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Studying the ability of *Dalbergia sissso* seedlings to tolerate planting in soil contaminated with Cadmium and Nickel

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Abstract : This investigation was carried out at Experimental area of National Research Centre, Dokki, Giza, during the two successive seasons of 2014 and 2015. The objective of this study is to evaluate the sensitivity of *Dalbergia sissso* seedlings grown on sandy soil conditions to various concentrations of both cadmium (Cd) and nickel (Ni) i.e. (0,20, 40 and 60 ppm) in irrigation water. Results showed that all tested treatments of both heavy metals (Cd and Ni) caused significant decrease in plant height as compared with control plants with the exception of 20 and 40 ppm Cd treatments. The fresh and dry weight of leaves stem and roots were significantly increased by 20 and 40 ppm led to significant decrease in fresh and dry weight of all seedlings organs in most cases. In this context, the obtained results stated that carbohydrates %, Chlorophyll (a, b) and carotenoids increased with the untreated plants.
The same results were obtained by both heavy metals on nitrogen and Potassium percentage. Cadmium and Nickel content increased by increasing Cd or Ni concentrations individually combined. This study recommends that the growth parameters and chemical constituents of *Dalbergia sissso* seedlings can tolerate cadmium and Nickel up to 40 ppm.
Key ward : *Dalbergia sissso* , Heavy metals , Cadmium, Nickel, Contamination.

Introduction

Dalbergia sissoo, originally comes from the Indian subcontinent and Southern Iran. In Punjab state of India, It is considered their state tree, however, in the Punjab province of Pakistan, it is considered their provincial tree. The tree comes from the family Fabaceae (Leguminosae). It is a medium to large tree and it is deciduous with a light crown and often crooked trunk. Leaves are compound with 5 leaflets and the flowers are pink-white shaped like the "Pea flower". It vegetatively reproduces through suckers that rise from the roots and through seeds. The plant is used for its timber, fire-wood, posts, fodder, erosion control, tool handles and as a windbreak. The plant's seeds produces oil and its bark produces thannin. *Dalbergia sissoo* suckers prolifically and can potentially from dense thickets to replace original vegetation **(**Hawkins [1]**).**

The otmospheric deposition , studge, sewage irrigation, utilization of metal . containing farmyard manures and industry and mind residues how to led to the increment a heavy metal content in soils which results in a possible risk for the health of human as those metal are transferred to our diets from crops. Those metals have a vital role in the environment as toxic species when they reach certain concentrations (Ngayiia *et al* [2], Ngayiia *et al* [3]) certain heavymetals have been observed to stunt the grwoth and reduce the produvtivity of crops at high concentrations (Liu *et al* [4]).

Cadmium is one of those metals that cause contamination, it is considered as a major environmental concern since it can residue in soil for thousands of years (Toppi and Gabrielli [5]), even through Cd is not a vital element for plants, it can be taken up by plants that grow in soils that have been contaminated by cadmium or had Cd supplements. Cadmium influences physiological processes and bio chemical mechanisms through affecting the concentrations and functions of mineral nutrients.

Cadmium have been reported to have interactions with the available nutrient elements (Aidid and Okamoto [6]), some of those nutrients are known to have protective roles against the toxic effects of Cd stress (Aidid and Okamoto [6], Khan *et al*[7]).

Nickel(Ni) is another heavy metal that can have harmful effects at high concentrations. In general, Nickel occurs in soil and surface water at levels lower than 1.00 and 0.005 ppm respectively. Ni pollution mainly occurs from mining, electro planting industries and smelting. Nickel contaminated soil and water have become a world-wide problem. High concentrations of Ni can result in Mitotic activities inhibition, decrease in the growth of plants and also can cause adverse effects on the quality and fruit yield. Despite the many reports on the toxic effects of Nickel, we still have knowledge of its toxicity or how it works (Mcllveen and Negusanti [8], McGrath [9], Zarcinas *et al* [10], Ahmed *et al*[11]). This study intended to find out the individual and combined effect of different concentrations of Nickel and Cadmium applications on growth and chemical composition of *Dalbergia sissoo*.

Materials and Methods :

The experiment trails were carried out under greenhouse conditions at National Research Centre, Dokki, Egypt during two successive seasons of 2014 and 2015. It intended to find out the individual and combined effect of different concentrations of Nickel and Cadmium applications on growth and chemical composition of *Dalbergia sissoo*.

Six months old seedlings of *Dalbergia sissoo* were obtained nursery of Forestry Department Horticulture Research Institute, Agriculture Research Centre. The seedlings were planted on 15th March in plastic pot 30 cm (one plant / pot, the average height of seedlings was (20 - 25 cm) filled with 8 kg soil. The investigated soil of the experimental of the following characteristics, 75.93 % Sand, 4.35 % Silt, 19.72 % Clay, pH 7.71, EC 0.71 dSm^{-1}, $CaCO_3$ 2.3 %, OM 1.58 %, Ca 2.8 %, Mg 0.1 %, Na 2.2 %, K 1.56 %, Cl 2.5 %, SO_4 2.8 $meqL^{-1}$. The physical and chemical properties of the soil were determined according to (Chapman and Pratt [12]),. The experiments were set in completely randomized design 5 replicates. The treatments were as follows: four cadmium levels (0, 20, 40 and 60 ppm) and four Nickel levels (0, 20, 40 and 60 ppm). Cadmium as cadmium nitrate ($Cd(NO_3)_2$) and Nickel as Nickel sulphate ($NiSO_4$) were used after dissolving in tap water and added as surface irrigation by one litre (2000 ml) depending on the field capacity. Irrigation scheme began after 30 days from transplanting and repeated twice every week till the end of the season (1st November). The available commercially fertilizer used through this experimental work was Kristalon (N : P : K, 19 : 19 : 19) produced Phayzon Company, Holand. The used rate of fertilizer was 5.0 gm /pot in four times. The plants were fertilized after 4, 8, 16 and 20 week. The following data were recorded: plant height (cm), fresh and dry weight of leaves, stems and roots (g). Obtained results were subjected to statistical analysis of variants according to the method described (Snedccor and Cochran [13]) and the combined analysis of the two seasons was calculated according to the method of (Steel and Torrie [14]). The following chemical analysis in plant leaves was determined, chlorophyll a, b and carotenoids contents were determined according to (Saric *et al* [15]). Total carbohydrates percentage was determined according to the method by (Dubois *et al* [16]). Nitrogen and potassium determined according to the method described by (Cottenie *et al* [17]). Heavy metal were determined by Atomic Absorption Spectrophotometer Perkin-Elmer Model 2380 following the method described by (Chapman and Pratt [12]).

Results and Discussion:

Vegetative Growth:

Data in Table (1) mentioned that plant height increased with Cd treatments at 20 and 40 ppm compared with the control and the other treatments. the increment was (11.39% and 24.43%) by plants treated with Cd at 20 and 40 ppm respectively compared with the untreated plants. Whereas, other treatments decreased plant height by increasing treatments concentrations. In this context, fresh and dry weight of all plants organs increased by treated plants with low concentration of Cadmium and Nickel compared with the control plants.

The increment in fresh weight of leaves were (7.52 and 20.90%) at 20 and 40 ppm Cd respectively and (81.99 and 78.59) at 20 and 40 ppm Ni respectively . In fresh weight of stem increments were (22.70 and 24.15%) at 20 and 40 ppm Cd respectively, and (20.54 and 0.39%) at 20 and 40 ppm Ni respectively. the same results were obtained in root with Cd and Ni at 20 and 40 ppm for both. Concerning the effect of Cd and Ni treatments on dry weight of leaves, stems and roots. results in the Table(2) mentioned that Cd at 20 and 40 ppm or Ni at 20 and 40 ppm increased dry weight of all plant organs. the increments of leaves dry weight were (34.38, 75.31%) at 20 and 40 ppm Cd and (15.63 and 5.31%) at 20 and 40 ppm Ni respectively , compared with the control plants. stem dry weight increased by Cd at 20 and 40 ppm(55.54 and 70.79%) and Ni at 20 and 40 ppm(73.60 and 8.80%) respectively, compared with the untreated plants. Also, the increments of roots dry weight were (128.66 and 192.57%) at 20 and 40 ppm Cd and (182.23 and 168.15%) at 20 and 40 ppm Ni respectively compared with the control plants. Regarding the effect of Cadmium and Nickel interaction, all growth charters (plant height, fresh and dry weight of leaves, stems and roots) decreased by increasing Cd and Ni concentrations. In general, high concentration of Cadmium and Nickel gave the lowest growth parameters. The reduction in the growth parameters could be attributed to the suppression of the elongation growth rate of cell, because of an irreversible inhibition performed by heavy metals on the proton pump responsible for the process. Growth parameters were used as useful indicators of metal toxicity in plants. (Athar and Ahmad[18], Latif[19], Khan and Khan[20]) reported that the influence of higher levels of Cd or Ni resulted in depressed plant growth, which suggests that heavy metals inhibit plant height, root, leaves and stems fresh and dry weight directly by inhibiting cell division or cell elongation or both. the obtained results agreed with (Rawia *et al* [21]) on *Cupressus sempervirns* and (Rawia *et al* [22]) on *Tagets erecta*

Table (1): Plant height (cm) and fresh weight of leaves, stems and roots(g) of *Dalbergia sissoo* as affected by Cadmium and Nickel treatments (Average of two seasons).

Characters / Treatments	Plant height(cm)	F.W.of leaves(g)	F.W.of stems (g)	F.W.of roots(g)
Control	38.36	15.55	36.03	22.90
Cd 20ppm	42.73	16.72	44.21	36.25
Cd 40ppm	47.73	27.80	44.73	39.67
Cd60ppm	28.16	8.71	13.28	26.77
Ni 20ppm	34.13	28.30	43.43	37.5
Ni 40ppm	24.11	18.77	36.17	27.78
Ni 60ppm	17.17	8.56	14.15	23.72
Cd 20ppm+Ni 20ppm	23.30	17.80	42.90	31.46
Cd 20ppm+Ni 40ppm	22.17	17.12	25.60	27.77
Cd 20ppm+Ni 60ppm	16.50	8.46	14.72	25.78
Cd 40ppm+Ni 20ppm	18.00	16.96	33.48	25.00
Cd 40ppm+Ni 40ppm	15.00	13.45	24.23	21.07
Cd 40ppm+Ni 60ppm	14.50	6.56	20.07	17.30
Cd 60ppm+Ni 20ppm	18.00	12.30	17.25	17.40
Cd 60ppm+Ni 40ppm	15.00	6.00	12.70	14.77
Cd 60ppm+Ni 60ppm	11.00	4.68	10.2	10.73
L.S.D at 5%	2.3	1.10	2.12	1.38

Table (2): Dry weight of leaves, stems and roots(g) of *Dalbergia sissoo* as affected by Cadmium and Nickel treatments (Average of two seasons).

Characters / Treatments	D.W.of leaves(g)	D.W.of stems (g)	D.W.of roots(g)
Control	3.2	5.34	4.71
Cd 20ppm	4.3	8.29	10.77
Cd 40ppm	5.61	9.12	13.78
Cd60ppm	2.81	3.51	6.77
Ni 20ppm	3.70	8.27	13.33
Ni 40ppm	3.37	5.81	12.63
Ni 60ppm	2.70	2.30	6.35
Cd 20ppm+Ni 20ppm	2.81	7.42	7.31
Cd 20ppm+Ni 40ppm	2.60	5.52	7.15
Cd 20ppm+Ni 60ppm	2.24	4.57	5.82
Cd 40ppm+Ni 20ppm	2.70	6.41	9.21
Cd 40ppm+Ni 40ppm	2.58	5.64	6.39
Cd 40ppm+Ni 60ppm	2.53	3.60	5.93
Cd 60ppm+Ni 20ppm	1.88	4.42	4.59
Cd 60ppm+Ni 40ppm	1.81	3.21	3.56
Cd 60ppm+Ni 60ppm	1.40	3.00	3.06
L.S.D at 5%	0.21	1.21	0.73

Chemical composition:

1- Carbohydrates percentage(%D.W.):

The results in Table (3) revealed that, Cd at 20 ppm containing the highest total carbohydrates percentage(44.11%) followed by plants treated with Cd at 40 ppm giving (42.30%) compared with the other treatments. Concerning the effect of interactions between heavy metals on carbohydrates %, the lowest values (24.00) of total carbohydrates percentage was recorded by applicated plants with Cd at 60 ppm + Ni at 60 ppm compared with the other treatments. Generally, carbohydrates % decreased by increasing heavy metals concentrations .This result may be due to the low export from mesophyll and higher starch accumulation harmed – *Dalbergia sissoo* might cause stronger resistance of photosynthetic apparatus of their and weak starch export from the mesophyll. Heavy metals had effect on the metabolism of carbon results from their possible interaction with the center of ribulosebis phosphate carboxylase (Stiborová etal [23]). This result is in harmony with those of (Arduini *et al* [24], Arun *et al* [25], XinChen *et al* [26], Rawia *et al* [22]) .

Table (3): Carbohydrates percentage and plant pigments mg/g.F.W. of *Dalbergia sissoo* as affected by Cadmium and Nickel treatments (Average of two seasons).

Characters / Treatments	Carbohydrates%	Pigments(mg.g F.W.)		
		Chlorophyll (a)	Chlorophyll (b)	Carotenoids
Control	29.40	2.750	1.036	4.081
Cd 20ppm	44.11	3.672	1.639	4.387
Cd 40ppm	42.30	3.621	1.461	4.329
Cd60ppm	28.11	2.631	1.002	3.709
Ni 20ppm	39.20	3.544	1.427	4.294
Ni 40ppm	38.31	3.376	1.413	4.273
Ni 60ppm	26.76	2.436	0.999	3.687
Cd 20ppm+Ni 20ppm	37.90	3.358	1.343	4.271
Cd 20ppm+Ni 40ppm	37.73	3.327	1.274	4.266
Cd 20ppm+Ni 60ppm	26.00	2.351	0.968	5.688
Cd 40ppm+Ni 20ppm	37.20	3.254	1.223	4.253
Cd 40ppm+Ni 40ppm	36.40	3.226	1.195	4.238
Cd 40ppm+Ni 60ppm	25.71	2.343	0.938	3.610
Cd 60ppm+Ni 20ppm	33.51	2.995	1.171	4.152
Cd 60ppm+Ni 40ppm	32.42	2.947	1.157	4.091
Cd 60ppm+Ni 60ppm	24.00	2.145	0.844	2.241

2- pigment content:

Data in Table(3) revealed that , Cd at 20 ppm showed that the highest content of chlorophyll (a) and (b) (3.672 and 1.639 mg/g F.W.) followed by cd at 40 ppm (3.621 and 1.461 mg/g F.W.) in the leaves respectively compared with the other treatments. While, the least value of chlorophyll (a) and (b) (2.145 and 0 844 mg/g F.W.) respectively were determined in the leaves of the plants treated with Cd at 60 ppm +Ni at 60 ppm. In this respect, the same results were obtained by heavy metals on carotenoids in plants treated with Cd at 20 ppm the highest value of carotenoids (4.387 mg/g F.W.) followed by plants treated with Cd at 40 ppm giving (4.329 mg/g F.W.) in leaves. On the other hand, the lowest value of carotenoids was obtained by plants treated with Cd at 60 ppm + Ni at 60 ppm. Generally, the highest concentration of Cd or Ni at 60 ppm individual or combination decreased pigments compared with the other treatments and the control plants.The same results are in agreement with those obtained by (Zengin and Munzuroglu[27]) on *Phaseolus vulgaris* L, (Latif[19]) on *Raohanus sativa*, (Dubey and Pandey[28]) on *Vigna mungo*, (Kadhim[29]) on *Phaseolus aureus* , (Rawia *et al* [21]) on *Cupressus sempervirns* and,(Rawia etal[22]) on *Tagets erecta* ,they found that the decrement of chlorophyll content with the enhancement concentrations of heavy metals such as Cd and Ni.

3- Nutrient content:

The data presented in Tabe (4) showed that the highest nitrogen % in plants was obtained by plants treated with Cd at 20 ppm (1.256%) followed by plants treated by Cd at 40 ppm (1.220%) compared with the control and the other treatments. The lowest value on N%(0.473%) was recorded with Cd at 40 ppm + Ni at 60 ppm compared with the treatments. Results also indicated that the average of potassium % ranged from 0.63% to 2.35%. The treated plants with Cd at 20 ppm gave the highest value of N% (2.35%) followed by those treated by Cd at 40 ppm (1.79%).The lowest value of Potassium % (0.63%) was recorded in plants treated with Cd at 40 ppm+Ni at 60 ppm compared with the other treatment.

Table (4): Nitrogen and potassium percent and Cadmium and Nickel ppm of *Dalbergia sissoo* leaves as affected by Cadmium and Nickel treatments (Average of two seasons).

Characters / Treatments	Nitrogen%	Potassium%	Cadmium ppm	Nickel ppm
Control	0.947	1.12	24	25
Cd 20ppm	1.256	2.35	17	20
Cd 40ppm	1.220	1.79	32	31
Cd60ppm	0.637	1.04	34	33
Ni 20ppm	1.129	1.68	16	19
Ni 40ppm	1.074	1.31	29	35
Ni 60ppm	0.619	0.98	30	39
Cd 20ppm+Ni 20ppm	1.038	1.19	14	18
Cd 20ppm+Ni 40ppm	1.031	1.18	27	29
Cd 20ppm+Ni 60ppm	0.509	0.91	28	30
Cd 40ppm+Ni 20ppm	1.011	1.16	11	17
Cd 40ppm+Ni 40ppm	1.001	1.14	25	26
Cd 40ppm+Ni 60ppm	0.473	0.63	26	28
Cd 60ppm+Ni 20ppm	0.946	1.10	19	24
Cd 60ppm+Ni 40ppm	0.837	1.09	21	22
Cd 60ppm+Ni 60ppm	0.831	1.07	22	21

The results in Table (4) revealed that the highest content of Cd concentrations (34ppm) was recorded on plants treated with Cd at 60 ppm followed by plants treated with Cd at 40 ppm (32 ppm) . Whereas, the least value of Cd concentration(11ppm) was observed giving (11ppm)at 40 ppm Cd +20 ppm Ni. The plants Ni concentration reached to the highest value when plants were treated with Ni at 60 ppm giving(39 ppm). but, the lowest value of Ni concentration was recorded with Cd at 40 ppm+Ni at 20 ppm. The activation of mineral content (Cd and Ni ppm) due to heavy metals concentration levels were similar obtained by (Latif [19], Pandey [30], Rawia *et al* [21], Rawia *et al* [22]).

Hence, this study recommends that the growth parameters and chemical constituents of *Dalbergia sissso* seedlings can tolerate cadmium and Nickel up to 40 ppm.

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