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ORIGINAL ARTICLE

Detect of Cadmium Pollution Environment effects on Sapling Deltoides species

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ABSTRACT
Heavy elements including cadmium are produced as a result of major urban, industrial and agricultural activities and they cause pollution of natural resources. On the other hand, considering the increasing need for tree planting in Iran, a comprehensive research on fast- growing deltoides poplar species and the role of these plants in absorption of heavy metals including cadmium is essential. In order to achieve to this purpose, after preparing the populous deltoides species plants in flower pots they were irrigated a nutrient solution containing cadmium chloride with 10 mg/kg of concentration for 20 days in two irrigation periods and at the end of this period the dry weight of the aerial organs decreased significantly (P> 0/05).Yet, there was a significant difference between the dry weight of the aerial parts of the treatment and the control but the dry weight of the control root did not have significant difference with the treatment but we observed a reduction in the height after treatment of the plants. Although the results show that there is no significant difference between the soil, the stem, the leaf and the root with concentration of zero (control) and also the leaf and the stem (treatment)with concentration of 10 and at 95% of confidence level, but there is a significant difference between the stem and treatment root and also between the root and the treatment soil at 95% of confidence level.

Keywords: *Absorption, Accumulation, Cadmium metal, Populus deltoides.*

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INTRODUCTION

The importance of cadmium among other toxic elements is because this element can be accumulated in large amounts, toxic to the humans and the animals, in the plant organs, But yet no toxicity sign appears in the plant[1]. Cadmium is absorbed through the root and the leaf and it is transferred to the humans or animals and it causes metabolic disorders. Cadmium has a high affinity with sulfhydryl and hydroxyl groups and hydrogen containing ligands. Therefore this element inactivates lots of important enzymes resulting in a disorder of photosynthesis, respiration and other metabolic processes in the plant[2] . One of the effective factors in cadmium absorption and appearance of its toxic signs in the plant is the nutritional statues of the plant especially regarding the trace elements. Cadmium is a metallic and soft bluish-white element. This element is obtained as the byproduct of zinc filtration and most of its characteristics resemble the zinc. Cadmium and its compound are highly toxic. The plants are able to control the concentration of the necessary and unnecessary heavy metals like cadmium, mercury, lead, selenium and arsenic[3,4] . The allowed concentration of cadmium ranges from 1-5 mg/kg of the soil [5].Cadmium absorption amount by the plant depends on its mobility and availability in the root environment and that itself depends on cadmium's chemical species in the soil. The soil features like soil cation exchange capacity, PH and soil organic matter affect the cadmium accumulation in the plant and its solubility and mobility in the soil. Some plants like lettuce, spinach, cabbage and celery have more tendencies to cadmium absorption and they accumulate it in their body with a much higher rate than other plants [6].
research titled "The Calcium Effect on Some Physiological Parameters in Eucalyptus and also Comparison of Cadmium Accumulation and Transfer" showed that the absorption amount of this metal in the root is

higher than the stem and the leaf. Casio et al. 2004, in their study have proved that the dry weight of the leaf in Arabiodopsishalleri plant (cadmium hyper accumulator) treated by 2.5 mg/kg concentration of cadmium was decreased up to26% (compared to the control). in research on Salsola Kali plant, introduced as the cadmium resistant plant, proved that the 5 mg/l treatment has caused 31% decrease in the dry weight of the aerial parts[7]. Also concluded in their research that although cadmium is not a nutrient element but it is easily absorbed through the plant roots and it is accumulated in the plant with the concentration amounts harmful to the food chain[8]. Cadmium accumulation in plant tissues in cellular level can also be toxic and cause growth reduction. Therefore cadmium absorption prevention by the plant roots may be an important strategy for minimizing the biological side effects of this element. The poplar genus has a specific and unique position within the existing collection of fast-growing trees specifically in plantation of large masses of trees all over the world. Because of the high quantity of asexual reproduction of this genus and its high growth rate it has been considered as a forest tree model in biotechnological studies and it has the vastest researches in the field of breeding and has been used as the second genus after the pine (Marchadir Vessigad). Considering that poplar plantation is also a practical solution for wood production, more studies is required for incensement and continuity of the production. Thus, the study of its survival and growth under environmental pressure is essential. But present research actually aims at studying the resistance, absorption and accumulation of the deltoides poplar plants against the cadmium toxic element and its effect on aerial organs (the leaf and the stem) and underground organs (root) of this species. This study also aims at surveying the question that, "Is it possible to introduce deltoides poplar as a plant with cadmium accumulation ability?"

MATERIAL AND METHODS

The uninfected soil (the natural soil used in this laboratory) was taken from 0-30 centimeters depth of one of the poplar nurseries, then it was transferred to the laboratory and was dried in laboratory temperature and after drying; it was sieved with a 2 mm sieve. Then, the soil samples were distributed into plastic flower pots with a volume of 7 liters.

Preparation of the Plants

The equal scions (by height, diameter and the number of sprouts) from a single poplar tree with 77.51 pd clones were used for the survey. First the scions with 20 cm height and 2-3 cm diameters and three sprouts were selected and they were planted in flower pots in February. The flower pots were placed in the exteriority and they were irrigated with water when necessary. The experiment duration was 5 months.

- Solution Spraying and Treatment of the Poplar Plants

In June, the plants were sprayed and treated with concentration of 10 mg cadmium solution, on the leaf, stem and the soil, using a spray from above, in the form of fogging. They were treated twice and during 20 days and after this period the samples were harvested.

-Determination of the Dry Weight and Evaluation of the Cadmium Metal Concentration Amount in the Plant

The plant organs were placed in an oven at 70°C and then the dry weight of the organs was measured with a “a & d digital scale", based on gram and with 0.0001 of accuracy value. To determine the cadmium concentration in plant organs, the plant is weighted inside the crucible and turned into ash in an electric furnace at 400 to 500 centigrade degrees, then they are digested with normal chloridric acid2 and the cadmium concentration in the extracts was determined using the atomic absorption device. The atomic absorption method is one of the most accurate methods in measuring the amount of elements. The measurement of the leaf, the stem and the root was done.

Data Analysis Method

The resulting data from experiment of the plants was organized, using SPSS software. For data analysis, first their normality was determined using Klomogrov-Smirnov test. Then, to analyze the data in order to determine the metal accumulation amount in aerial and underground organs of the plant, unilateral variance test was applied and to compare the effect of cadmium concentration on the examined parameters, the Duncan's test was used. Also, to compare the concentration of the leaf and the stem against the root, Pearson's correlation analysis was utilized and the transfer coefficient of the cadmium metal from roots to the aerial organs of the plant was calculated. The quantitative statistical feature and the frequency of the cadmium metal accumulation chart in aerial and underground organs were also presented in tables and charts.

RESULTS AND DISCUSSION

After measuring the dry weight of the leaf and considering table (1), the non- paired T-test related to the effect of cadmium metal on dry weight of the leaf of deltoides poplar plants, it is observed that there is a significant difference at 95% level in the cadmium amount per the leaf dry weight between the zero concentration (control) with mean value of 14.8667 and the examined concentration of 10 with the mean value of 10.1313 and mean difference of 4.7334. Also, according to table (2), non-paired T-test related to cadmium metal effect on dry weight of the plant stems, it is observed that there is a significant difference at the 95% level between the existing cadmium metal amount per the stem dry weight in concentration of zero (control) with mean value of 34.9333 and the examined concentration of 10 with mean value of 25.4833 and the mean difference of 9.45.

Table1: non-paired T-test results as per the dry weight of deltoides poplar plant leaf in two concentrations (zero and 10)

Statistics of the groups

cadmium effect on dry weight of the leaf	number	mean	Standard deviation	Standard error of the mean
Control leaf dry weight	3	14.8667	0.30551	0.17638
Treatment leaf dry weight	6	10.1333	1.71425	0.69984

T-test table of two independent samples

Cadmium effect on dry weight of the leaf	F	Significance level	t	Freedom degree	Decision criteria of equality of the mean	Standard deviation mean	Standard deviation error	95% confidence interval of the difference	
								Lower limit	Upper limit
Control leaf dry weight	38.494	0.000*	4.591	7	0.003	4.73333	1.03095	2.29552	7.17114
Treatment leaf dry weight			6.558	5.599	0.001	4.73333	0.72173	2.93621	6.53046

*significance at 95% level

Table2: non-paired T-test results per the dry weight of stems of the deltoides poplar plants with two concentrations (zero and 10)

Statistics of the two groups

Cadmium effect on dry weight of the stem	number	mean	Standard deviation	Standard deviation error mean
Control stem dry weigh	3	34.9333	1.30128	0.75130
Treatment stem dry weight	6	25.4833	5.49488	2.24327

T-test table of two independent samples

Cadmium effect on dry weight of the stem	F	Significance level	t	Freedom degree	Decision criteria of equality of the mean	Standard deviation mean	Standard deviation error	95% confidence interval of the difference	
								Lower limit	Upper limit
Control stem dry weight	78.681	0.000*	2.846	7	0.025	9.45000	3.32045	1.59839	17.30161
Treatment stem dry weight			3.995	5.599	0.007	9.45000	2.36574	3.66030	15.23970

*significance at 95% level

Cadmium Effect on Dry Weight of the Root

Considering the non-paired T-test of table3, related to the cadmium metal effects on dry weight of the roots of deltoides poplar plants, it has been observed that there is no significant difference at 95% level between the existing cadmium metal amount per the root dry weight in zero (control) concentration with the mean value of 2.2333 and the examined10 with the mean value of 1.0500 and the mean difference of 1.1833.

Table3: the results of the non-paired T-test per the dry weight of roots of the deltoides poplar plants in two (zero and 10)concentrations.

Statistics of the two groups

Cadmium effect on dry weight of the root	number	mean	Standard deviation	Standard deviation error mean
Control root dry weigh	3	2.2333	0.20817	0.12019
Treatment root dry weight	6	1.0500	0.28810	0.11762

T-test table of two independent samples

Cadmium effect on dry weight of the root	F	Significance level	t	Freedom degree	Decision criteria of equality of the mean	S.D. mean	Standard deviation error	95% confidence interval of the difference	
								Lower limit	Upper limit
Control root dry weight	2.309	$0.172^{n.s}$	6.251	7	0.000	1.18333	0.18930	0.73572	1.63095
Treatment root dry weight			7.037	5.608	0.001	1.18333	0.16816	0.76478	1.60188

*n.s= non-significant

According to the results of the variance analysis test(ANOVA), the resulted data of the cadmium effect on dry weight of the leaf, stem and root of the deltoides poplar plants in zero(control) concentration and concentration of 10 shows that in characteristics of dry weight of the aerial organs and the root, the amount of sig is smaller than the significance level of 5%, thus it is concluded that, up to 95 percents, there is a significant difference between the dry weight mean of the aerial organs and the root, in terms of cadmium metal concentration amount(table4).

Considering the fact that p – value is smaller than $\propto$, H_0 hypothesis is rejected in this test.

Sig = p – value= 0.000<0.05=$\propto$

Table4: the results of variance analysis per the dry weight of aerial organs and roots of the deltoides poplar plants in concentrations of zero (control) and 10.

ANOVA

	Total of the squares	Freedom degree	Mean of the squares	F	The significance level
Treatments	3619.220	5	723.844	89.555	0.000*
Error	169.737	21	8.083		
Total	3788.956	26			

*significance in 95% of confidence level

The comparison of the dry weight mean of the underground organs and the roots of deltoides poplar plants within examined concentrations, using Duncan's test showed that there is no significant difference at 95% of confidence level between the treated root and the control root but there is a significant difference at 95% of confidence level between the control root and the treatment leaf and also the between the treatment leaf and the control leaf. Also, according to the test it was observed that there is a significant difference at the 95% of confidence level between the control leaf and the treatment stem and also the treatment stem and the control stem, and the data analysis results have been presented in table5 and figure1. As it is observable, the significance level of the F-test in ANOVA table equals 0.000 which is smaller than 0.05 of significance level. So, it is concluded that the null hypothesis is probably rejected up to 95 percents. Further, we conclude that since the within-group variance is bigger than the between-group variance, the mean differences are due to the sampling error or chance.

Table5: the results of Duncan's test on dry weight of aerial organs and root of the deltoides poplar plants in two concentrations (zero and 10).

The effect of cadmium metal on dry weight of aerial organs and the root		Subset for alpha = 0.05				
	N	1	2	3	4	5
Treatment root	6	1.0500				
Control root	3	2.2333				
Treatment leaf	6		10.1333			
Control leaf	3			14.8667		
Treatment stem	6				25.4833	
Control stem	3					34.9333
Sig.		0.562	1.000	1.000	1.000	1.000

Research titled "A Survey of Cadmium Resistance, Absorption and Accumulation in *Matthiola Chenopodiffolia* Plant in Two Populations Collected from Two Metal Infected and Uninfected areas", concluded that incensement of the cadmium concentration decreased the dry weight of aerial parts and the root significantly and also the root resistance index of both populations, yet no significant difference in terms of these factors was observed between the two populations. Also, the results showed that there is a direct relation between amount of the metal in nutrient solution and the amount of metal absorption and accumulation in the plant [9].

Concluded that although cadmium is not a nutrient element but it is absorbed through the roots of the plant easily and it is accumulated in the plant with the concentrations harmful to the food chain. Cadmium accumulation in plant tissues can also be toxic in cellular level and may cause growth reduction. Therefore, prevention of cadmium absorption by plant roots can be an important strategy in minimizing the biological disadvantages of this element [10].

in their research titled "The Study of the Accumulation of Heavy Metals in the bed, leaf and root of the mangrove trees" in Bushehr province, found that the amount of nickel, vanadium and zinc in sediments is always more than the root and the leaf. Nevertheless, the accumulation of cadmium, copper and lead in the root is more than the sediment and the leaf. Also, in no samples the amount of the examined heavy metals in the leaves exceeded the root and the sediment. research titled "The cadmium Effect on Some Biological Parameters in Eucalyptus and Also Comparison of Cadmium Accumulation and Transfer" proved that, the absorption of this metal in the root is more than the stem and the leaf [4.5].

CONCLUSION

Considering the conducted surveys in this research we can conclude that according to the applied concentration and the fact that the cadmium concentration of 10mg/kg, distributed the physiology and the genetics of the populous deltoides plant so, it is not a species with high ability of infected environment filtration and omission of cadmium metal from the soil.

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SUGGESTIONS

1. Considering the conducted surveys during this research, we can express that according to the applied concentration, the populous deltoides poplar species is not a species with a high ability of filtration of the infected environments or omitting the cadmium metal from the soil, it is recommended to experiment this species with lower cadmium concentrations like 2.5 or 5mg/kg and also in other environments and larger species, because it probably has a high absorption and accumulation ability in lower concentrations and natural environments.
2. Since deltoides poplar is not a totally inappropriate species, but only has not much ability in high concentrations therefore, it is recommended to be used along with other species like plane tree, persimmon, *eucalyptus occidentalis* or herbaceous plants or clover which have showed a higher ability in cadmium absorption and its omission from the environment.
3. Also, we suggest the study of other varieties of the poplar too because there may be the possibility that their ability in heavy metal absorption is higher than the deltoides variety.

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