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INTERACTIVE EFFECTS OF COPPER AND MERCURY ON RESPONSE OF ISABGOL

Abstract

Copper and Mercury causes phytotoxic effects in excess amount. Environmental pollution by metals became extensive as mining and industrial activities increased nowadays. Isabgol (Plantago ovata Forsk) is an important medicinal plant. Seeds are very cooling in nature and form rich mucilage with boiling water and in inflammatory conditions of the mucous membrane of gastrointestinal and genital urinary tracts, in chronic dysentery and diarrhea. It was of interest to study interactive effects of Cu and Hg on response of Isabgol. Earthen pots were filled with garden soil before sowing. Soil was contaminated with 200 ppm and 600 ppm of $Cucl_2$, $Hgcl_2$ and $Cucl_2$+$Hgcl_2$. Seeds were sown. Plants were raised under field conditions. The various growth parameter i.e. root stem elongation, leaf number, fresh weight and dry weight of root, stem and leaf were regularly recorded. The vegetative growth i.e. roots, stem elongation, leaf number and fresh weight and dry weight of root stem and leaf was lowered by all the treatments. Lowering was dose dependent and interaction of metal gave additive effects. Heavy metal uptake was also determined from seeds.

Keywords: heavy metals, phytotoxic, interaction, heavy metal uptake

Introduction

Copper is essential element. Mercury is highly toxic for plant growth. The source of Cu and Hg is soil. Industrialization enhances the level of Cu and Hg in soil, water and air. The effects of Cu on plants are reviewed by Fernandes and Henriques (1991). Effects of excess copper on growth response are reported by Pandey and Sharma (1999) for Safflower, Nautiyal and Chatterjee (2002) for spinach, Dube et al., (2005) for rice. High Phytoavailibility of heavy metals in the soil can inhibit plant growth and crop yields Hodson and Donner (2013). The thylakoid membrane of the chloroplast and photosystem II in a partial is the primary target of copper toxicity (Burkhead et.al., 2009). Plants employ various inherent and extrinsic defense strategies for tolerance or detoxification whenever confronted with the stressful condition caused by the high concentrations of heavy metals. As a first step towards dealing with metal intoxication, plants adopt avoidance strategy to preclude the onset of stress via restricting metal uptake from soil or excluding it, preventing metal entry into plant root (Viehweger, 2014). Toxic effects of mercury in plants include abscission of older leaves, growth reduction, and vigor inhibition of root and leaf development, decreased chlorophyll content and nitrate reductase activity (Vyas and Puranik, 1993). Copper and Mercury had predominant effect on growth parameters and chlorophyll content (Gadallah, 1994). Plant breeders are therefore developing crop genotypes that take up less of the toxic heavy metals can produce a commercial yield on contaminated soil (Uraguch and Fujiwara, 2013). Combined effects of mixtures have to be taken into account to ecological risk assessment. Interaction of more than one heavy metal 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 bioaccumulated contaminants (Spurgeon et al., 2010). Copper interacts with many elements during absorption and translocation steps in plants. Copper-iron antagonism is indicated by Cu-induced Fe chlorosis in citrus and wheat. Interacting effect between Cu and Fe shows antagonistic relationship. The toxicity of Cu can be reduced by the application of Fe. Cheshire et. al., (1967) reported antagonistic influence of Fe on Cu nutrition of oats. Responses of medicinal plants to mixture of heavy metals are rare. Isabgol is an important medicinal crop of Gujarat was selected. Thus it was of interest to study the interactive effects of Copper and Mercury on response of Isabgol.

Materials and methods

The earthen pots were filled with garden soil. The potted soil was contaminated with following heavy metal separately.
200mg $CuCl_2$/$HgCl_2$/kg soil
600mg $CuCl_2$/$HgCl_2$/kg soil
200mg (each) Cu+Hg/kg soil
600mg (each) Cu+Hg/kg soil
The pots without any condition of heavy metal considered as control. 20 pots were kept for each treatment. Seeds of Isabgol (Plantago ovata Forsk var Guj 2) were sown in pots. The plants were raised using normal practice under field conditions. An interactive effect of heavy metal on Isabgol was studied as follows:

(A) STUDY ON GROWTH
Following growth parameters were studied from 10 plants of each treatment. Method of Gregory (1921, 1926) and Hunt (1978) was used for the study.

VEGITATIVE GROWTH
Root length-cm/plant, stem length-cm/plant, leaf number-no/plant, fresh weight of root, stem, leaf and whole plant -g/plant, dry weight of root, stem, leaf and whole plant -g/plant

(B)STUDY ON HEAVY MEATL DETERMINATION

The heavy metal was determined (Trivedi et al., (1987) from seeds with the help of AAS.

Results:

Figure: 1 represents the data on elongation of Isabgol grown without and with heavy metal contaminated soil. The retardation in root elongation of 200ppm of heavy metal treated plants was in the order of Cu+Hg> Hg> Cu, When concentration was 600ppm it was in the range of Cu+Hg> Hg> Cu. The data indicates that binary mixture of toxic metals was most effective treatment.

Stem elongation of control and heavy metal treated Isabgol plants was increasing with increasing time; increment was rapid in plants grown without any heavy metal. Hg and its interaction were more effective treatments than other treatment.

Heavy metals lowered the leaf number. Effects of heavy metal depend upon age of the plant, type of interaction etc. Decrease in leaf number may be the reason of overall reduction in growth of the plants

Figure: 2 represents that fresh weight of Isabgol grown without and with heavy metals was increased with time. Except 200ppm Cu all treatments lowered root fresh weight, 600ppm was more effective than 200ppm. The heavy metal toxicity on root fresh weight was in the order of Cu+Hg>Hg>Cu.

Stem fresh weights of control and Cu a treated plant were rapidly increased with time but rate was slow with other treatments.

Leaf fresh weight of control and 200ppm Cu treated plants was increased with time. When concentration was 600ppm the leaf fresh weight was highly reduced in heavy metal treated plants and reduction was in the order of Cu+Hg=Hg> Cu.

Data on dry weight of Isabgol grown without and with heavy metal contaminated soil are presented in **Figure: 3.** 200ppm of Cu, Hg and their all interactions lowered the root dry weight in the order of Cu+Hg>Hg> Cu, but in 75days old plants Hg gave more adverse effect

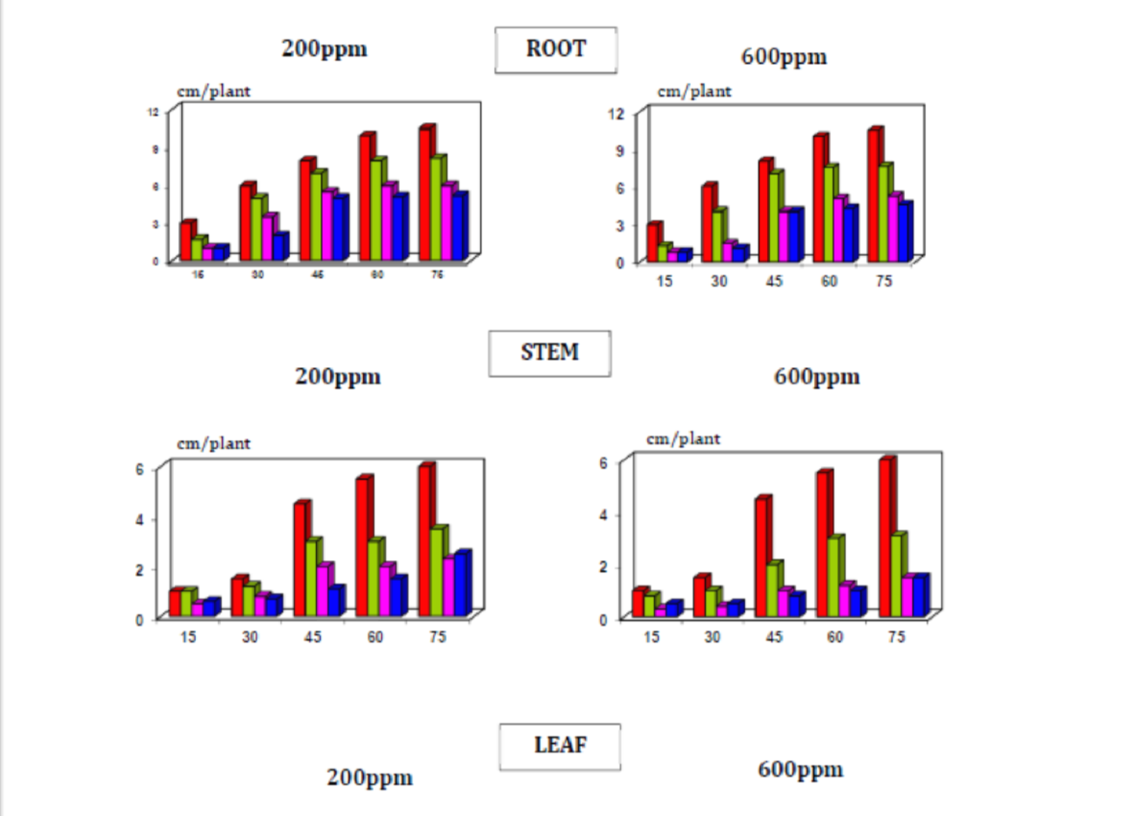
Stem dry weight of Isabgol grown without and with heavy metal contaminated soil. The stem dry weight of Isbgol was lowered by heavy metals and heavy metal toxicity was in the order of Cu+Hg>Hg>Cu. The effects were related with concentration. 200ppm Cu was less effective but 600ppm Cu caused 50% reduction in stem dry weight.

Leaf dry weight of Isabgol was lowered by all the treatments having 200ppm concentration, lowering was extreme when plants were grown with Hg. Leaf dry weight was also equally affected by Hg and Cu+Hg (200ppm each). It shows that Cu did not induce any additional or alleviating effect in presence of toxic metal Hg. 600ppm heavy metal reduced leaf dry weight, effects were related with age.

Whole plant fresh weight of Isabgol in control and treated plants was increased with increasing time, maximum rate was found in control plants. 200ppm and 600ppm heavy metals lowered the whole plant fresh weight. The effects of 200ppm heavy metal was in the order of Cu+Hg>Hg>Cu. The whole plant fresh weight was little with Hg, Cu+Hg. The mixture of heavy metals having 200ppm concentration of each metal caused additive effects. When concentration was 600ppm the effects of mixture of heavy metal on whole plant fresh weight was controlled by Hg and it was so much so that binary mixture of Cu+Hg are shown in **Figure: 4**.

Figure: 5 represents the data on whole plant dry weight of Isabgol grown without and with heavy metal contaminated soil. Whole plant dry weight was slowly increased up to 60days then rapid increase was found**.** Whole plant dry weight was lower in treated plants than that in control plants. 200ppm Hg and its interactions caused significant reduction in dry weight

FIG. 1: ELONGATION AND LEAF NUMBER OF ISABGOL GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL



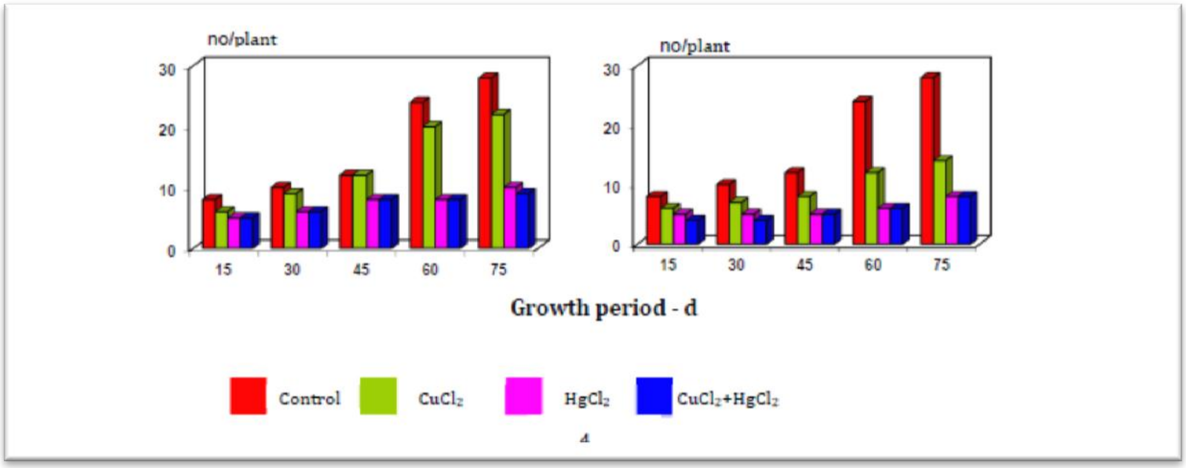
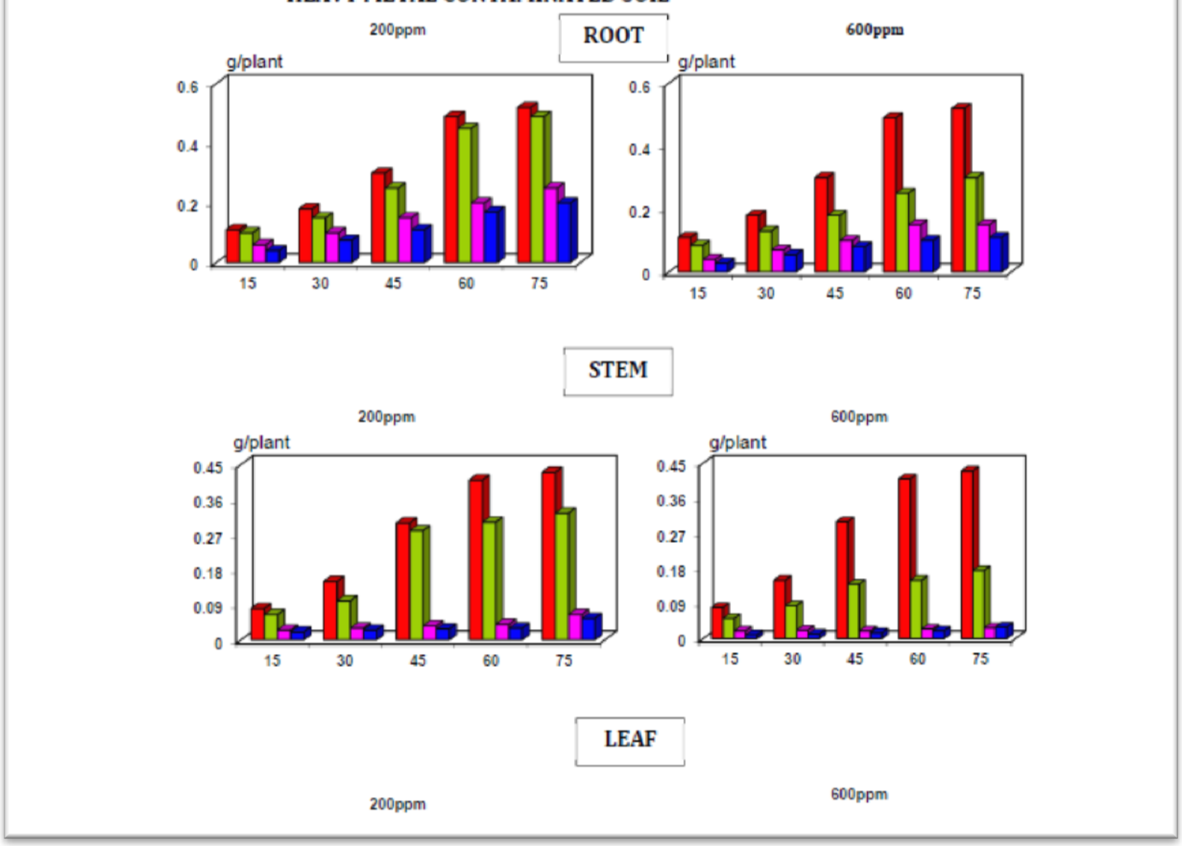


FIG. 2: FRESH WEIGHT OF ISABGOL GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL



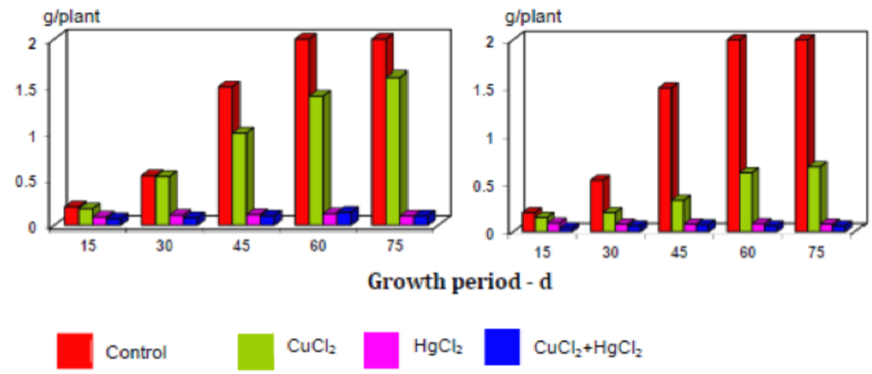


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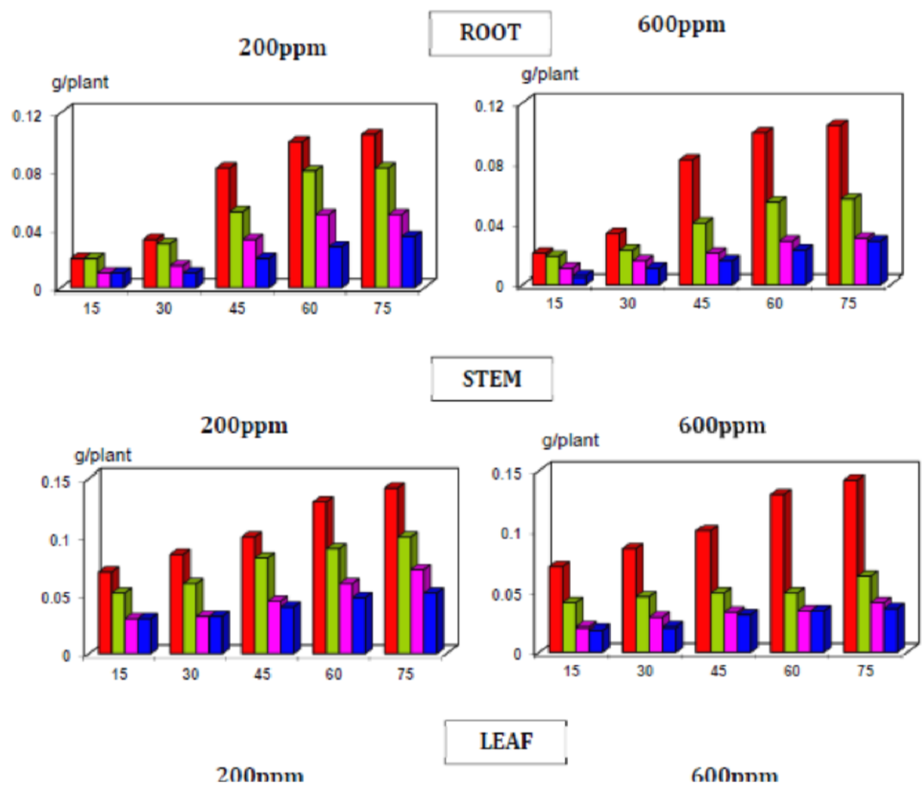
FIG.3: DRY WEIGHT OF ISABGOL GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL



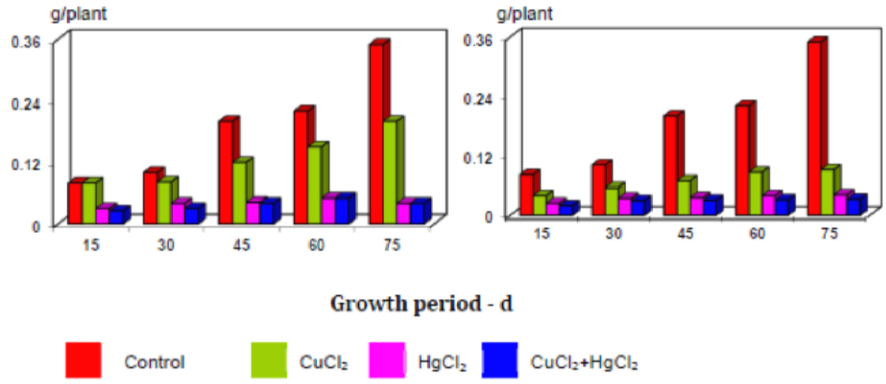


FIG.4: WHOLE PLANT FRESH WEIGHT OF ISABGOL GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL

200ppm **600ppm**

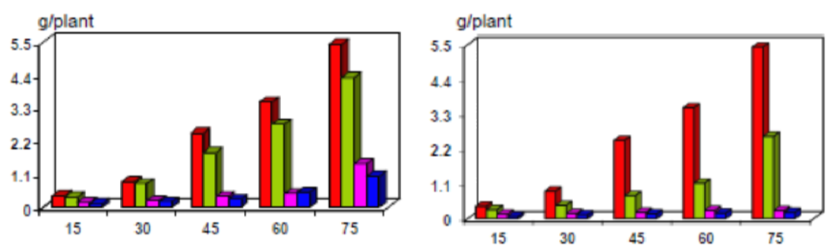


FIG.5: WHOLE PLANT DRY WEIGHT OF ISABGOL GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL

200ppm **600ppm**

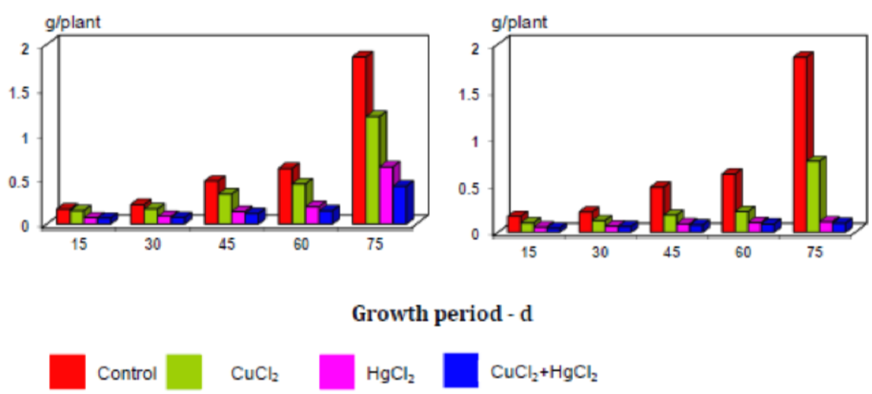


Table: 1 shows the values of heavy metal (ppm) in the seeds of Isabgol grown without and with heavy metal contaminated soil. Cu was detected in seeds of control plants of Isabgol while Hg was found in seeds of plants grown with Hg and their interactions.

TABLE 1: UPTAKE OF HEAVY METAL (ppm) IN THE SEEDS OF ISABGOL GROWN WITHOUT AND WITH HEAVY METAL CONTAMINATED SOIL

TREATMENT	METAL UPTAKE-ppm	
	Cu	Hg
CONTROL	1.1	*
200ppm		
$CuCl_2$	1.4	*
$HgCl_2$	*	0.04
Cu+Hg	1.5	0.07
600ppm		
$CuCl_2$	1.6	*
$HgCl_2$	-	-
Cu+Hg	-	-

- NO FLOWERING

* METAL NOT PRESENT

The amount of Cu was higher in plants grown with single metal Cu, 600ppm caused more accumulation than 200ppm. When Cu and Hg content were compared in the plants grown with single metal and mixture of Cu+Hg it was found that amount of both the metals were more in the plants grown with mixture of heavy metals i.e. mixture promoted the uptake of individual metal. When plants were grown with 600ppm flowering did not occur in Hg and Cu+Hg treated plants i.e. seeds were available only from Cu treated plants.

Conclusion:

Elongation and leaf number, fresh weight and dry weight of Isabgol grown on heavy metal contaminated soil were lowered by all the heavy metal treatments having 200ppm and 600ppm. Interactions caused additive effects. Cu was detected in seeds of control, CuCl2 and

Cu+Hg treated plants. Hg was absent in control plants but detected in Hg and Cu+Hg treated plants.

There is a great necessity to find out how heavy metals affect medicinal plants in low amount and it is also essential to improve understanding of the exact mechanisms involved in the level of their interaction with different plant species in alleviating adverse effects of heavy metals. Contamination of soil by heavy metals in changing environment poses a serious concern. Furthermore before using the seeds for drug purpose, seeds must be analyzed for presence of Hg.

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