Research Journal of Agriculture and Forestry Sciences ISSN 2320 – 6063
Vol. **5(7),** 1-5, July **(2017)** *Res. J. Agriculture and Forestry Sci.*

Effect of metallic pollutants (cobalt, nickel, lead) on growth performance and biomass accumulation of Mpt's *Acacia nilotica*

Funde D.M.[1], R.B. Kothikar[2*], Mina Koche[2] and M.N. Naugraiyya[1]
[1]Indira Gandhi Krishi Vishwavidyalay, Raipur, CG, India
[2]Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, MS, India
rajkumarkothikar@gmail.com

Available online at: www.isca.in
Received 15th April 2017, revised 21st June 2017, accepted 4th July 2017

Abstract

Experiment was conducted to study the effect of metallic pollutants viz., Cobalt, Nickel and Lead on growth performance and biomass accumulation of Acacia nilotica 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 control was found superior for maximum biomass accumulation.*

Keywords: Cobalt, Nickel, Lead, growth, biomass, Acacia nilotica.

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 nilotica* belongs to family Luguminoceae and evergreen tree with a short, thick, cylindrical trunk, thin spreading crown and feathery foliage. It is commonly grown along roadsides, canal banks, drainage embracement and railway tracks. Farmers grow this tree naturally on the agricultural land, wasteland and on field boundaries. Therefore, present study was aimed to determine effect of metallic pollutants on growth performance and biomass accumulation of multipurpose tree species *Acacia nilotica* for the development of eco-friendly environment.

Materials 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 nilotica* 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 after which uniform swelled seeds were selected and sown three seed in each container[1]. 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 polythene bag 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.

Results and discussion

Effect of metallic pollutants on growth performance of *Acacia nilotica*: Growth performance in plants of *Acacia nilotica* 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. Similar results were observed by Susilawati and Setiadi[2] in their preliminary research on natural hybrids of *Acacia spp.* 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[3-5].

Effect of Cobalt chloride: Shoot and root length, leaves number, collar diameter and number of nodules per plant of *Acacia nilotica* was significantly influenced by Cobalt Chloride (Table-1). Numerically a higher shoot length (72.61 cm) and root length (58 cm), leaves number (48.12 plant^{-1}), collar diameter (6.37 mm) and number of nodules (33.29 plant^{-1}) per plant was recorded in control followed by 100 ppm *viz,* shoot length (67.89 cm) and root length (56.42 cm), leaves number (46.82 plant^{-1}), Collar diameter (6.13 mm) and number of nodules (31.01 plant^{-1}). Statistically insignificant result was found for Collar diameter and root nodule between 500 and 700 ppm. However, the least shoot length (46.39 cm), root length (42.23cm), leaves number (35.60 plant^{-1}), Collar diameter (4.05 mm) and number of nodules (19.08 plant^{-1}) was measured at 2000 ppm where the reduction in shoot length and diameter was 37 %, and 27 % in leaves number and root length while in case of root nodules it reduced by 43% at 90 DAS. Similar impression of Cobalt Chloride was observed by Peralta *et al.*[5] in case of *Medicago sativa* crop. In legumes Cobalt is required for symbiotic fixation of nitrogen in very-very small quantity[6] 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[3].

Chatterjee and Chatterjee[7] studies the phytotoxicity 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.

Effect of Nickel Chloride: The data presented in Table-2 regarding growth performance showed that, various concentrations of Nickel Chloride exhibited significant effect on shoot and root length, leaves number, Collar diameter and number of nodules in seedlings of *Acacia nilotica.* The maximum shoot length (72.61 cm), root length (57.10 cm), number of leaves (48.12 plant^{-1}), Collar diameter (6.37 mm) and number of nodules (33.29 plant^{-1}) was observed in control at the 90 DAS. The application of 100 ppm Nickel Chloride reduced the growth of shoot and root length by 7 per cent while Collar diameter and nodulation by 5 per cent and the overall reduction in different growth parameters was 27 to 37 per cent at higher concentration of $NiCl_2$ (2000 ppm), where the shoot length (48.84 cm), root length (41.48 cm), leaves number (35.25 plant^{-1}), Collar diameter (4.10 mm) and nodules (21.10 plant^{-1}) it was observed at 2000 ppm $NiCl_2$. Gabriella and Anton[8] 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[9] 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[10] reported more or less similar result in case of *Vigna radiata*.

Effect of Lead Chloride: Seedling of *Acacia nilotica* grown in presence of Lead Chloride significantly influenced by different concentrations and the data presented in Table-3. Perusal of table showed the better growth performance in control (0 ppm), where the shoot length (72.61 cm), root length (57.10 cm), number of leaves (48.12 plant^{-1}), Collar diameter (6.37 mm) and nodules (33.29 $plant^{-1}$) was found maximum followed by 100 ppm, which gave shoot length (67.6 cm), root length (52.45 cm), number of leaves (46.7 $plant^{-1}$), Collar diameter (6.0 mm) and number of nodules (30.9 $plant^{-1}$). The gradual reduction in growth parameters was observed as concentrations of $PbCl_2$ increased. However, minimum shoot length (45.03cm), root length (38.86cm), leaf number (35.15 $plant^{-1}$), Collar diameter (3.92 mm) and nodules (18.0 $plant^{-1}$) were observed at 2000 ppm of Lead Chloride. Lead is a biological non-essential element and it interferes with the general metabolism of plant particularly in synthesis of chlorophyll and photosynthesis rate[11] and ultimately growth performance of plant is affected. Similar results were also observed in exhaustive maize crop by Kalimuthu and Sivasubramanian[4] when crops were grown after seed soaking in different concentrations of Lead. Al-Yemini[12] analyzed the process of reduction in root and shoot length with Lead in *Vigna radiata*, in presence of higher Lead content in cell, retarded the cell division and differentiation and reduce their elongation and effect the plant growth and development[13]. The differential response in root and shoot might be due to more rapid accumulation in root than shoot in case of *Parkinsonia acculeata*[14].

Effect of metallic pollutants on Biomass accumulation of *Acacia nilotica:* 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[15].

Effect of Cobalt Chloride: The data presented for biomass accumulation (Table-1) seedlings of *Acacia nilotica* at 90 DAS revealed that among tested treatments of Cobalt Chloride, control (0 ppm) reported highest dry matter accumulation in leaves, above ground parts, below ground parts and the total plant *i.e.* 3.62g, 9.20g, 3.95g and 13.15g respectively. Results show significant difference among tested treatment of Cobalt Chloride, and the mean values of dry matter ranges from 1.94-3.62g, 5.35-9.20g, 2.52-3.95g and 7.86-13.15g for leaves, above ground, below ground and total plant respectively. Least values were recorded under 2000 ppm treatment. The Shoot / Root ratio was maximum in control (2.32) and minimum in 2000 ppm of $CoCl_2$ (2.12). Jajetiya and Arey[16] 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. Chatterjee and Chatterjee[7] reported the restriction in biomass of barley and cauliflower due to abnormal metabolism due to excess supply of Cobalt, Chromium and Copper in the soil.

Effect of Nickel Chloride: The data presented in Table-2 revealed that, different seven treatments of Nickel Chloride showed statistically significant variations for on biomass accumulation in total plant as well as it different components. Control (0 ppm $NiCl_2$) treatment gave highest leaves (3.62g), above ground part (9.20g), below ground part (3.95g) and total dry matter (13.15g), while these values were least in 2000 ppm treatment of $NiCl_2$. Overall dry matter in leaves, above ground part, below part and total plant was ranged 1.88–3.62g, 5.55–9.20g, 2.33–3.95g and 7.89–13.15g respectively. Highest (2.38) shoot / root ratio was recorded in 2000 ppm treatment and lowest (2.16) in 500 ppm treatment. Singh[17,10] 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[18]. Sharma[19] also studied similar results in case of using Mercury. Peralta *et al*.[5] 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: Dry weight of leaves, above and below ground parts and total plant of *Acacia nilotica* was significantly affected by concentrations (0 to 2000 ppm) of Lead chloride (Table-3). The growth and biomass was recorded in control treatment (0 ppm $PbCl_2$) was superior among all seven treatments, followed by 100 ppm Lead Chloride, while at 2000 ppm concentration the biomass of plant was recorded lowest. Thus the dry matter accumulation was ranged from 1.50-3.62g, 5.28-9.20g, 1.87-3.95g and 7.15-13.15g for leaves, above and below ground parts and total plant.

The shoot/ root dry weight ratio was maximum (2.82) in 2000 ppm and minimum (2.23) in 200 ppm $PbCl_2$. 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 and Al-Helol[20] 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*[12].

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 nilotica*.

The application of Cobalt, Nickel and Lead Chlorides inhibited the performance of *Acacia nilotica*. 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) and biomass accumulation (dry weight of leaves, shoot and root).

Table-1: Effect of different concentration of Cobalt Chloride on growth performance of *Acacia nilotica* at 90 DAS.

Treatments	Shoot length (cm)	Collar diameter (mm)	Leaf number plant^{-1}	Root length (cm)	Root Nodules	Dry weight gm plant^{-1}				
						Leaves	Above ground	Below ground	Total	Shoot /root
T_1 (0 ppm)	72.61	6.37	48.12	58.00	33.29	3.62	9.20	3.95	13.15	2.32
T_2 (100 ppm)	67.89	6.13	46.82	56.42	31.01	3.52	8.80	3.85	12.65	2.28
T_3 (200 ppm)	64.41	5.95	44.96	54.02	28.55	3.38	8.30	3.70	11.99	2.24
T_4 (500 ppm)	62.18	5.65	43.33	51.02	26.46	3.19	7.81	3.52	11.34	2.21
T_5 (700 ppm)	60.31	5.53	41.18	47.79	25.51	2.84	7.14	3.13	10.27	2.28
T_6 (1000 ppm)	58.15	4.90	38.88	44.78	23.30	2.23	6.10	2.82	8.92	2.16
T_7 (2000 ppm)	46.39	4.05	35.60	42.23	19.08	1.94	5.35	2.52	7.86	2.12
SE(m)±	0.47	0.06	0.12	0.31	0.46	0.03	0.05	0.02	0.05	
SE(d)±	0.66	0.08	0.17	0.44	0.65	0.04	0.07	0.02	0.07	
CD at 5%	1.42	0.18	0.57	0.94	1.39	0.08	0.14	0.05	0.15	

Table-2: Effect of different concentration of Nickel Chloride on growth performance of *Acacia nilotica* at 90 DAS.

Treatments	Shoot length (cm)	Collar diameter (mm)	Leaf number plant^{-1}	Root length (cm)	Nodules No./ plant	Dry weight gm plant^{-1}				
						Leaves	Above ground	Below ground	Total	Shoot /root
T_1 (0 ppm)	72.61	6.37	48.12	57.10	33.29	3.62	9.20	3.95	13.15	2.32
T_2 (100 ppm)	67.83	6.08	47.21	53.08	31.83	3.46	8.86	3.75	12.62	2.36
T_3 (200 ppm)	64.61	5.97	45.47	49.71	29.81	3.22	8.12	3.66	11.78	2.21
T_4 (500 ppm)	62.68	5.77	43.06	49.02	28.03	2.88	7.53	3.48	11.01	2.16
T_5 (700 ppm)	59.89	5.50	40.58	46.96	25.74	2.60	6.91	3.13	10.04	2.20
T_6 (1000ppm)	57.28	4.84	37.72	44.26	23.97	2.29	6.26	2.78	9.04	2.25
T_7 (2000 ppm)	48.84	4.10	35.25	41.48	21.10	1.88	5.55	2.33	7.89	2.38
SE(m)±	0.53	0.03	0.14	0.57	0.34	0.02	0.05	0.03	0.07	
SE(d)±	0.74	0.04	0.20	0.81	0.49	0.03	0.07	0.04	0.09	
CD at 5%	1.60	0.09	0.43	1.73	1.05	0.05	0.16	0.08	0.20	

Table-3: Effect of different concentration of Lead Chloride on growth performance of *Acacia nilotica* at 90 DAS.

Treatments	Shoot length (cm)	Collar diameter (mm)	Leaf number plant^{-1}	Root length (cm)	Nodules No./ plant	Dry weight gm plant^{-1}				
						Leaves	Above ground	Below ground	Total	Shoot /root
T_1 (0 ppm)	72.61	6.37	48.12	57.10	33.29	3.62	9.20	3.95	13.15	2.32
T_2 (100 ppm)	67.60	6.00	46.70	52.45	30.90	3.21	8.42	3.72	12.13	2.26
T_3 (200 ppm)	62.53	5.70	44.43	50.34	28.49	2.81	7.73	3.46	11.19	2.23
T_4 (500 ppm)	60.52	5.57	42.46	48.04	26.22	2.44	7.07	3.12	10.19	2.26
T_5 (700 ppm)	58.66	5.37	40.49	45.98	24.21	2.16	6.55	2.70	9.25	2.42
T_6 (1000 ppm)	56.69	4.81	37.61	42.50	21.35	1.87	5.79	2.40	8.32	2.41
T_7 (2000 ppm)	45.03	3.92	35.15	38.86	18.00	1.50	5.28	1.87	7.15	2.82
SE(m)±	0.39	0.02	0.13	0.55	0.29	0.03	0.067	0.03	0.06	
SE(d)±	0.56	0.03	0.19	0.78	0.41	0.04	0.08	0.04	0.08	
CD at 5%	1.20	0.07	0.40	1.68	0.88	0.08	0.17	0.08	0.17	

References

1. Agrawal R.L. (2003). Seed technology. Oxford & IBH Publishing Co. Pvt. Ltd., 550-551.

2. Susilaawati S. and Setiadi D. (2003). Preliminary research on natural hybrid of Acacia mangium and Acacia auriculiformis in moong. Proceeding of International Conference on "Advances in Genetic Improvement of Tropical Tree species" at Indonesia, 1-3 Oct. 2002., 153-156.

3. Arey N.C. and Jagetiya B.L. (1998). Toxic effect of Cobalt on Barley growth in soil culture. *Environment and Development*, 63(2), 193-198.

4. Kalimuthu K. and Sivasubramanian R. (1990). Physiological effect of heavy metals on Zea mays (Maize) seedlings. *Indian J. Plant Physiol.,* 33(3), 242-244.

5. Peralta J.R., Gardea-Torresdey J.L., Tiemann K.J., Gomez E., Arteaga S., Rascon E. and Parsons J.G. (2000). Study of the effect of heavy metals on seed germination and Plant growth on Medicago sativa Grown in solid media. *Conference on Hazardous Waste Research,* 135-139.

6. Ahmed S. and Evans H.J. (1959). Effect of cobalt on the growth of soybeans in the absence of supplied nitrogen. *Biochemistry, Biophysics Research Communication*, 1(5), 271-275.

7. Chatterjee J. and Chatterjee C. (2000). Phytotoxicity of Cobalt, Chromium and Copper in Cauliflower. *Environment and Pollution*, 109, 69-74.

8. Gabriella M.G. and Attila Anton (2002). Heavy metal up take by two radish varieties. *Acta Biologica Szegediensis*, 46(3-4), 113-114.

9. Baker A.J.M., McGrath S.P., Sidoli C.M.D. and Reeves R.D. (1994). The possibility of in-situ heavy metals decontamination of polluted soil using crop of metal accumulating plants. *Resources conservation and Recycling*, 11, 41-49.

10. Singh S.N. (1985). Effect of Nickel on germination, seedling growth, total nitrogen and phosphate in Vigna radiata cultivars. *Indian Journal of Ecology*, 12(1), 162-165.

11. Singh B.P. (1998). Growth and Growth analysis of Bhalia (*Flemingia macrophylla* (Wild.)O. Ktze) in relation to date of sowing and size of polythene bags in nursery. *Indian Journal of Forestry,* 21(1), 34-37.

12. AL-Yemeni M.N. (2001). Effect of Cadmium, Mercury and Lead on seed germination and early seedling growth of Vigna ambacensis L. *Indian J. Plant Physiol*., 6(2), 147-151.

13. Kasturi R., Petrotive N., Knezevic A. and Kabie D. (1998). Effect of Lead on the morphology and anatomy of Maize plants (*Zea mays* L.). *Natural Science*, 87, 121-129.

14. Shaukat S.S., Mushtaq M. and Siddiqui Z.S. (1999). Effect of Cadmium, Chromium and Lead on Seed germination, early seedling growth and phenolic contents of Parkinonia acculeata L. and Pennisettium americanum L. Schumann. *Pakistan Journal of Biological Science*, 2(4), 1307-1313.

15. Nandakumar P.B.A., Dushenkov V., Motto H. and Raskin I. (1995). Phyto-extraction: The use of Plants of Remove Heavy metals from Soils. *Environmental Science Technology,* 29(5), 1232-1238.

16. Jagetia B.L. and Arey N.C. (1995). Effect of different Nickel salts on germination in moong. *Environment and Development* (Ed. Grover and Thakural) Pub. Scientific Publishers, Jodhpur, 189-192.

17. Singh S.N. (1983). Effect of Nickel on germination, seedling growth in Luffa aegyptica L. cultivars. *Geobias.* 10, 86-88.

18. Gavis Jerome and Ferguson John F. (1972). The cycling of Hg through environment. *Water Research,* 6(9), 989-1008.

19. Sharma S.S. (1982). Effect of Mercury on Germination and seedling growth of different varieties of Phaseolus aureus. *Indian Journal of Ecology*, 9(1), 78-81.

20. Al-Yemeni M.N. and Al-Helol A.A. (2000). Some metabolic changes in germinated *Acacia farnesiana* L. Seeds. *Journal of Science Engineers,* 27(2), 311-319.