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Effect of heavy metals on germination and growth of *Cucumis sativus*

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Abstract

Germination and growth tests of* Cucumis sativus *have been carried out in the presence of increasing Pb, Ni and Cu concentrations. Low metals concentrations (0.00-0.064 mM) exerted a positive effect on plant growth: in particular, Cu showed a stimulating effect at high (0.64 mM) concentrations, probably due to its own characteristic of essential metal. Finally, the metals bioaccumulation data into the seeds pointed out the toxicity level for tested metals.

Introduction

The human activities and the rapid urbanization contribute to increase the environmental pollution, affecting the natural geological and biological redistribution of heavy metals in the air, water and soil [1]. The heavy metals cannot be degraded or destroyed and even at very low levels may influence plant growth and reproduction, as they can be assimilated and transferred in the food chain by the process of biomagnification. Therefore, the biota characterization can be utilized to monitor the environmental pollution. The method more commonly used for environmental biomonitoring consists of evaluating the seed germination and root elongation [2]. In this work *Cucumis sativus*, recommended by the U.S. EPA, 1996 [3], has been used to test the toxicity and bioabsorption at heavy metals increasing concentrations. These metals are potentially phytotoxic elements which are released into the environment from the ever-expanding technological development.
In addition, the evaluation of metal content into seeds allowed to evaluate the toxicity level of each element.

Materials and methods

In this study 5 mL of increasing Pb, Ni and Cu concentrations (0.008-6.4 mM) were put in contact with 10 seeds of *Cucumis sativus* and incubated at 25 ± 2 °C in a germination chamber (Haereus BK 6160) for 72 h under dark conditions [4]. Each test was carried out in quadruplicate. After incubation, the root elongation was examined: a root longer than 1 mm were regarded as germinated, and seeds with a root longer than 3 mm were recorded by analogical calibre. Hence, the seeds were collected, dried to constant weight at 75 °C for 24 h, crushed, weighted and mineralized by digestion with HNO_3 and H_2SO_4 (10:1 v/v) and the solved metals content was determined by atomic absorption spectrophotometer (model AA240FS, Varian, Palo Alto, CA).

Results

Results have highlighted similar behaviours for Ni and Pb respectively (Figs. 1, 2).

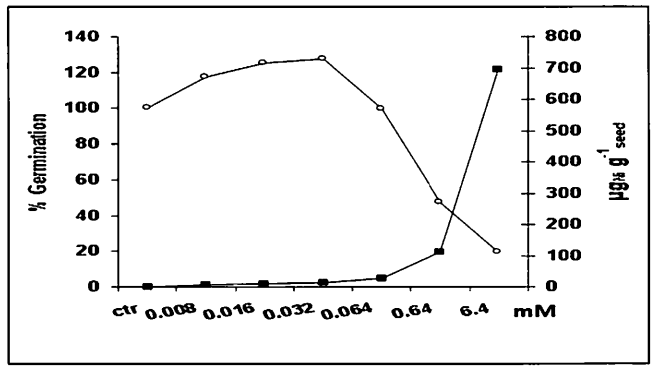

Figure 1. Germination rate (o) and Ni bioaccumulation (■)

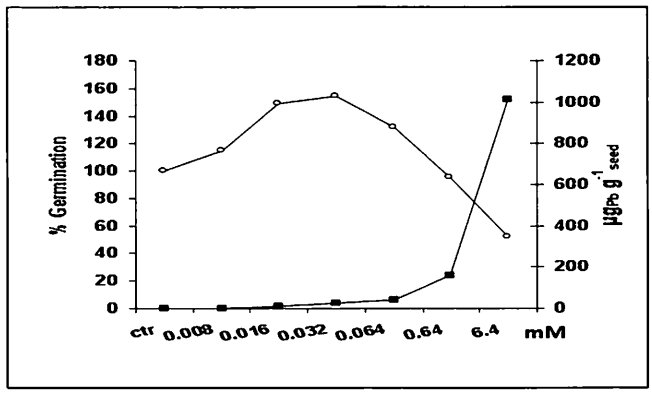

Figure 2. Germination rate (o) and Pb bioaccumulation (■)

For both metals, a concentration until 0.032 mM establishes a positive effect on the germination, with

an increasing germination rate of about 55 and 28%, respectively, compared to the control. An increment of two metals concentration (0.064-6.4 mM) involves an evident and progressive inhibition of the germination, till causing to 6.4 mM 48 and 81% inhibition, respectively. On the contrary, (Fig. 3) the copper seems to exercise a less negative effect on *Cucumis sativus* growth; in fact, 0.064 and 0.64 mM Cu concentrations stimulated the germination with increase of 32 and 48% germination rate, respectively. Fig.4 shows the bioaccumulation percentage of every metal. Bioaccumulation level reaches maximum values to 55 and 13% for nickel and lead respectively, while it is higher (almost 90%) for copper.

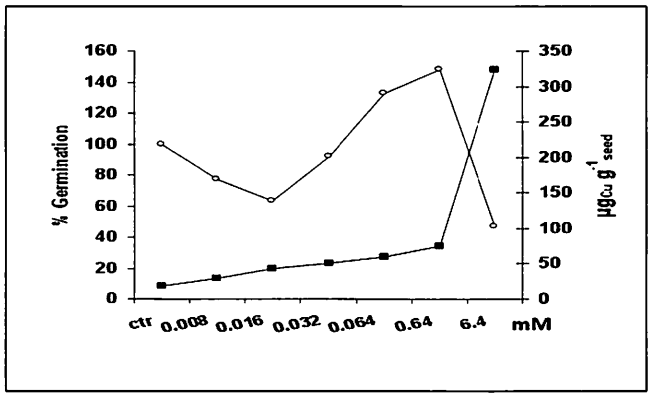

Figure 3. Germination rate (o) and Cu bioaccumulation (■)

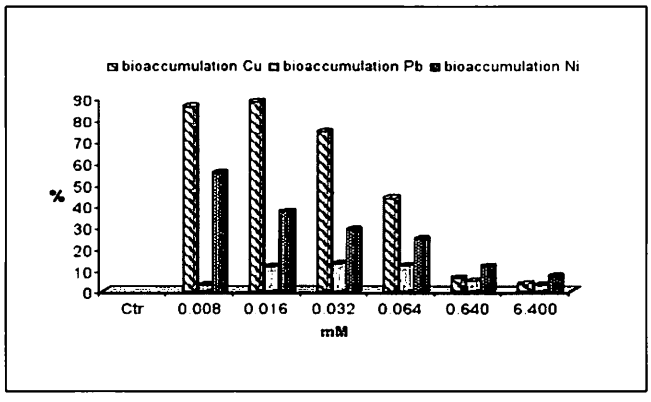

Figure 4. Bioaccumulation percentage of Cu, Pb e Ni in seeds

Discussion

The germination trend (Figs. 1,2,3) pointed out that Pb, Cu and Ni, at certain levels, can stimulate the seeds growth; in particular Cu, essential metal, showed a high stimulation on germination. These results are consistent with Carlson *et al.*, 1991 [5] which showed that cabbage, wheat and radish treated with low Ni concentration exhibited a radicle elongation. The metals bioaccumulation in seeds can give indications about the toxicity threshold for each element. An amount of 75 $\mu g_{Cu} g^{-1}{}_{seed}$ did not inhibit the growth, while for Ni and Pb the threshold is more low: 14 and 26 $\mu g_{Me} g^{-1}{}_{seed}$, respectively.

References

[1] Senesi G.S., Baldassarre G., Senesi N., Radina B. 1999. Trace element inputs into soils by anthropogenic activities and implications for human health. Chemosphere, 39: 343-377.

[2] Wang W., Keturi P.H. 1990. Comparative seed germination tests using ten plant species for toxicity assessment of a metal engraving effluent sample. Water Air Soil Poll., 52: 369–376.

[3] USEPA, 1996. Ecological Effects Test Guidelines. OPPTS 850.4200 Seed Germination/Root Elongation Toxicity Test. EPA 712-C-96-154.

[4] Baudo R., Beltrami M., Barbero P., 2004. Test di germinazione e allungamento radicale. Acqua & Aria, 2: 69-85.

[5] Carlson C.L., Adriano D.C., Sajwan K.S., Abels S.L., Thoma D.P., Driver J.T. 1991. Effects of selected trace metals on germination seeds of six plant species. Water Air Soil Poll., 59: 231-240.