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Varsha Sharma
Department of Forestry, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

MN Naugraiya
Department of Forestry, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

GS Tomar
Department of Forestry, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Correspondence
Varsha Sharma
Department of Forestry, College of Agriculture, IGKV, Raipur, Chhattisgarh, India

Toxic effects of cobalt, chromium, lead and nickel chloride on growth performance of siris (*Albizia spp*.)

Varsha Sharma, MN Naugraiya and GS Tomar

Abstract
The effect was conducted in the nursery of Department of Forestry, Indira Gandhi Krishi Vishwavidyalaya, Raipur (C. G.) during 2011-12. The experiments was carried out to determine the inhibitory effect of different concentrations *viz;* 0 (control), 100, 200, 500, 700, 1000 and 2000 ppm of Cobalt, Chromium, Lead, and Nickel chloride on seed germination, survivorship, growth performance, biomass accumulation and eco-physiological growth behavior of nursery crop of Siris. Application of metallic pollutant in soil reduced seed germination progressively with increasing the concentrations. However cent per cent survivorship was observed in all the cases. The growth performance *viz*; shoot length with collar diameter, leaves number and leaf area, root length per plant along with biomass accumulation in different parts revealed that various concentrations of Cobalt, Chromium, Lead, and Nickel chloride showed statistically significant influences, with maximum values in control conditions followed by 100 ppm and minimum at 2000 ppm concentrations. Inhibition by pollutants was more in *Albizia procera* and less in *Albizia lebbeck.* Similarly Lead chloride inhibited performance of Siris more than Nickel, Chromium and Cobalt chloride respectively.

Keywords: heavy metals, toxicity, survival, growth performance.

Introduction
The toxicity of heavy metals is a problem for ecological, evolutionary and environmental reasons. Heavy metals pose severe threat to the environment on the long term basis and non-reversible. The metals commonly found in the environment beyond the critical level as a result of human activities include Cu, Zn, Ni, Pb, Cd, Co, Hg, Cr and some of these metals act as a micronutrient at concentration by living organisms for normal physiological activities (McGrath, *et al*. 2002), but their accumulation is toxic to most of life forms. The negative effects of metals can occur on soil micro flora and fauna, higher animals, plants and humans. Heavy metals such as lead and Chromium are highly toxic pollutants as they are added in the environment through automobile exhausts. Inhibition of germination and retardation of plant growth are commonly observed due to lead toxicity. Negative effects of lead toxicity on seed germination and seedling growth of some tree species were examined (Iqbal & Siddiqui, 1992; Shafiq & Iqbal, 2005). The increasing influx of heavy metals into water bodies from industrial, agricultural, and domestic activities is of global concern because of their well-documented negative effects on human and ecosystem (Mataka *et al.* 2006). *Albizia species*, (Siris) *viz*; *A. lebbeck* (L.) Benth and *A. procera*, (Roxb.) Benth. Belongs to family leguminous. It is medium to tall in size, evergreen tree with spreading crown. It is also an important multipurpose and hardy species tree in arid and semi-arid regions of India for Social Forestry Programmes and Farm Forestry plantations to be grown on field boundaries and hedges. Siris is native to Indian continent is frequently grown as farmers need, on degraded land, road side, river, canal bank. The species has great potentials for not only producing the various products but also has aesthetic values. The tree is also used extensively as a shade tree in Tea gardens of Assam and Terai region of West Bengal. As the species has high coppicing nature, green manuring capabilities, nodulates readily, fixes nitrogen, and leaves highly palatable and proteinaceous (Prisen,1986), it suits best for Agro Forestry System and a desirable species for energy plantations. This tree is found on a wide range of soil types including those that are alkaline and saline but not subject to water logging.

Material and Methods

The experiment was conducted in the experimental field of "Department of Forestry" at "Indira Gandhi Krishi Vishwavidyalaya Raipur". Fast growing and nitrogen fixing multipurpose tree species viz. *Albizia lebbeck* and *Albizia procera* were selected for study as they are indigenous and very common in the Chhattisgarh with valuable fuel, fodder, and domestic firewood. Seedling of tree species will be raised in conteiner (polybags) having capacity of 1kg soil (Black Cotton soil + sand mixture). Seven concentrations comprise of 0, 100, 200, 500, 700, 1000, and 2000 ppm of each metallic pollutants *i.e.* $CoCl_2$, $CrCl_2$, $NiCl_2$, and $PbCl_2$ were used on the basis of soil dry weight. The application of each concentration of pollutant was given separately in the soil of each bag, so that it could be homogenous. The quantities of metallic elements were determined for each concentration on the basis of 1 kg dry weight of soil, in a completely randomized designed (CRD) with three replications.

Results and Discussion

After four months of exposure, leaf samples of the plants species were analyzed for morphological and biochemical parameters and impact of different heavy metals on these parameters was investigated.

Effect of metallic pollutants on seed germination of nursery crop of *Albizia lebbeck* and *Albizia procera*

Metals play a vital role in the growth and development of plant but excess amount absorbed by plants produced toxic effects abnormalities in the cells and its physiology ultimately behavior of growth of plants. Seed germination started same time in both species (*Albizia lebbeck* and *Albizia procera*). The germination in control condition was recorded more than 80 percent with more or less same rate of germination in *Albizia lebbeck* and *Albizia procera*. Germination and emergence of seeds in different concentrations of four metallic chlorides was adversely influenced, however *Albizia procera* recorded fast germination as compared to the *Albizia lebbeck*.

Germination in the presence of Cobalt chloride maximum in both species at 100ppm, where by 5 and 6 percent declination was recorded in (0 ppm) control compare to 100 ppm in *Albizia lebbeck*, *Albizia procera* respectively. Germination was recorded 61.11 and 52.22 per cent in 700 ppm in *Albizia lebbeck* and *Albizia procera*, respectively while 60.0 per cent germination was recorded at 200 ppm (T_2) in *Albizia procera* this showed that *Albizia lebbeck* are found more tolerable for the Cobalt chloride as compare to *Albizia procera.* In *Albizia procera* at 2000 ppm Cobalt chloride reduce the germination up to 48.89 per cent respectively. Thukral and Poriminder, (1987) studied the germination and seedling growth in *Cyamopsis tetragoroloba* in presence of cobalt and found that Cobalt delayed as well as suppressed the germination process.

In present study 60.0 per cent germination was recorded in 1000 ppm and 58.89 in 2000 ppm of Cobalt chloride at 30 DAS in *Albizia lebbeck* while in the case of *Albizia procera* 48.89 per cent germination was recorded in 2000 ppm (T_7) of Cobalt chloride.

Since seed germination is the first physiological process affected by Chromium, the ability of a seed to germinate in a medium containing chromium would be indicative of its level of tolerance to this metal (Peralta *et al.* 2001). Seed germination was increased 5 per cent at 100 ppm Chromium chloride in *Albizia procera* over control. Though it was more or less 60 per cent at 27 DAS at 200 ppm (60.00%) in *Albizia procera* and *Albizia lebbeck*. In case of *Albizia lebbeck* the maximum germination was recorded 85.56 per cent at 100 ppm which was 4.45 percent higher than control. Similarly in *Albizia procera* it was recorded 80 per cent in 0 ppm and 85.56 per cent in 100 ppm (T_2) in presence of Chromium chloride at different treatments. Perata *et al.* (2001) found that in presence of 40 ppm of Chromium reduced by 23 percent ability of seed of lucern (*Medicago sativa* cv. Malone) to germination and grow in the contaminated medium. Reductions of 32 to 57 per cent in sugarcane bud initiation was observed with 20 and 80 ppm chromium, respectively (Jain *et al.* 2000)

Nickel is one of the major metallic pollutants in the ecosystem and even relatively low concentrations of it suppress the growth of plant (Ernst *et al.* 1992). Germination of seed under different concentration of Nickel chloride was increased and it declined 8.34 per cent in *Albizia lebbeck* at 100ppm Nickel chloride as compare to control (T1), where the 8 per cent declination of germination was recorded in *Albizia procera* at same concentration of Nickel chloride. While at 500 ppm Nickel chloride, the germination further dropped to 55.56 and 60.0 per cent in both *Albizia procera* and *Albizia lebbeck*, and similarly it was recorded 24.44 per cent respectively at 2000 ppm (T7) of Nickel chloride. Thus *Albizia lebbeck* were more tolerant to nickel chloride as compared to *Albizia procera*. Singh (1983 and 1985) studied the role of Nickel on *Vigna radiata* and identified that higher concentration of Nickel suppressed the mobilization of N and P resulting the enzymatic systems crucial for germination and initial stage of seedling growth. Agrawal *et al.* (1961), Jagatiya and Areay, (1998) also worked out the role of different Nickel salts on germination of Moong, where higher concentrations become more inhibitory but the sulphate of Nickel was more inhibitory than chloride or nitrates.

Lead (Pb) toxicity has become an important issue due to their constant increase in the environment. In the present investigation, seed germination of *Albizia lebbeck* and *Albizia procera* gradually decreased with the increase in concentration of lead chlorides. Lead treatments significantly (P<0.05) decreased seed germination of *Albizia lebbeck* and *Albizia procera* gradually decreased with the increase in concentration of lead chlorides. Lead treatments significantly (P<0.05) decreased seed germination as compared to control (T1). Germination was decreased by 8.0 per cent in both *Albizia lebbeck* and *Albizia procera* at 100 ppm of Lead chloride. Though it was reduced to 60.00 per cent in *Albizia lebbeck* at 700 ppm and 24.44 in *Albizia procera* at 2000 ppm, after 30 days of sowing. Kalimuthu and Siva, (1990) found reduction in seed germination in Maize, treated with 20, 50, 100 and 200 µg/m/Lead acetate and Mercuric chloride.

Effect of Metallic pollutants on survivorship of nursery crop of MPTs *Albizia lebbeck* and *Albizia procera*

The germination of seeds and emergence of seedlings were counted at every two days interval in the nursery and the mortality was computed during this period in different sets of pollutant treatment and their concentrations for all the tree species. Thus application of metallic pollutants decrease germination percentage but did not cause mortality till the growth of 90 days. Thus result revealed that *Albizia lebbeck* and *Albizia procera* found tolerant to various concentrations of $CoCl_2$, $CrCl_2$, $PbCl_2$ and $NiCl_2$ metallic pollutant.

Both the *Albizia* species have the potential to tolerate the toxicity of these four heavy metallic pollutants up to certain concentration i.e. 200 ppm and showed 100 per cent survivorship during the course of study, though the rate of germination was found to be influenced in the presence of different concentrations of the chlorides of Cobalt, Chromium, Lead and Nickel.

Effect of metallic pollutants on growth performance of Nursery crop of MPTs.

Growth performance of *Albizia* species under different pollutant was recorded for their shoot and root length, collar diameters, number of leaves and dry weight accumulation in leaves, above ground and below ground parts. Similar results were observed by Susilawati and Setiadi (2003) in their preliminary research on a natural hybrid of *Acacia mangium* and *Acacia auriculiformis.* They found that mother trees and their seedling showed intermediate and similar growth behavior as these species. Similar results were observed by Farooqui *et al.* (2011) in their research *Albizia lebbeck* showed inhibition in all growth variables at different levels of Lead treatments. Root, shoot and seedling length were highly affected with increasing concentrations of chemical.

Chlorides of heavy metals particularly $CoCl_2$, $CrCl_2$, $PbCl_2$, and $NiCl_2$ influenced the growth performance of plants, provided they all are available in the soil (Arey and Jajetiya, 1998, Kalimuthu and Sivasubramanian, 1990 and Peralta *et al.* 2000). The reduction of growth performance in presence of $CoCl_2$ was comparatively less at lower concentration and it was up to 17 per cent in case of shoot length at 200 ppm, but afterward it was recorded 31 to 44 percent in case of *Albizia procera* at 1000 ppm, while at 2000 ppm as compared to plants grown in control. Collar diameter of *Albizia lebbeck* and *Albizia procera* was more or less similar and it was reduced up to 76.51per cent and 50.18 per cent, at 2000 ppm.

The pattern of growth reduction in root length was more rapid in *Albizia procera* followed by *Albizia lebbeck*. Similar impression of Cobalt chlorides was observed by Pertalta *et al.* (2000) in case of *Medicago sativa* crop. In legumes, Cobalt is required for symbiotic fixation of nitrogen in very small quantity (Ahmed and Evars, 1959) otherwise it caused toxicity to plants if it exceeds certain low levels (Haselkoyy, 1995).

The retardation in different growth parameter of leguminous tree species under various concentrations of Cobalt chloride may either be low mitotic activities in the meristematic zone or be inhibition of cell enlargement resulted in growth inhibition in both conditions (Arey *et al.* 1998). Chatterjee (2000) studies the phytotoxicity impact of Cobalt, Chromium and Copper on Cauliflower and concluded that even these metals inhibited the concentration of most of the macro and micro nutrients, mostly P, S, Mn, Zn translocation were affected significantly leading to decrease in water potential, transpiration and increased diffusive resistance and relative water contents in leaves and finally reduced the growth and productivity of plants.

Chromium is a highly toxic non-essential metal for microorganism and plants and is detrimental to their growth and development. Chromium chloride caused suppression in seeding growth even at lower concentrations, at initial dose (100 ppm) it gave 15 per cent and 9 per cent reduction in *Albizia lebbeck* and *Albizia procera*. However 42 per cent reduction at 700 ppm $CrCl_2$ was recorded in *Albizia procera* and *Albizia lebbeck*. At 2000 ppm $CrCl_2$ maximum reduction in shoot length was seen in *Albizia lebbeck* 50 per cent followed by 48 per cent in *Albizia procera*. Collar diameter of growing plants reduced in presence of $CrCl_2$ where at 2000 ppm the reduction in collar diameter more in *Albizia procera* (59%) followed by *Albizia lebbeck* (55%). Reduction in root length due to $CrCl_2$ was more in *Albizia lebbeck* (48%) followed by *Albizia procera* (45%) respectively. In all the growth parameters the statistical significant difference were observed among various concentration. Similar result was found by the Li *et al.* (2008) significant reduction in root growth of *Albizia lebbeck* with the increase in concentration of cadmium treatment was also observed as compare to control.

Lead is a biological non-essential element and it interference with the general metabolism of plant particularly in synthesis of chlorophyll and photosynthesis (Singh, 1988) and ultimately growth of plant is affected. Application of 100 ppm $PbCl_2$ in the *Albizia lebbeck* and *Albizia procera* 8.4 per cent less as compared to control. The reduction in collar diameter was minimum in *Albizia lebbeck* (58%) and maximum in *Albizia procera* (66%) at 2000 ppm $PbCl_2$. The inhibition in root length more or less followed similar trend in both the species at 200 ppm with lower reduction in *Albizia procera* (48%) and higher in *Albizia lebbeck* (50%). Similar results were also observed in exhaustive maize crop (Kalimuthu and Sivasubramanian, 1990). When crops were grown after seed soaking in different concentrations of Lead. Alyemini (2001) analyzed the process of reduction in root and shoot length with lead in *Vigna radiata*. In the presence of higher Lead content in cell, the cell division and differentiation was retarded which reduced elongation and affected the plant growth and development (Lone *et al.* 1978, Kasturi *et al.* 1998). The differential response in root and shoot might be due to more rapid accumulation in root than shoot (Shaukat *et al.* 1999) in case of *Parkinsonia aculeata*. In present study the Lead was comparatively more toxic than Nickel, Cobalt and Chromium.

Nickel chloride caused suppression in seedling growth even at lower concentrations, at initial dose (100 ppm) it gave 15 and 10 per cent reduction in shoot length as compared to control for *Albizia lebbeck* and *Albizia procera* respectively. However, 35.5 per cent reduction at 700 and 1000 ppm $NiCl_2$ respectively. At 2000 ppm $NiCl_2$ maximum reduction in shoot length was seen in *Albizia procera* (59.51) per cent followed by *Albizia lebbeck* (60.00%). Collar diameter of growing plants reduced in presence of $NiCl_2$ and followed more or less similar pattern up to 1000 ppm $NiCl_2$ where at 200 ppm the reduction in collar diameter was more in *Albizia procera* (73%) and less in *Albizia lebbeck* (48%). Reduction in root length due to $NiCl_2$ was more in *Albizia lebbeck* (50.07%) followed by *Albizia procera* (47%) per cent reductions occurred respectively. In all the growth parameters the statistical significant difference were observed among various concentration. Gabriella and Anton (2002) studied the capacity tolerance heavy metals by any plant species. Indicator plants are used as higher accumulator plants (Baker *et al.* 1994) for low concentration but an increasing the level of concentrations the inhibitory effect resulted in decrease growth. The presence of nickel suppressed total nitrogen and phosphate mobilization. Nralagu (1930), Singh (1985) reported more or less similar result in case of *Vigna radidata*. Jain and Arey (1993) studied the level of toxicity of various heavy metals with similar results where increasing concentration of chromium, uranium and silver for *Triticum aestivum* resulted in reduction chlorophyll content.

Table 1: Effect of different concentrations of Cobalt Chloride on growth performance of *Albizia lebbeck*

Treatments (ppm)	Germination		Length (cm)		Shoot CD(mm)	Leaves (n plant^{-1})	Dry weight (g plant^{-1})				
	(%)	Angular value	Shoot	Root			Leaves	Shoot	Root	Total	S/R
T1 (0)	81.11	64.33	19.27	19.81	2.43	22.00	1.28	1.35	1.40	4.02	0.92
T2 (100)	85.56	67.62	15.90	18.93	2.05	15.67	1.23	1.21	1.56	4.00	0.79
T3 (200)	73.33	58.89	12.83	17.37	1.73	15.33	1.15	1.23	1.42	3.80	0.81
T4(500)	65.56	54.03	12.37	14.63	1.21	14.33	0.98	1.09	1.22	3.29	0.81
T5 (700)	61.11	51.41	11.55	13.48	1.05	12.67	0.95	1.04	1.17	3.16	0.81
T6 (1000)	60.00	50.77	10.77	11.87	0.70	10.33	0.86	0.91	1.00	2.76	0.86
T7 (2000)	58.89	50.07	10.47	10.55	0.57	10.00	0.54	0.74	0.92	2.20	0.58
S Em ±		25.21	0.74	0.31	0.08	1.17	0.06	0.42	0.15	0.16	
S Ed ±		35.65	1.05	0.44	0.12	1.66	0.09	0.59	0.21	0.23	
CD (at 5%)		NS	2.25	0.94	NS	3.55	0.18	NS	NS	0.50	

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