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INTERACTIVE EFFECTS OF Cu AND Cd ON GORWTH AND PROTEIN METABOLISM OF GARDEN CRESS SEEDLINGS

Abstract

Soil is a source of metal. Copper is the trace elements while cadmium is phytotoxic for plants. Garden cress is an important medicinal plant. It is cultivated from the seeds. Thus seed germination and seedling growth are essential events for the plant. Earthen pots were filled with sterilized silica sand and sand was contaminated with $Cucl_2$, $CdCl_2$ and $HgCl_2$, the treatments were Cu, Cd, Cu+Cd (200 and 600ppm each). The pots were not added with heavy metals considered as control. On the completion of 10days control and treated seedlings were studied for elongation of root, shoot, fresh weight and dry weight. The seedlings were analyzed for protease activity, protein and total amino acid. Cu, Cd and their interaction inhibited the seedling growth. Heavy metal inhibited the level of protease activity, protein and total amino acid. Cd and its interaction with Cu inhibited seedling growth and protein metabolism.

Keywords: *Heavy metals, protein metabolism, garden cress, interactions.*

Introduction

Environmental pollution by metals became extensive as mining and industrial activities increased in the late 19^{th} and early 20^{th} century. The current worldwide mine production of Cu, Cd, Pb and Hg is considerable (Kennish 1996). Heavy metal pollution is considered as one of the most serious problems worldwide and has significant environmental and human health impact. Copper and cadmium contamination is widespread due to their intensive industrial and agricultural use. Cu is essential micronutrient for plant growth in low concentrations. It constitutes plant enzymes, which trigger a variety of physiological processes in plants (photosynthesis, respiration, cell wall metabolism, etc.). but excess amount of Cu reduces plant growth, disturbs nutrients metabolism, inhibits enzymes activities, causes cell damages, suppresses photosynthetic activity (Xiong et al., 2006; Martínez-Peñalver et al.,2012). Cd is non-essential element and is strongly phytotoxic and causes severe biochemical, physiological and morphological effects. Cd inhibits the plant growth, alters the functionality of membranes, interferes with enzymatic activities related to photosynthesis, and disturbs nutrient uptake and translocation in plant (Sandalio et al., 2001, Larbi et al., 2002; López-Millán et al., 2009). It is very important to find the combined effects of chemicals on living organisms. Mixture toxicity of contaminants can be classified as additive, synergistic and antagonistic. The mechanisms of mixture toxicity depend on the chemistry of mixtures compounds, their interaction in the environmental media that may influence the bioavailability, toxicological modes of action, interaction among bio accumulated contaminants (Spurgeon et al., 2010). The aim of the study was to test the single and combined toxicities of Cu and Cd to Garden cress (*Lepidium sativum* L.) on growth and metabolism.

Materials and Methods

The earthen pots were filled with refined acid washed silica sand and following concentrations of heavy metals were added to the sand before sowing the seeds of Garden cress.

200 ppm - 200 mg $CuCl_2$/$CdCl_2$ / kg sand
600 ppm - 600 mg $CuCl_2$/$CdCl_2$/ kg sand
200 ppm (each) - 200 mg (each) Cu+Cd/ kg sand
600 ppm (each) - 600 mg (each) Cu+Cd/ kg sand

The pots without any addition of heavy metal were considered as control. Uniform graded 20 seeds of Garden cress were sown in each pot separately. Three pots were kept for each treatment. Necessary irrigation was done. Experiment was carried out at 28 ± 2 °C under laboratory conditions. On completion of 10days, interactive effects of heavy metal were studied as follows:

(A) Study on Seedling growth: -
Ten days old control and treated seedlings (10 in each case) were studied for root elongation, shoot elongation, fresh weight and dry weight of root, stem and cotyledons.

(B) Study on Metabolism:

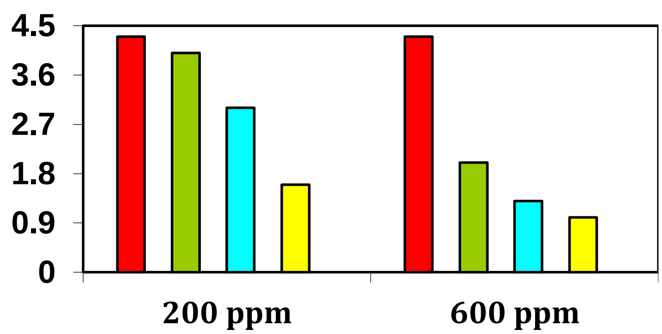
Ten days old control and treated seedlings (600 ppm) in replicates were analyzed for enzymic activities and metabolites.

Protein Metabolism:
Protease Activity (Penner and Ashton 1976)
Protein Content (Lowery et al., 1951)
Total Amino Acid Content (Harding and McClean,, 1916)

Results:

FIG. 1: ROOT SHOOT ELONGATION OF 10DAYS OLD GARDEN CRESS SEEDLINGS GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SAND

ROOT LENGTH (cm/seedling)



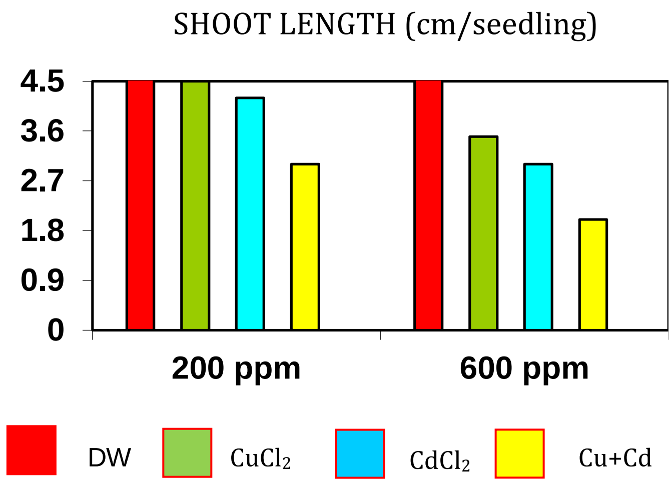


Figure 1 represents the data on root shoot elongation of 10days old Garden cress seedlings grown without and with heavy metal contaminated sand. Heavy metal also lowered the root shoot elongation of Garden cress seedlings grown on contaminated sand. Root was much more affected than shoot by all the heavy metals.

FIG. 2: FRESH WEIGHT OF 10DAYS OLD GARDEN CRESS SEEDLINGS GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SAND

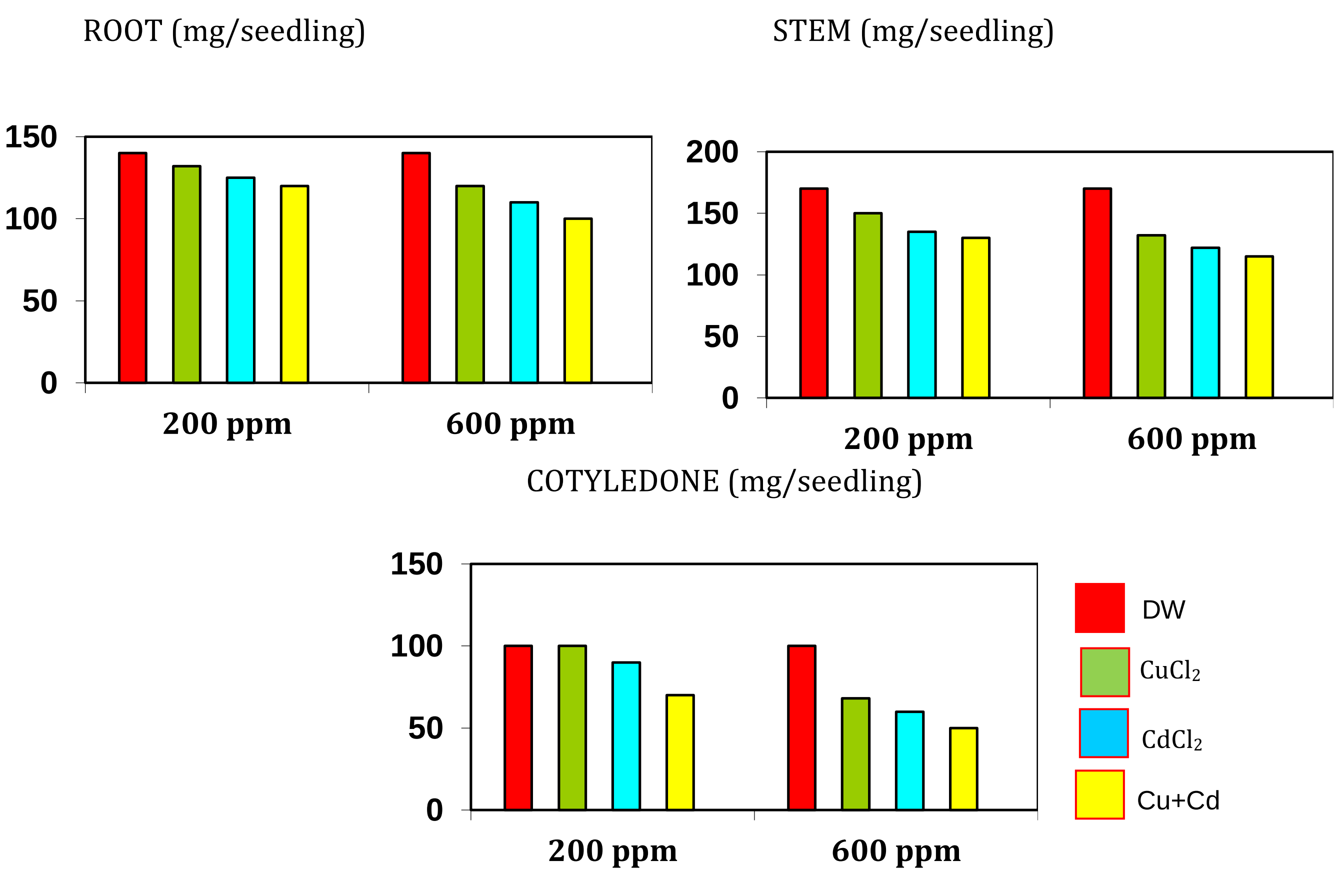
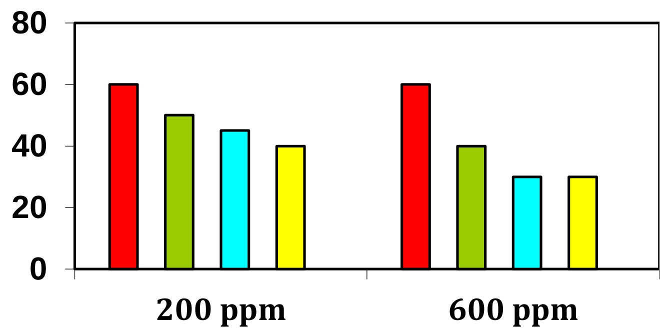


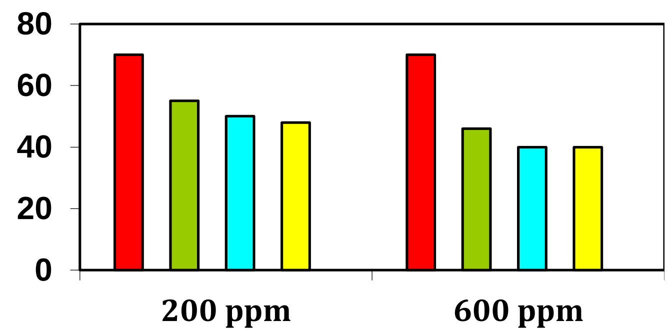
Fig: 2 represents the data on fresh weight of 10days old Garden cress seedlings grown without and with heavy metal contaminated sand. The presence of Cu, Cd, (200ppm, 600ppm) and their interactions added to the sand lowered the fresh weight of root, stem, cotyledon of 10days old Garden cress seedlings, the lowering was correlated with concentration of metal. The effects of heavy metals and their interactions on fresh weight are discussed earlier. The data suggest that heavy metal may disturb the water uptake thus fresh weight of all the organs were lowered, effects were dependent on dose of heavy metal, nature of metal and interaction of heavy metals.

FIG. 3: DRY WEIGHT OF 10DAYS OLD GARDEN CRESS SEEDLINGS GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SAND

ROOT (mg/seedling)



STEM (mg/seedling)



COTYLEDONE (mg/seedling)

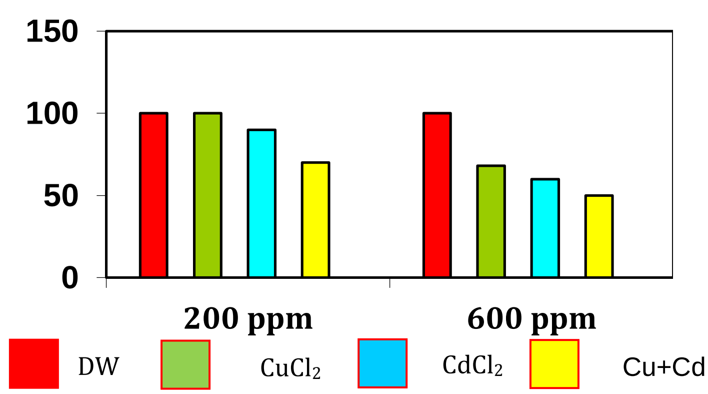


Fig: 3 represents the data on dry weight of 10days old Garden cress seedlings grown without and with heavy metal contaminated sand. The dry weight of root, stem and cotyledon was lowered in seedlings grown on sand contaminated with single metal, binary mixture of Cu, Cd having 200 and 600ppm concentrations. 600ppm of Cd and Cu+Cd were equally reduced dry weight of root and stem but in cotyledon mixture was inhibitory than single metal. The adverse effects were higher with 600ppm than with 200ppm of all the metals

Fig: 4 PROTEIN METABOLISM OF 10DAYS OLD GARDEN CRESS SEEDLINGS GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SAND

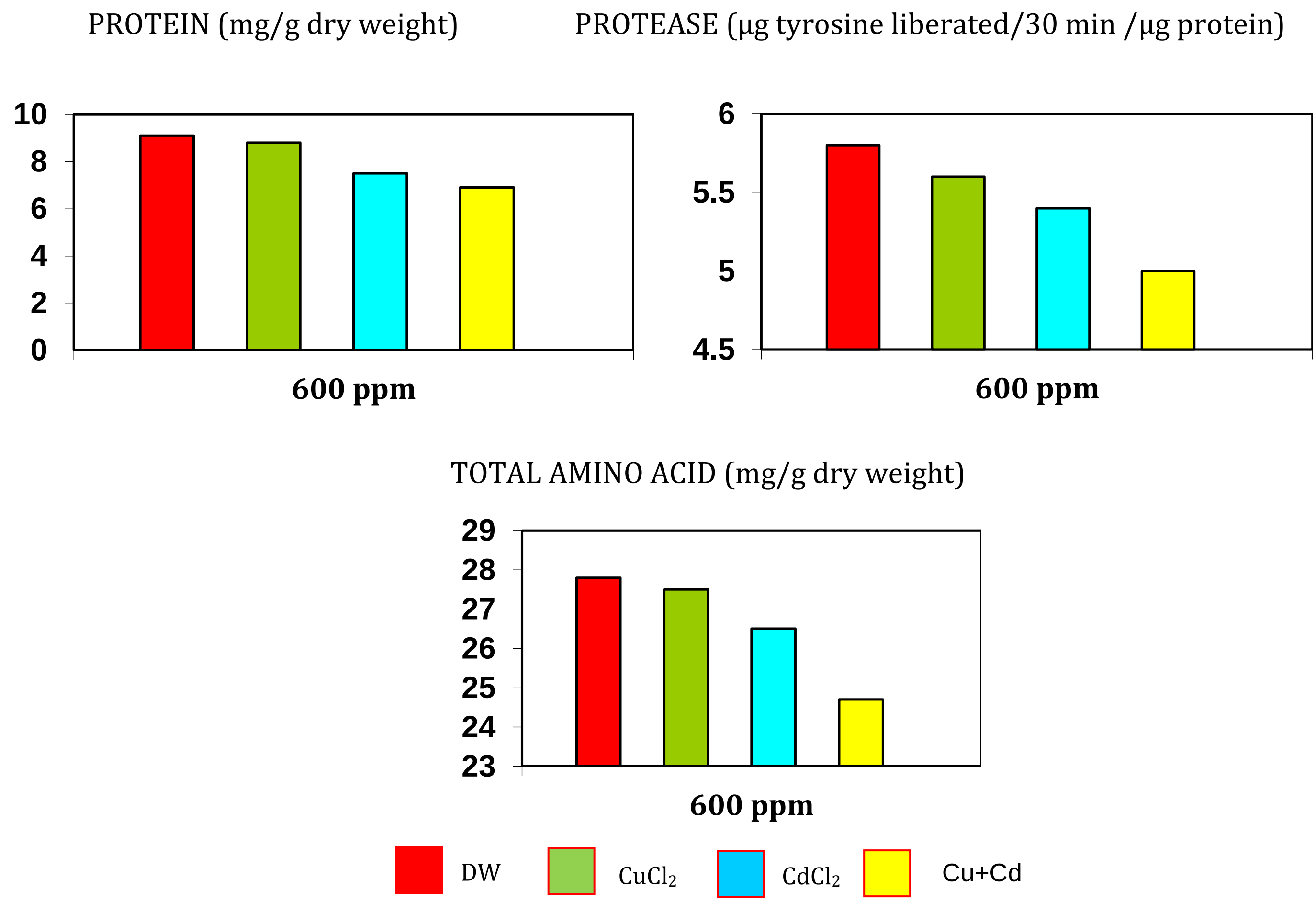


Fig: 4 represent the data on protein metabolism of 10days old Garden cress seedlings grown without and with heavy metal contaminated sand. The protein content was lowered in Cd and mixture of heavy metal treated seedlings of Garden cress. Cu did not cause significant effect. The less amount of protein may be correlated with poor growth of seedlings. The seedling survival may be correlated with non-significant effect of heavy metals on total amino acid content

Conclusion

The root-shoot elongation of Garden cress seedlings grown on heavy metal contaminated sand was lowered by 200ppm and 600ppm of Cu, Cd, and binary mixture of both the concentrations of all the three metals. Root in comparison to shoot was affected much more by heavy metal. The mixture of heavy metals caused more damage than single metal. The presence of 200ppm and 600ppm of Cu, Cd, alone and their mixtures in the sand lowered the fresh weight of root-stem and cotyledon of Garden cress seedlings. The dry weight of root, stem and cotyledon of seedlings of Garden cress grown on heavy metal contaminated sand was lower than that in control seedlings. Cd has received considerable attention because it is easily absorbed by plants, thereby interfering with its functioning. In the present work, Cd was found to be the most toxic to the seedling.

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