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

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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 percent survival 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 container (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. CoCl₂, CrCl₂, NiCl₂, and PbCl₂ 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 percent in 700 ppm in Albizia lebbeck and Albizia procera, respectively while 60.0 percent germination was recorded at 200 ppm (T₂) 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 percent respectively. Thukral and Poriminder, (1987) studied the germination and seedling growth in Cyamopsis tetragonoloba in presence of cobalt and found that Cobalt delayed as well as suppressed the germination process. In present study 60.0 percent 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 percent germination was recorded in 2000 ppm (T₇) 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 percent 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 (T₂) 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 percent 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 100ppp 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/mLead acetate and Mercuric chloride.

Effect of Metallic pollutants on survivalship 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 CoCl₂, CrCl₂, PbCl₂ and NiCl₂ 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 survival 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 CoCl₂, CrCl₂, PbCl₂, and NiCl₂ 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 CoCl₂ 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 76.51 per 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 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 NiCl₂ respectively. At 2000 ppm NiCl₂ 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 NiCl₂ and followed more or less similar pattern up to 1000 ppm NiCl₂ 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 NiCl₂ 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. Nrlagu (1930), Singh (1985) reported more or less similar result in case of Vigna radiata. 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

<table>
<thead>
<tr>
<th>Treatments (ppm)</th>
<th>Germination (%)</th>
<th>Angular value</th>
<th>Shoot Length (cm)</th>
<th>Root Length (cm)</th>
<th>Shoot CD(mm)</th>
<th>Root CD(mm)</th>
<th>Leaves (n plant⁻¹)</th>
<th>Dry weight (g plant⁻¹)</th>
<th>S/R</th>
<th>CD (at 5%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1 (0)</td>
<td>81.11</td>
<td>64.33</td>
<td>19.27</td>
<td>19.81</td>
<td>2.43</td>
<td>22.00</td>
<td>1.28</td>
<td>1.35</td>
<td>1.40</td>
<td>4.02</td>
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<tr>
<td>T2 (100)</td>
<td>83.56</td>
<td>67.62</td>
<td>19.50</td>
<td>19.13</td>
<td>2.50</td>
<td>15.67</td>
<td>1.57</td>
<td>1.21</td>
<td>1.67</td>
<td>3.94</td>
</tr>
<tr>
<td>T3 (200)</td>
<td>73.33</td>
<td>58.89</td>
<td>12.83</td>
<td>17.37</td>
<td>1.73</td>
<td>15.33</td>
<td>1.15</td>
<td>1.23</td>
<td>1.42</td>
<td>3.80</td>
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<tr>
<td>T4 (500)</td>
<td>65.56</td>
<td>54.03</td>
<td>12.37</td>
<td>14.63</td>
<td>1.21</td>
<td>14.33</td>
<td>0.98</td>
<td>1.09</td>
<td>1.22</td>
<td>3.29</td>
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<td>T5 (700)</td>
<td>61.11</td>
<td>51.41</td>
<td>11.55</td>
<td>13.48</td>
<td>1.05</td>
<td>12.67</td>
<td>0.95</td>
<td>1.04</td>
<td>1.17</td>
<td>3.16</td>
</tr>
<tr>
<td>T6 (1000)</td>
<td>60.00</td>
<td>50.77</td>
<td>10.77</td>
<td>11.87</td>
<td>0.70</td>
<td>10.33</td>
<td>0.86</td>
<td>0.91</td>
<td>1.00</td>
<td>2.76</td>
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<tr>
<td>T7 (2000)</td>
<td>58.89</td>
<td>50.07</td>
<td>10.47</td>
<td>10.55</td>
<td>0.57</td>
<td>10.00</td>
<td>0.54</td>
<td>0.74</td>
<td>0.92</td>
<td>2.20</td>
</tr>
<tr>
<td>S Em ±</td>
<td>25.21</td>
<td>7.43</td>
<td>0.74</td>
<td>0.31</td>
<td>0.08</td>
<td>1.17</td>
<td>0.06</td>
<td>0.42</td>
<td>0.15</td>
<td>0.16</td>
</tr>
<tr>
<td>S Ed ±</td>
<td>35.65</td>
<td>1.05</td>
<td>0.44</td>
<td>0.12</td>
<td>0.16</td>
<td>1.66</td>
<td>0.09</td>
<td>0.59</td>
<td>0.21</td>
<td>0.23</td>
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References