soil with organic amendments (peat, compost and vermicompost at 5.0%, 7.5% and 10.0% addition rates (calculated on soil dry weight basis). Soils were passed through a 1-cm sieve. Amendments were added and thoroughly mixed by hand. The pots were filled with 9 kg soil. All treatments were performed in triplicate. Three control pots were also set up without amendment. Pots were watered and stored in a greenhouse, where they were left to settle a minimum of 6 weeks at room temperature before planting the barley.

The winter barley were grown in a climate chamber with regular watering and random rotation of the position of the pots. On reaching commercial ripeness the barley plants were gathered and the contents of Pb, Zn and Cd in their different parts – roots, stems, leaves and grains, were determined by the method of the dry mineralization.

Total content of heavy metals in soils was determined in accordance with ISO 11466. The mobile heavy metals contents in soils were determined by 1 M NH_4NO_3. To determine the heavy metal content in the samples, inductively coupled emission spectrometer (Jobin Yvon Horiba "ULTIMA 2", France) was used.

RESULTS AND DISCUSSION

I. Effect of soil amendments on the mobile forms of Pb, Zn and Cd

In many plants there is direct relation between the content of microelements in the soil solution and their uptake by the plants. This relation is most evident with cadmium and less evident with zinc and lead (Kabata Pendias, 2001). The soil amendments used for phytostabilization may have a significant effect on the mobile forms of Pb, Zn and Cd as a result of sedimentation, absorption and change in the degree of oxidation.

The quantity of mobile forms of Pb, Zn and Cd depended on the soil amendments and the treatment (type and rate). The results presented in Figure 1 showed that the impact of soil amendments on mobile forms of Pb, Zn and Cd was explicitly expressed and led to their effective immobilization.

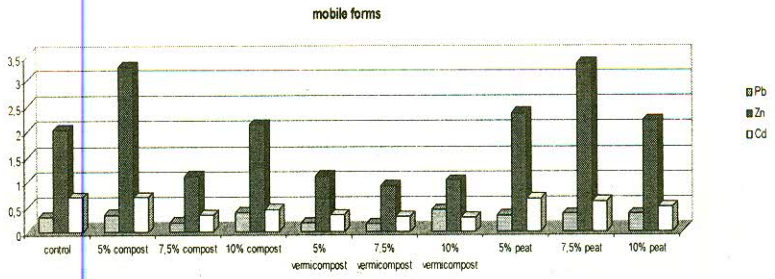

Fig. 1. Effect of the soil amendments on the quantity of the mobile forms of Pb, Zn and Cd

II. Effect of organic amendments on the Pb, Zn and Cd accumulation in barley

1. Accumulation of Pb, Zn, Cu and Cd by barley plants

The results for the influence of the organic additives on the accumulation and distribution of Pb, Zn and Cd in the barley plants are presented in Figure 2. The contamination of the barley was due mainly to the presence in the soil of heavy metals, which entered the plants through their root system. In all three elements the main part was accumulated in the roots. This was explained with the fact that on penetration in the plazma inactivation and precipitation of considerable quantities of heavy metals takes place, probably as a result of the formation of little mobile compounds with the organic substance.

The movement and the accumulation of the heavy metals in the vegetative organs of the barley plants differed considerably. Their quantities in the stems and leaves of the barley were considerably lower compared to the root system which showed that their movement through the conductive system was strongly restricted.

The heavy metal accumulation in barley grains was likely caused by the conductive system The results obtained showed that heavy metal content in the

barley grains, were very high (exceeding the maximum permissible concentrations) and did reach the phytotoxic levels reported by Lopez-Mosquera at al. (2000).

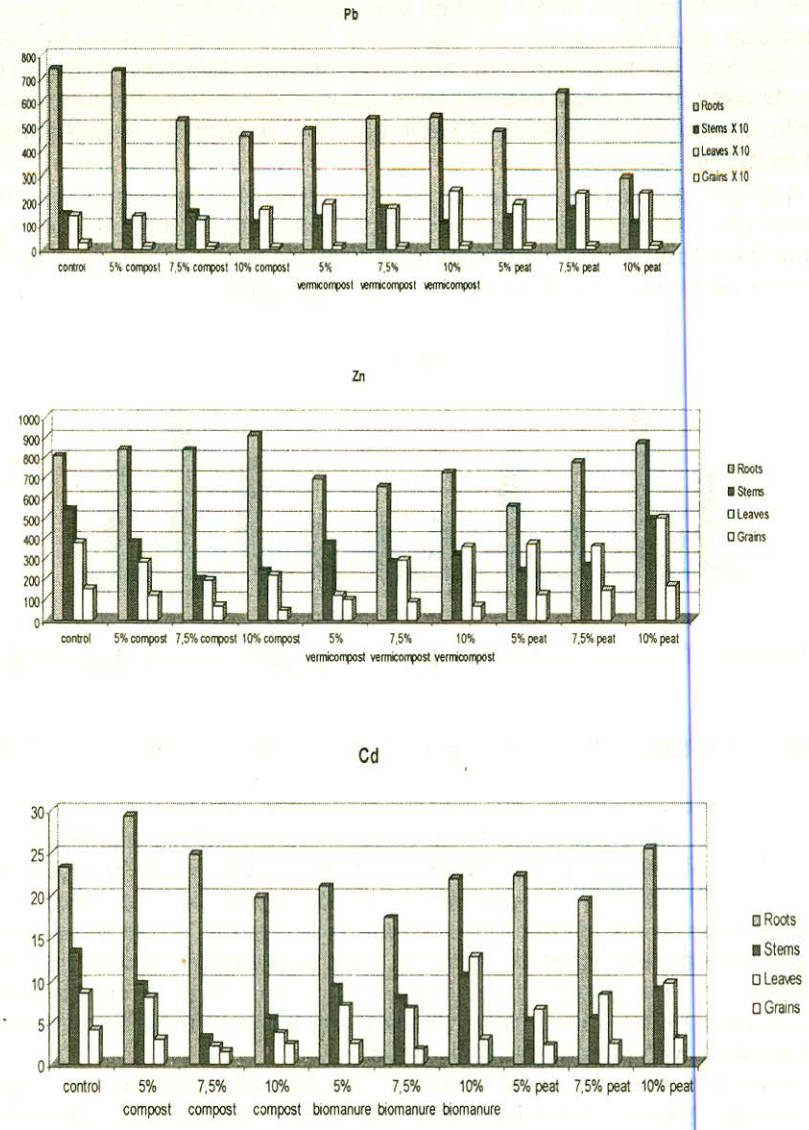

Fig. 2. Effect of the organic amendments on the quantity of Pb, Zn and Cd (mg/kg) in barley plants

These results did confirm those obtained by Madejon et al. (2002), according to whom cadmium, lead, arsenic and copper content in grains may reach levels considered toxic for the food-web.

2. Organic additives impact

According to the literature the content of organic substance in soil has a significant impact on uptake and translocation of heavy metals in soil and their uptake by plants. Zn, Pb and Cd are adsorbed on organic matter, which generate stable forms and lead to their accumulation in organic horizons of soil and peat (Kabata Pendias, 2001). The results obtained by us showed that Pb, Zn and Cd uptake by barley depended on the soil amendments and treatment (type and rate). Compost, vermicompost and peat addition led to decreased Pb content in barley roots and stems, and increased Pb content in leaves. Organic amendments led to decreased Pb content in the barley grains, and this decrease was best expressed with 10% compost, 7.5% vermicompost and 5% peat (Fig.2).

Impact of organic amendments on Pb accumulation in barley grains depended significantly on their quantity. Increase of compost quantity led to a decrease of the Pb content in barley grains: the concentration of Pb with 10% compost was 1,2 mg/kg. When the soil was treated with vermicompost, Pb content remained practically unchanged (1.8 - 1.9 mg/kg). When the soil was treated with peat, Pb concentration increased from 1.8 to 2.1 mg/kg.

Changes in Zn content in barley organs were rather complex. Zn content in roots increased in the plants treated with compost amendments and decreased with vermicompost and peat amendment. Zn content in stems and leaves decreased with all amendments used in the experiments, and this decrease was best expressed with 7.5% compost and 5% peat. Organic amendments led to decreased Zn content in the barley grain, and this decrease was best expressed with 10% compost, 10% vermicompost and 5% peat.

Cadmium content in barley roots, stems and leaves decreased with all amendments used in the experiments. Organic amendment addition was especially effective for the reduction of Cd content in barley grains. Increase of compost, vermicompost and peat doses led to a decrease of Cd content in barley grain by up to 1.50 mg/kg (7.5% compost), and 1.75 mg/kg (7.5% vermicompost).

Organic amendments significantly reduced heavy metals concentration in barley grain, but the effect differed among them. Also, there was a dose effect for amendments. The peat treatments had only slight effects on the uptake of heavy metals. Thus, there was little benefit of peat treatments for phytoremediation purposes at these sites.

The compost and vermicompost treatments had significant effects on the uptake of heavy metals. The high doses of compost and vermicompost treatments led to the maximal reduction of Cd, Zn and Pb in barley grain (64%, 53% and 47%, respectively).

CONCLUSIONS

1. Organic amendment application led to an effective immobilization of Pb, Zn and Cd mobile forms in soil. A correlation was found between the quantity of the mobile forms and the uptake of Pb, Zn and Cd by the barley grain.
2. Organic amendments significantly reduced heavy metals concentration in barley grain, but the effect differed among them. Also, there was a dose effect for amendments. The peat treatments had only slight effects on the uptake of heavy metals. Thus, there was little benefit of peat treatments for phytoremediation purposes at these sites.
3. The compost and vermicompost treatments had significant effects on the uptake of heavy metals. The 7.5% compost and vermicompost treatments led to the maximal reduction of Cd, Zn and Pb in barley grain (64%, 53% and 47%, respectively).
4. The organic amendments are of great interest for the purpose of phytostabilization. Evaluation of their potential, however, requires further study of the effect of organic amendments on a wider range of agricultural crops.

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