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Effect Of Metallic Pollutants (Cobalt, Nickel, Lead) On Growth Performance And Biomass Accumulation Of Mpt's Acacia Auriculiformis

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Abstract: ***Experiment was conducted to study the effect of metallic pollutants viz., Cobalt, Nickel and Lead on growth performance and biomass accumulation of Acacia auriculiformis a multipurpose tree species. Growth performance studies revealed that the concentrations of Cobalt Chloride significantly affect the shoot and root length, leaf number, Collar diameter and nodulation of growing seedling and found to be decreased with increasing the concentrations of*** $CoCl_2$***. The shoot and root length, leaf number, Collar diameter and nodulation were significantly affected by different concentrations of Nickel Chloride. Different concentrations of Lead Chloride significantly influenced the growth of shoot, root, number of leaves and nodulation and the highest growth performance for all the parameters was seen in control treatment but there was gradual decreased with increasing the concentration. In case of biomass accumulation studies, different levels of Cobalt chloride, Nickel Chloride and Lead chloride in soil showed statistically significant variation in leaves dry matter of above ground parts and below ground parts, total plant along with shoot / root ratio and found control was superior for maximum biomass accumulation.***

Keywords: Cobalt, Nickel, Lead, growth, biomass, Acacia auriculiformis

I. INTRODUCTION

Since the down of the industrial revolution, mankind has been introducing numerous hazardous compounds in to the biosphere. These hazardous pollutants consist of a variety of organic compounds and heavy metals, which pose serious threat not only to human health but also to other flora and fauna of the earth. Heavy metal poses severe threat to the environment the long term basis and non reversible. The metals commonly found in the environment beyond the critical level as a result of human activities includes Cu, Zn, Ni, Pb, Cd, Co, Hg, Cr and As. There is an urgent need to reduce excess metals present in soil, sediments and water bodies so as to prevent environmental contamination. Recently, scientist and engineers have started to generate cost effective technologies that includes the use of micro organisms and live plant in the cleaning process of polluted areas. Several studies have been conducted in order to evaluate the effect of different heavy metal concentration on live plants. Most of these studies have been conducted using seedlings or adult plants. *Acacia auriculiformis* is medium to tall, spreading tree. It is widely planted in the Pacific and elsewhere as a forestry tree and for other purposes. It is fast growing nitrogen fixing tree species of humid tropical. It tolerates degraded areas moist to wet sites. Presently it is widely cultivated in South East Asian countries. Therefore, present study was aimed to determine effect of metallic pollutants on growth performance and biomass accumulation of multipurpose tree species *Acacia auriculiformis* for the development of eco-friendly environment.

II. MATERIAL AND METHODS

Experiment was conducted in the experimental field of Department of Forestry, IGKKV, Raipur in completely randomized block design with seven concentrations replicated thrice. Fast growing and nitrogen fixing multipurpose tree species *Acacia auriculiformis* was selected for the study. Uniform sized and shape of seed of tree species was selected and treated with hot water (85^0C) for breaking the hard seed coat dormancy. When water started boiling the container removed from heating source and temperature immediately come down at 75 to 80^0C. Seed was kept in this water and left for overnight (Agrawal, 2003) after which uniform swelled seeds were selected and sown three seed in each container. After emergence and establishment of seedlings thinning was done to maintain one seedling in each container. Seven concentrations consisting of 0, 100, 200 500, 700, 1000 and 2000 ppm of metallic pollutants Cobalt chloride, Nickel chloride and Lead chloride were used on the basis of per bag of soil on dry weight basis. The application of different treatments of each pollutant was given and mixed separately in the soil of each bag, so that it could be homogeneous. Thus multiplying of 100 ml stock solution of each concentration of each pollutant was prepared in the lab for 60 bags and one treatment without any pollutant served as control.

Soil was prepared thoroughly by crushing into uniform fine grade. Sand were cleaned and washed thoroughly to get uniform size particles. Mixture of vertisols and sand were prepared in 1:1 ratio to fill in the polybag of 9.5 x 24cm size having capacity of 1.30 kg. Care was taken to keep soil free from weeds and other soil borne pathogens. The soil, sand and bore well water are filled in the bags and analyzed for their physical and chemical characteristics and as well as concentration of Cobalt, Nickel and Lead chloride in Department of Forestry I.G.K.V. and National Mineral Development Corporation Raipur. Height of seedlings was measured in centimeters from the base of the plant to the tip of the shoot with the help of standard meter scale. Collar diameter of the seedling was recorded near the base of stem in millimeter with help of digital Vernier caliper. The number of leaves obtained in each treatment was counted. The leaf area was calculated by using graphic methods along with dry weight. Root lengths of the seedlings were measured in centimeter by standard meter scale from lowest tip of the root of the seedling to the start of base of the shoot. Number of nodules per plants was recorded by simple count method. Leaves shoot, and roots were reported from each sample plant and weighed to record the fresh weight in grams. The sample of leaves, shoot, and roots were dried in hot air oven for 24 hrs. at 80^0C than again weighed for their dry weight for the observations of biomass accumulation.

Experiment was framed as per CRD design and the data generated from the experiment was compounded and tabulated for its statistical analysis as per the standard statistical / package. Lotus-123 Spreadsheet software (Lotus smart sheet-123/ MS office Excel) was used for all the mathematical and statistical calculation.

III. RESULT AND DISCUSSION

A. EFFECT OF METALLIC POLLUTANTS ON GROWTH PERFORMANCE OF ACACIA AURICULIFORMIS

Growth performance in plants of *Acacia auriculiformis* under different pollutants was recorded for their shoot and root length, Collar diameter, number of leaves and nodules, dry weight accumulation in leaves, above ground and bellow ground parts. *Acacia auriculiformis* is exotic species and behaved more or less similarly. Similar results were observed by Susilawati and Setiadi (2003) in their preliminary research on natural hybrids of *Acacia mangium* and *Acacia auriculiformis*, they found that mother trees and their seedlings showed intermediate and similar growth behavior as these species has relationship. Chlorides of heavy metal particularly $CoCl_2$, $NiCl_2$ and $PbCl_2$ influence the growth performance of plants provides if they are available in the soil (Arey and Jajetiya, 1998, Kalimuthu and Sivasubramanian, 1990, Peralta *et al*., 2000).

EFFECT OF COBALT CHLORIDE: Different growth characteristics of *A. auriculiformis* at 90 DAS were found statistically significant (Table 1). The growth performance of each parameter decreased gradually with increasing the concentrations. The highest shoot length (18.08 cm), root length (57.42 cm), number of leaves (15.98 plant^{-1}), collar diameter (2.94 mm) and number of nodules (9.95 plant^{-1}) was recorded in Control (T1). The non-significant response was found between 100 and 500 ppm, 1000 and 2000 ppm for collar diameter while 700 and 1000 ppm in nodules respectively. However, the least shoot length (8.18 cm), root length (33.13 cm), number of leaves (9.96 plant-1), collar diameter (2.18 mm) and number of nodules (6.53 plant-1) was reported in concentration of 2000 ppm. Similar impression of Cobalt Chloride was observed by Peralta *et al*., (2000) in case of *Medicago sativa* crop. In legumes Cobalt is required for symbiotic fixation of nitrogen in very-very small quantity, otherwise caused toxicity to plants if it exceed certain low levels. 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 some or be inhibition of cell enlargement resulted growth inhibition in both the conditions (Arey and Jajetiya, 1998). Chatterjee and Chatterjee (2000) studied the phyto-toxicity impact of Cobalt, Chromium and Copper on cauliflower that excess these metals inhibited the concentration of most of the macro and micro nutrients, particularly P, S, Mn, Zn translocation were affected most significantly leading to decrease water potential, transpiration rates and increased diffusive resistance and relative water contents in leaves and finally reduced the growth and productivity of plants.

Treatments	Shoot length (cm)	Collar diameter (mm)	Leaf number plant^{-1}	Root length (cm)	Nodules No. plant^{-1}	Dry weight (gm plant^{-1})				
						Leaves	Above ground	Below ground	Total	Shoot/Root
T_1 (0 ppm)	18.08	2.94	15.98	57.42	9.95	0.94	1.79	1.08	2.87	1.66
T_2 (100 ppm)	17.11	2.71	15.37	54.86	9.21	0.80	1.55	1.00	2.56	1.55
T_3 (200 ppm)	16.20	2.68	14.90	49.56	8.83	0.69	1.36	0.91	2.28	1.49
T_4 (500 ppm)	13.63	2.63	14.57	45.39	8.06	0.61	1.21	0.85	2.05	1.42
T_5 (700 ppm)	11.19	2.48	13.25	39.26	7.55	0.55	1.06	0.79	1.85	1.34

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T_6 (1000 ppm)	09.85	2.23	12.28	35.79	7.41	0.48	0.89	0.67	1.56	1.32
T_7 (2000 ppm)	08.18	2.18	09.96	33.13	6.53	0.34	0.65	0.52	1.17	1.25
SE(m)±	0.18	0.04	0.09	0.22	0.16	0.01	0.03	0.01	0.04	-
SE(d)±	0.25	0.05	0.12	0.31	0.22	0.02	0.04	0.02	0.05	-
CD at 5%	0.53	0.11	0.27	0.68	0.47	0.04	0.08	0.04	0.11	-

Table 1: Effect of different concentration of Cobalt Chloride on growth performance of Acacia auriculiformis at 90 DAS

EFFECT OF NICKEL CHLORIDE: It is evident from the data (Table 2) that, Nickel Chloride concentrations significantly ($P \leq 0.05$) influenced the shoot and root length, Collar diameter and number of leaves and nodules per plant of *Acacia auriculiformis*. The highest shoot length (18.08 cm), root length (57.42 cm), number of leaves (15.98 plant^{-1}), Collar diameter (2.94 mm) and number of nodules (9.95 plant^{-1}) in control (T_1) treatment. Shoot length in 700 and 1000 ppm concentration was statistically at par while Collar diameter was found at par between 100 to 200 ppm and 200 to 500 ppm. However, the lowest shoot length (8.09cm), root length (39.37 cm), number of leaves (9.80 plant^{-1}), Collar diameter (2.12 mm) and number of nodules (4.20 plant^{-1}) was measured in 2000 ppm where these were reduced up to 44.7 %, 62.6 %, 61.3 %, 73.9 % and 42 % respectively as compare to control (T_1). Gabriella and Anton (2002) narrated that capacity of tolerance the particular heavy metals by any plant species are known. Significantly indicators plants and are used as higher accumulator plants (Baker *et al*., 1994) for low concentration but on increasing the level of concentrations the inhibitory effect imposed which resulted the decrease in growth. The presence of Nickel marked suppression in total nitrogen and phosphate content mobilization. Singh (1985) reported more or less similar result in case of *Vigna radiata*.

Treatments	Shoot length (cm)	Collar diameter (mm)	Leaf number plant^{-1}	Root length (cm)	Nodules No. plant^{-1}	Dry weight (gm plant^{-1})				
						Leaves	Above ground	Below ground	Total	Shoot/Root
T_1 (0 ppm)	18.08	2.94	15.98	57.42	9.95	0.94	1.79	1.08	2.87	1.66
T_2 (100 ppm)	16.14	2.72	15.39	53.73	9.21	0.82	1.58	0.97	2.55	1.62
T_3 (200 ppm)	14.36	2.65	14.90	51.84	7.51	0.75	1.44	0.87	2.31	1.65
T_4 (500 ppm)	12.74	2.58	14.61	50.44	6.74	0.68	1.31	0.74	2.05	1.77
T_5 (700 ppm)	10.56	2.40	13.31	47.77	5.98	0.63	1.17	0.65	1.82	1.80
T_6 (1000 ppm)	09.94	2.27	12.10	46.50	5.40	0.54	1.00	0.54	1.54	1.85
T_7 (2000 ppm)	08.09	2.12	09.80	39.37	4.20	0.40	0.73	0.40	1.13	1.82
SE(m)±	0.24	0.03	0.07	0.31	0.15	0.01	0.03	0.02	0.03	-
SE(d)±	0.35	0.04	0.11	0.43	0.21	0.02	0.04	0.03	0.04	-
CD at 5%	0.74	0.08	0.23	0.93	0.45	0.04	0.09	0.05	0.08	-

Table 2: Effect of different concentration of Nickel Chloride on growth performance of Acacia auriculiformis at 90 DAS

EFFECT OF LEAD CHLORIDE: Length of shoots and roots, Collar diameter and number of leaves and nodules per plant was significantly influenced by different concentrations of Lead Chloride (Table 3). Application of Lead Chloride showed negative impact on these parameters. The highest shoot length (18.08 cm), root length (57.42 cm), number of leaves (15.98 plant^{-1}), collar diameter (2.94 mm) and number of nodules (9.95 plant^{-1}) were measured in control. The non-significant response was found only in growth of Collar diameter between 100 to 200 ppm, 200 to 500 ppm and 1000 to 2000 ppm. However, the least shoot length (8.05 cm), root length (37.67 cm), leaf number (9.69 plant^{-1}), Collar diameter (2.10 mm) and number of nodules (2.94 plant^{-1}) was measured in 2000 ppm concentration of $PbCl_2$, where the reduction was calculated up to 44.5 % 65.5 %, 60.6 %, 71.4 % and 29.5 % respectively. Lead is a biological non-essential element and it interferes with the general metabolism of plant particularly in synthesis of chlorophyll and photosynthesis rate (Singh 1998) and ultimately growth performance of plant is affected. Similar results were also observed in exhaustive maize crop by (Kalimuthu and Sivasubramanian, 1990) when crops were grown after seed soaking in different concentrations of Lead. Al-Yemini (2001) analyzed the process of reduction in root and shoot length with Lead in *Vigna radiata*, in presence of higher Lead content in cell that retarded the cell division and differentiation and reduce their elongation and effect on the plant growth and development (Kasturi *et al*., 1991). 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 acculeata*.

Treatments	Shoot length (cm)	Collar diameter (mm)	Leaf number plant^{-1}	Root length (cm)	Nodules No. plant^{-1}	Dry weight (gm plant^{-1})				
						Leaves	Above ground	Below ground	Total	Shoot/Root
T_1 (0 ppm)	18.08	2.94	15.98	57.42	9.95	0.94	1.79	1.08	2.90	1.66
T_2 (100 ppm)	16.43	2.69	15.33	53.72	9.00	0.77	1.41	0.93	2.35	1.52
T_3 (200 ppm)	14.48	2.63	14.83	48.60	7.15	0.69	1.20	0.70	1.90	1.71
T_4 (500 ppm)	12.10	2.57	13.89	46.95	6.12	0.63	1.08	0.64	1.72	1.68
T_5 (700 ppm)	11.25	2.36	12.40	44.93	4.94	0.56	0.99	0.57	1.56	1.73
T_6 (1000 ppm)	09.84	2.20	11.12	42.07	3.96	0.48	0.85	0.52	1.37	1.63
T_7 (2000 ppm)	08.05	2.10	09.69	37.67	2.94	0.30	0.56	0.41	0.96	1.36
SE(m)±	0.14	0.03	0.10	0.33	0.14	0.02	0.03	0.01	0.03	-
SE(d)±	0.19	0.05	0.14	0.47	0.20	0.02	0.04	0.02	0.05	-
CD at 5%	0.41	0.10	0.31	1.00	0.42	0.05	0.09	0,04	0.11	-

Table 3: Effect of different concentration of Lead Chloride on growth performance of Acacia auriculiformis at 90 DAS

A. EFFECT OF METALLIC POLLUTANTS ON BIOMASS ACCUMULATION OF ACACIA AURICULIFORMIS

Accumulation of dry matter in form of biomass in growing plant is the final outcome of performance of that vary species which survived in a given eco system either having positive or negative relationship to available resources or living neighbors. Here in the study the application metallic pollutants *viz.*, Chlorides of Cobalt, Nickel and Lead known for creating toxicity but there be a differences in the uptake of metal for species (Nandakumar, *et al*., 1995).

EFFECT OF COBALT CHLORIDE: The presence of Cobalt Chloride at various concentrations significantly ($P \leq 0.05$) influenced the total dry matter accumulation in above ground and below ground parts of *Acacia auriculiformis* at 90 DAS (Table 1). The control had no Cobalt Chloride treatments, hence gave highest dry weight for leaves (0.94 g), above ground (1.79 g) and below ground (1.08 g) aggregating total 2.87 g per plant biomass, while the lowest was at 2000 ppm concentration of $CoCl_2$ treatment *i.e.* 1.17g 0.34g, 0.65g, and 0.52g plant^{-1} respectively. The shoot/root ratio was found maximum at 0 ppm (1.66) followed by 100 ppm (1.55) with minimum at 2000 ppm (1.25). Jajetiya and Arey (1995) used the Cobalt concentrations for cultivation of moong and they found toxic effect of Cobalt even at very lower concentration and ultimately reduction in dry matter production. The restriction in biomass of barley and cauliflower due to abnormal metabolism due to excess supply of Cobalt, Chromium and Copper in the soil (Chatterjee and Chatterjee, 2000).

EFFECT OF NICKEL CHLORIDE: Availability of Nickel Chloride in soil showed statistically significant response on biomass accumulation in above and below ground parts (Table 2). Control treatment (0 ppm) gave maximum dry weight production of above and below ground dry weight. Among the concentrations of Nickel Chloride, 100 ppm was found less effective, hence after the control the dry matter was accumulated for leaf (0.82 g), above ground (1.58 g), below ground (0.97 g) and their total biomass (2.55 g) followed by 200 ppm (T_3), while the minimum was recorded at 2000 ppm *i.e.* $NiCl_2$ 0 .40 g, 0.73 g, 0.40 and 1.13 g, respectively. The shoot/root ratio was maximum at 700ppm $NiCl_2$ (1.85) followed by 2000 ppm (1.82) with minimum at 100 ppm (1.62). Singh (1983, 1985) studied the rate of Nickel on *Vigna rediata* and *Luffa aegyptica* where the dry weights of seedling decrease with increasing the concentration of Nickel in the soil. Such inhibitory effect of Nickel on seedling growth and its biomass accumulation was due to binding of metal with sulphydryl group of proteins Lead to check the mobilization of nitrogen and phosphors through enzymes (Jerome and Ferguson 1972). Sharma (1982) also studied similar results in case of using Mercury. Peralta *et al*. (2000) also reported similar results in preliminary study of alfalfa with several doses of Cd, Cr, Cu, Ni and Zn where higher concentrations reduced the growth and dry matter.

EFFECT OF LEAD CHLORIDE: It is evident from Table 3 that, the dry matter accumulation in above and below ground parts was significantly influenced by different concentrations of Lead Chloride. The dry weight for leaf, above and below ground parts and total plant was ranged from 0.30 - 0.94g, 0.56 - 1.79g, 0.41 - 1.08g and 0.96 - 2.90g, respectively at 90 DAS among seven concentrations of $PbCl_2$. Where the highest values were recorded in control (0 ppm) and lowest at 2000 ppm $PbCl_2$. The shoot/root ratio was maximum at 700 ppm (1.73) followed by 200 ppm (1.71) and minimum at 2000 ppm (1.36), through it was 1.66 in control at 90 DAS. Lead has been identified an important metal caused severe lethal effect on mankind directly or indirectly through edible plant material. It cases anti-vital role in growth and development of plants mostly. Al-Yemeni (2001) reported the similar trend of biomass accumulation in case of *Vigna ambaconsis* and worked the metabolic activities during the process of germination and growth of seedlings of *Acacia farnesiana* (Al-Yemeni and Al-Helol, 2000).

IV. CONCLUSION

The present study leads to the conclusion that the significant inhibitory effects of metallic pollutants *viz.*, Cobalt Chloride, Nickel Chloride and Lead Chloride on growth performance, biomass accumulation of *Acacia auriculiformis*. The application of Cobalt, Nickel and Lead Chlorides inhibited the performance of *Acacia auriculiformis*. Increasing the concentrations from 100, 200, 500, 700, 1000 to 2000 ppm there was decrease in the growth performance (shoot and root length, leaves number, Collar diameter number of nodules), biomass accumulation (dry weight of leaves, shoot and root).

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