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LEAD PHYTOEXTRACTION AND REMANENT EFFECT OF Pb AND EDTA TREATMENT

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Abstract: *Phytotechnologies exploit natural plant physiological and biochemical processes, and green plants can be used for decontamination of soils polluted with trace elements and organic compounds (phytoremediation). A significant part of agricultural land in Europe and elsewhere is contaminated with heavy metals, some of which still in agriculture use. Plants play a crucial role in the contamination of the food chain by toxic metals, via primary accumulation before entry into animal or human body. Nowadays, the use of plants for the removal of atmospheric contaminants is less developed, but it will become extremely relevant to sustainable development and human health. Phytoextraction can be considered absorption of trace elements into roots, then translocation into shoots, followed by the harvest and destruction of the contaminated plants, with possible recycling strategies to recover metals from biomass or ash. The paper presents the preliminary tests regarding the remanent effect of Pb and EDTA treatment on the capacity of lead translocation into maize plants. It is presented the second vegetation cycle of maize plants on cambic chernozem soil material treated with both three different lead concentrations (1000 mgPb·kg-1, 2000 mgPb·kg-1, 300 0mgPb·kg-1) and EDTA remanent contents. The treatments (Pb and EDTA) were applied before seeding, at the beginning of the cicle I and consisted in the application of three lead concentrations (1000 mgPb·kg-1, 2000 mgPb·kg-1, 3000 mgPb·kg-1) and 6 concentrations levels of EDTA (expressed as ratio between EDTA and Pb). To study the remanent effect, we limited the number of doses of EDTA to 4 concentrations (0; 0.5; 1; 2). Similar with the first cycle, the plants weight, the plants height and the lead content from maize shoots are strongly influenced by the treatments with Pb, EDTA or Pb+EDTA. Pb concentration in biomass increased with EDTA concentration for the same Pb pollution degree. This study, as a preliminary test, evaluated the maximum permissible levels as concern both the lead accumulation degree and the chelating agent concentrations required to perform some phytoextraction conditions.*

Key words: *phytoextraction, soil pollution, Pb, EDTA, remanent effect.*

INTRODUCTION

Among the phytoremediation approaches, the phytoextraction supposes to choose a high yield biomass plant, but in the same time to be resistant at the toxicity of pollutants [1].

The implementation and integration of a phytoextraction technology requires both the use of special plants species and the assessment of preliminary tests to better understand and control the knowledge capacity to accumulate and tolerate high heavy metals concentrations, the period of time till harvesting, growth cycles for plants, the biomass yield, the polluted soil characteristics, etc.

Several chelating agents can effectively increase the solubility of heavy metals contaminants in soils and subsequently enhance their uptake by several crops [2].

METHODS AND MATERIALS

The experiments achieved during the Cycle II of vegetation were preliminary tests and have been focused on the remanent effect of Pb and EDTA treatment as regard the relationship between the Pb accumulation in the maize shoots and the addition of certain organic agents to the soil.

The working methods were the same as those in the Cycle I [3].

As a plant test it has been used the maize.

The vegetation period was also for 7 weeks.

The doses have been established according to the Cycle I conclusions (V17; V18-V29): Pb as $Pb(NO_3)_2$ (1000 mg $Pb{\cdot}kg^{-1}$, 2000 mg $Pb{\cdot}kg^{-1}$, 3000 mg $Pb{\cdot}kg^{-1}$) and EDTA:Pb ratios between 4 and 2 levels depending of Pb soil concentrations.

The experiments were set up in the same plots used in Cycle I. The seeding was effected after Cycle I harvesting and the studies focused on the remanent effect of Pb and EDTA treatments.

Based on the conclusions of the pot experiments described in the Cycle I, to study the remanent effect, we conducted the new experiments optimizing the rates, limiting and eliminating those doses which can not enhance the phytoextraction expressed in a high-yielding biomass and high Pb accumulation in the maize shoots.

All the plants were harvested by cutting the shoots 0.5 cm above the surface of the soil.

The Pb concentrations from maize shoots were analysed using atomic absorption spectrometry [4].

Similar with the Cycle I study, the statistical data concerning the plants weight, the shoots height and the Pb accumulations showed a high influence of Pb, EDTA or Pb+EDTA treatments.

RESULTS AND DISCUSSIONS

1. Experiment: maize (Cycle II) – soil material with one Pb concentration level (1000 mg $Pb{\cdot}kg^{-1}$) and some EDTA contents (expressed as EDTA:Pb molar ratio): 0; 0.5; 1 – remanent effect.

Statistical data revealed that both the weight and the height of the maize shoots distinct significantly decreased related to the increasing of EDTA content (Tukey *test*).

Compare with the control, according with Fisher *test*, the Pb contents in the maize shoots distinct significantly increased for all the treatments.

The figures 1, 2 and 3 present the evolution of weight, height and Pb content of the maize shoots observed during the Cycle I and Cycle II at the dry matter yields of the crops on an artificial polluted soil material with 1000 mg $Pb{\cdot}kg^{-1}$ and four levels of EDTA contents. From statistical point of view, the three parameters evolution is similar for the two crops (Cycle I and Cycle II).

There are still differences between the two harvests as concern the aboveground biomass weight like a value.

Even at the control, the weight of the aboveground biomass harvested after Cycle II was
5 times higher than that harvested after Cycle I (fig. 1) and this is due to the warm and light various conditions during the 2 cycles.

Cycle I was developed in the laboratory, on April-May period and Cycle II in the Green House conditions, on June-July period when the light was very intensely and the temperatures were higher.

This explains also the increasing of Pb concentrations in the aboveground biomass (fig. 3).

2. Experiment:maize (Cycle II) – soil material treated with 2000 mg $Pb{\cdot}kg^{-1}$ and some EDTA contents (expressed as EDTA:Pb molar ratio): 0; 0.5; 1 – remanent effect.

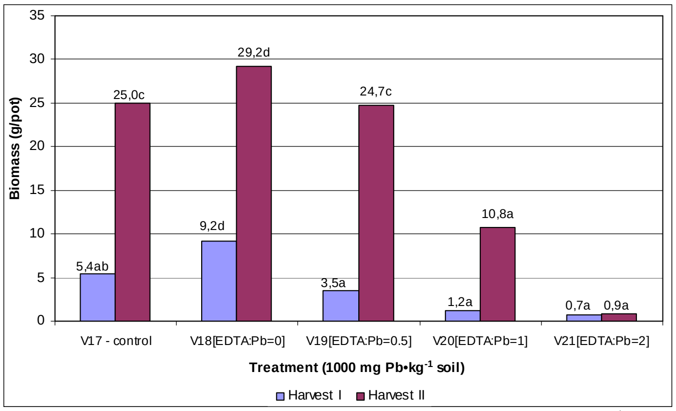

Figure 1: Plant weight related to the treatment (1000 mg Pb·kg^{-1}) in the first and second harvest (remanent effect).

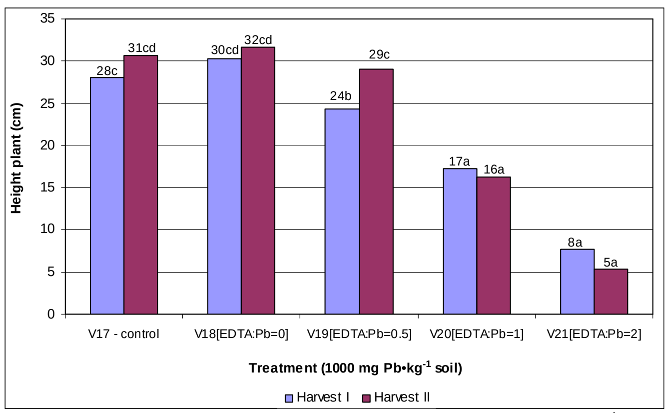

Figure 2: Plant height related to the treatment (1000 mg Pb·kg^{-1}) in the first and second harvest (remanent effect).

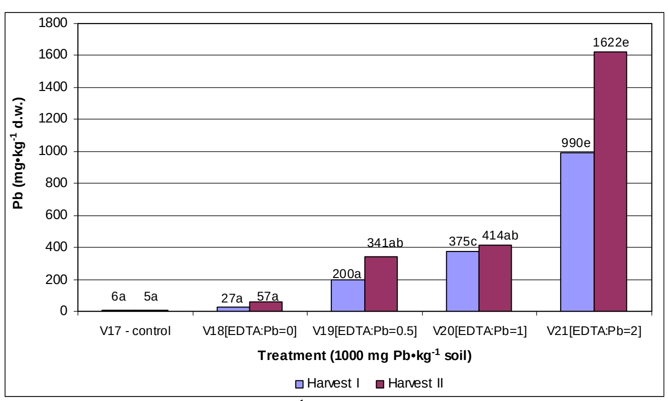

Figure 3: Lead concentration (mg·kg^{-1} dry matter) in maize related to the treatment (1000 mg Pb·kg^{-1}) in the first and second harvest (remanent effect).

As we mentioned in the Cycle I conclusions of the laboratory preliminary test, this experiment was conducted using only 3 levels of EDTA as a molar ratio: 0; 0.5; 1[3].

Considering the two measured parameters, shoots weight and Pb accumulation in the plants it was established that maize can be use as a hiperaccumulator plant only up to 0.5 EDTA:Pb ratio. It is a conclusion that confirmed the Cycle I results.

In the figures 4, 5 and 6 are simultaneously presented the evolution during the Cycle I and Cycle II of the three measured indicators: weight, height and Pb content related to the treatment applied in the pots at the beginning of the Cycle I (remanent background contents of 2000 mg $Pb \cdot kg^{-1}$ and EDTA).

From statistical point of view, the evolution is similar for the two harvests and for the three indicators: the biomass weight and the shoots height significantly decreased with the increasing of EDTA content and the Pb concentrations significantly increased in the aboveground biomass.

There are differences between the values of the weights at the harvests in Cycle I and Cycle II due to various plant growth conditions in the laboratory and in the Green House experiments (fig. 4).

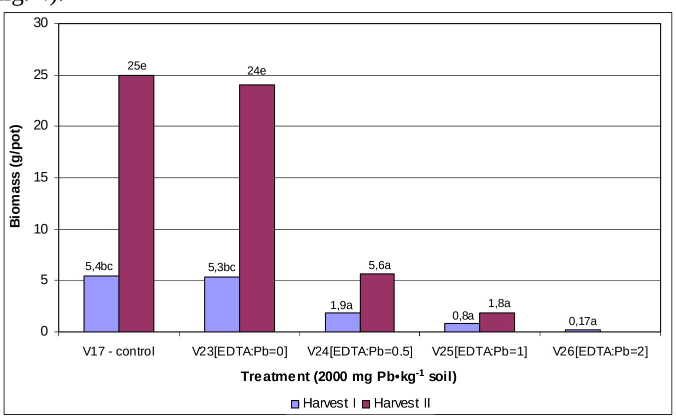

Figure 4: Plant weight related to the treatment (2000 mg $Pb \cdot kg^{-1}$) in the first and second harvest (remanent effect).

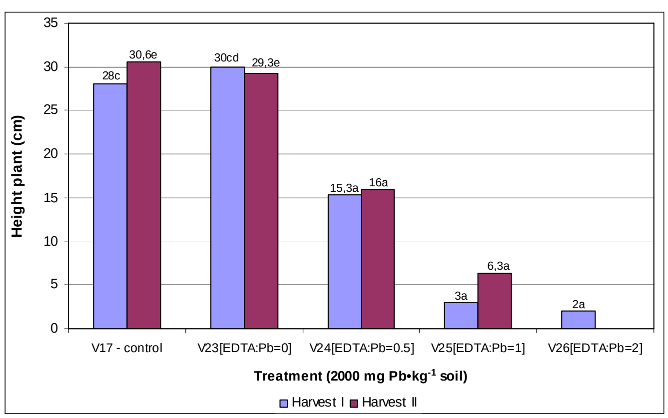

Figure 5: Plant height related to the treatment (2000 mg $Pb \cdot kg^{-1}$) in the first and second harvest (remanent effect).

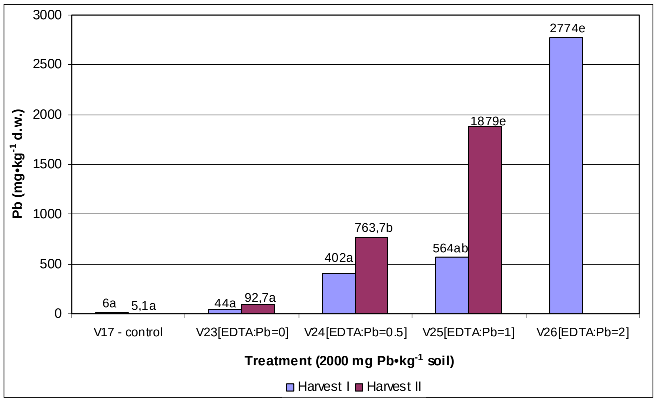

Figure 6: Lead concentration (mg·kg^{-1} dry matter) in maize related to the treatment (2000 mg Pb·kg^{-1}) in the first and second harvest (remanent effect).

3. *Experiment: maize (Cycle II) – soil material treated with one Pb concentration (3000 mg Pb·kg^{-1}) and different contents of EDTA (expressed as EDTA:Pb molar ratio): 0; 0.5 – remanent effect.*

In this experiment we seeded only in the plots treated during at the beginning of Cycle I with 0 and 0.5 EDTA contents (expressed as a molar ratio).

The plants had low biomass production and low tolerance to Pb which negatively affected crop growth at the elevated Pb concentration of 3000 mg Pb·kg^{-1} and at 1 and 2 EDTA:Pb ratios. Moreover, these treatments leaded to plants death.

Figures 7, 8 and 9 presents the evolution of plants weight and height and Pb concentrations in the maize shoots during the Cycle I and Cycle II and the effect of residual treatments as a perspective for phytoextraction purposes.

4. The experiment with three Pb concentrations levels (1000, 2000 and 3000 mg Pb·kg^{-1}) and 0.5 EDTA:Pb ratio, according with Tukey *test*, demonstrated that the biomass weight, the shoots height and the Pb content in the plants decreased and respectively increased related to the remanent treatment effect (Table 1).

The Pb accumulation in the maize shoots significantly increased without the decreasing of biomass weight only for 1000 mg Pb·kg^{-1}treatment at a EDTA:Pb ratio up to 0.5.

As concern the doses with 2000 mg Pb·kg^{-1} and 3000 mg Pb·kg^{-1} and EDTA:Pb ratio of 0.5, the biomass weight significantly decreased compared with control and the Pb contents significantly increased, too.

Table 1

Biomass weight, shoots height and Pb concentration in maize shoots on a soil polluted material (1000, 2000 and 3000 mg Pb·kg^{-1} – remanent content) and the same content of EDTA (EDTA:Pb=0.5) – remanent content

Treatment*	Biomass weight (g/pot)	LS**	Shoots height (cm)	LS**	Pb (mg·kg^{-1} d.w.)	LS**
V17 – control (Chernozem Fundulea)	25.0		30.6		5.1	
V19: Soil + [1000 mg Pb·kg^{-1}+ EDTA (EDTA:Pb=0.5)]	24.7	-	29.0	-	341.0	***
V24: Soil + [2000 mg Pb·kg^{-1}+ EDTA (EDTA:Pb=0.5)]	5.6	000	16.0	000	763.6	***
V29: Soil + [3000 mg Pb·kg^{-1}+ EDTA (EDTA:Pb=0.5)]	3.8	000	10.7	000	1445.0	***

* Remanent effect

**LS – Level of Significance

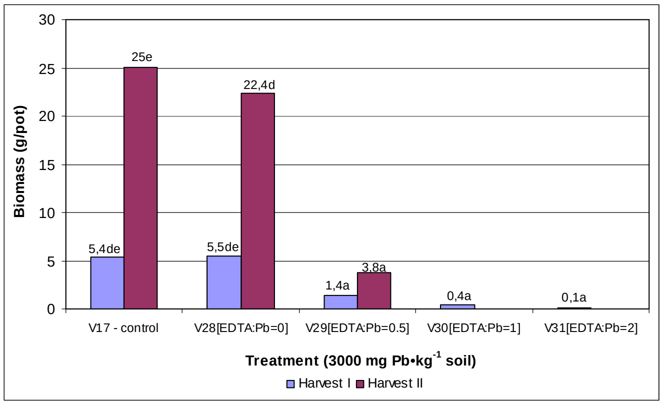

Figure 7: Plant weight related to the treatment (3000 mg Pb·kg^{-1}) in the first and second harvest (remanent effect).

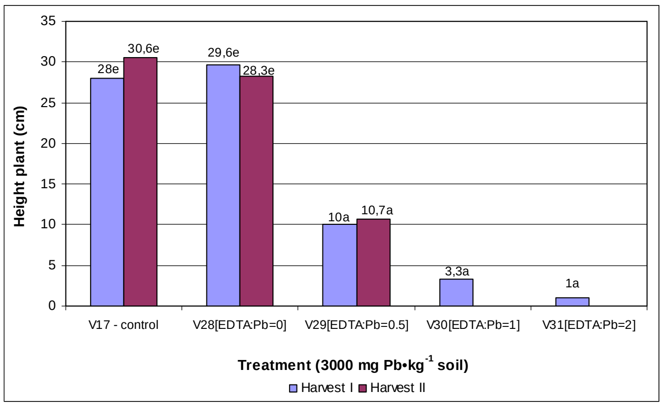

Figure 8: Plant height related to the treatment (3000 mg Pb·kg^{-1}) in the first and second harvest (remanent effect).

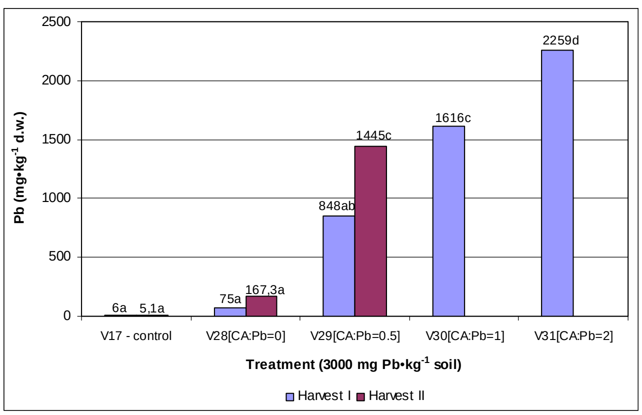

Figure 9: Lead concentration (mg kg^{-1} dry matter) in maize related to the treatment (3000 mg Pb·kg^{-1}) in the first and second harvest (remanent effect).

CONCLUSIONS

1. The statistical data concerning the evolution of the biomass weight, the maize shoots height and the Pb content in the plants during the Cycle I are similar with those resulted in Cycle II.

2. The chelating agent (EDTA) can effectively increase the solubility of Pb in soil and in the same time, there is a relationship between the enhancing of Pb solubility in soil material and the doses applied to improve the phytoextraction conditions.

3. On a soil material artificial polluted with 1000 mg $Pb \cdot kg^{-1}$, the optimum molar ratio EDTA:Pb do not exceed 0.5 value.

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