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Original Article

Effects of Salinity Levels on Heavy Metals (Cd, Pb and Ni) Absorption by Sunflower and Sudangrass Plants

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ABSTRACT
Large parts of Iran have arid and semiarid regions and one of the important problems of these regions is soil and water salinity. Also heavy metal enters in the soil through the various ways such as: sewage sludge and pesticides. As a result salinity and heavy metals concentration in soil are two major problems in parts of arid and semiarid regions. The aim of this research was studying the effect of different salinity levels on availability of some heavy metals. Experiments were conducted in a completely randomized design with factorial layout in the greenhouse of Research Center of Agriculture and Natural Resources, Isfahan, Iran. The factors include heavy metals in 3 levels (Cd, Pb, Ni), salinity in 3 levels (EC (dS/m): 2, 7, 12) and plant in two kinds (Sunflower and Sudangrass) with three replications. The result of soil analysis showed that availability amount of heavy metal (Cd, Pb, Ni) was increased in soil with increasing of salinity. The result of plant analysis showed that there was corresponding increase in concentration of absorbed Cd in all parts (root, stem, leaf) of Sunflower and Sudangrass with increasing salinity. The amount of Pb with regard to low mobility in plant and soil was equal to zero in stem and leaf of two plants, but it was increased in root of two plants with increasing of salinity. Due to high mobility of Ni in plant tissues was noticeable the amount of absorbed Ni in root, stem and leaf of both plants. But the amounts of its in root of Sudangrass were much more than root of Sunflower.
Key words: *Sunflower, Sudangrass, Salinity, Heavy metals, Cd, Pb, Ni*

INTRODUCTION

In attention to vast areas of Iran are considered as arid and semi-arid regions, water and soil salinity is one of the major problems of these areas. Salinity is a limiting factor in crop growth [1]. In saline conditions, lower activity of nutrient ions causes to imbalance of nutrients in plants and thus increases detrimental ions in plant [2]. On the other hand, heavy metals enter into soil by various ways, such as atmospheric precipitation, using chemical and manure fertilizers, compost, sewage, agricultural and industrial waste and pesticides. The amount of entering these elements to agriculture lands depends on agriculture management. For example, the most important entry pathway of cadmium to agriculture lands is phosphorous fertilizers and for lead this way is sewage waste and agricultural and industrial waste and other industrial pollutants. In spite of differences in the behavior of heavy metals in soil, in terms of mobility and absorption, in most cases, it way possible that removal through leaching or uptake by the plants is much lower than the rate of their entry into the soil. In such condition, leading to gradual accumulation of these elements in soil ([3]. Bingham [4] observed that in a pot experiment, with increasing NaCl, concentration of Cd and Pb increases in soil. Studies of McLaughlin [5] showed the increasing of Cd concentration in potato and sunflower in relation with the increase in the Cl concentration in soil. In saline soils, for many reasons, including the formation complexes of cadmium with chloride, solubility of Cd and its absorption increases by plant. Also, results obtained of other researchers showed that salinity with Cl has an effective role in increasing solubility of Cd and its absorption by plant. Increase of Cd absorption in saline soils is reported in many crops [6-8]. Sudangrass is a kind of surghom, which is used for direct grazing and consumption as green grass. One of the good characteristics of this plant is resistant to heat and dryness and thus production of high biomass [9]. Sunflower also is resistant to heat and dryness thus it is classified as plant relatively tolerant to salinity [9]. Because of water and soil salinity problem and pollution of soil with heavy metals which may be intensified in future, danger of increase in the absorption of heavy metals in plants will be higher [10]. The aim of this study was the Effects of Salinity Levels on Heavy metals (Cd, Pb and Ni) absorption by Sunflower and Sudangrass Plants.

MATERIALS AND METHODS

Preparing the experiment soil:

Soil was selected from a non-polluted soil which belonged to agricultural lands and it was far from industries and pollutants. In order to ensure non-pollution with heavy metal, soil was analyzed (Table 1).

Table 1: Analysis of tested soil

Parameter	unit	Concentration
pH	-	7.4
OM	%	2
CEC	Cmol kg	12
Texture	-	Sandy clay loam
P	mg kg-1	25
K	mg kg-1	400
Cd	mg kg-1	0.09
Pb	mg kg-1	0.06
Ni	mg kg-1	0.08

To add heavy metals to soil, first heavy metals were mixed in one liter deionized water and sprayed to soil. Cd concentration for each pot soil was 20 mg/kg and Pb and Ni concentration was considered 300 mg/kg [11]. In order to reach to desired salinity, saline waters were used and pots were irrigated with that. In order to achieve electrical conductivity, we used this formula:

$$LR = EC_W / 5(ECe-Ecw)$$

LR: water requirement

ECw : Salinity of irrigation water

ECe : Salinity of soil saturated extract.

Then, 5 seeds were considered for every pot, which 3 plants were raised in each pot after germination. Irrigation time was determined regarding field capacity and permanent wilting point.

Experiment design and location

In this reserch, we were performed the effects of salinity in 3 levels (2 , 7 and 12 dS/m), the supply of heavy metals in 3 levels (Cd, Pb, Ni) and plants in 2 levels (Sunflower and Sudangrass) with three replications. Experiments were conducted in a completely randomized design with factorial layout during 2010-2011 in the greenhouse of Research Center of Agriculture and Natural Resources, Isfahan, Iran.

Statistical analysis

Data from experiments were analyzed using SAS software [12]. Averages of main and interactions effects of experimental factors were evaluated by Duncan test. For drawing diagrams was used EXCEL software.

RESULTS AND DISCUSSION

Concentration of heavy metals in soil in different salinity level

The results of soil analysis showed that, total amount of heavy metal (Cd, Pb, Ni) was decreased in soil with increasing of salinity, but there is no statistically significant difference between them. Concentration of absorbable heavy metals (Cd, Pb, Ni) was increased in soil with increase of salinity, but Duncan test showed that there is a significant difference between salinity 2 and 7 with 12, but there is no significant difference between salinity 7 and 12 (Table 2).

Table 2: Comparison of absorbed concentrations of cadmium, lead and nickel in soil at different levels of salinity using the Duncan test

Concentration of absorbed lead in soil (mg/kg)	Concentration of absorbed lead in soil (mg/kg)	Concentration of absorbed cadmium in soil (mg/kg)	Salinity (dS/m)
23.4 b	7.31 b	7.71 b	2
24.7 b	8.11 a	9.66 a	7
26 a	9.36 a	10.47 a	12

In saline soils, for many reasons, including heavy metals forming complexes with chloride, Exchange of sodium with heavy metals in adsorption sites and less absorption of heavy metals complexes with chloride on soil and clay particles caused increase absorbable form of heavy metals in soil solution [13]. So researchers has reported complexes chloride with Cadmium (CdCln) absorb less in soil particles, at result these complexes remain in soil and absorbability will be increased by plant [14].

Concentration of heavy metals in soil two plant:

Comparison between the soil two plants showed that there wasn't significant difference in concentration of absorbable Cd, Pb and Ni.

Concentration of Cd , Pb and Ni in organs of Sunflower in different salinity levels

Cd metal were absorbed in three organs (root, stem, leaf) and by increasing salinity, their concentration increased in root, stem and leave of sunflower. Because of good mobility of Cd in plant, its concentration was very high in leaf (Figure 1).

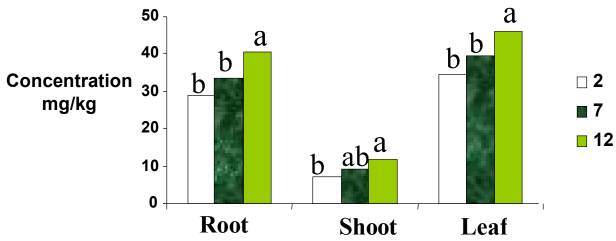

Figure 1: Cd concentration in root, stem and leaf of sunflower in different salinity
Columns with the same letters in every organ, there is no statistically significant difference at 5% level

Ni metal has good correlation with Ni concentration in soil and that was because of easy uptake of Ni by root and its transfer in plant. But Ni concentration increased in (root, stem, leaf) of plant with increasing of salinity (Figure 2).

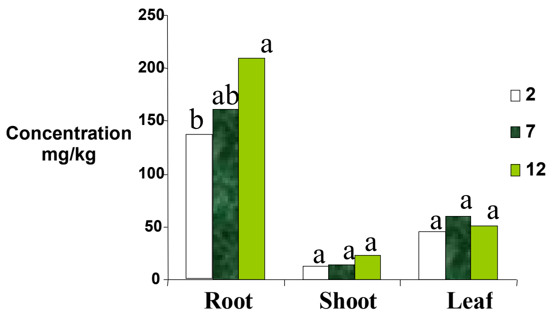

Figure 2: Ni concentration in root, stem and leaf of sunflower in different salinity
Columns with the same letters in every organ, there is no statistically significant difference at 5% level

The amount of Pb with regard to low mobility in plant was equal to zero in stem and leaf, but in root was absorbed low and its concentration increased with increase of salinity (Figure 3).

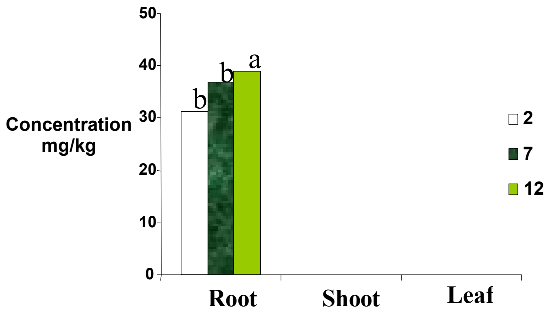

Figure 3: Pb concentration in root, stem and leaf of sunflower in different salinity
Columns with the same letters in every organ, there is no statistically significant difference at 5% level

Concentration of Cd , Pb and Ni in organs of Sudangrass in different salinity levels
Due to high mobility of Cd, this metal was absorbed by root, stem and leaf of sudangrass and by increasing salinity, concentration of that increased in plant organs (Figure 4).

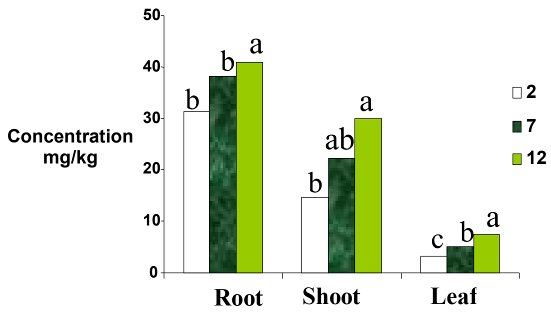

Figure 4: Cd concentration in root, stem and leaf of sudangrass in different salinity
Columns with the same letters in every organ, there is no statistically significant difference at 5% level

Ni metal was absorbed by root, stem and leaf organs. Its concentration in root was very high and in stem and leaf was very low. But by increasing salinity, its concentration increased in plant organs (Figure 5).

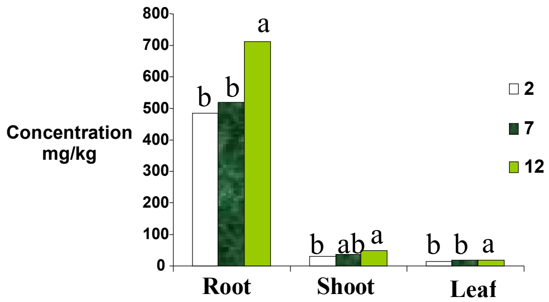

Figure 5: Ni concentration in root, stem and leaf of sudangrass in different salinity
Columns with the same letters in every organ, there is no statistically significant difference at 5% level

Regarding low mobility of Pb in plant, its concentration in stem and leaf was equal to zero, but in root it was absorbed very low and with increasing salinity, concentration of that increased in root (Figure 6).

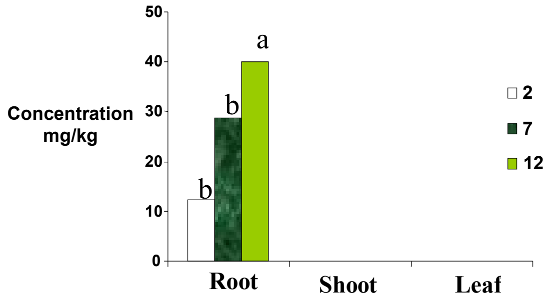

Figure 6: Pb concentration in root, stem and leaf of sudangrass in different salinity
Columns with the same letters in every organ, there is no statistically significant difference at 5% level

Comparison of Cd, pb and Ni metals concentration in organs of sudangrass and sunflower in different salinity levels
Concentration of Cd in root and stem of Sudangrass was higher than sunflower, because of its widespread root. But, Cd concentration in sunflower leaves was higher than sudangrass and there is statistically significant difference in stem and leaf of both plants (Figure 7). There are a lot of researches about Cd absorption and its transfer to above-ground organs and more researches showed that according to high mobility of Cd in soil and plant, high amounts transfer to above-ground organs. Plants like crops, bean, sunflower and leave-like vegetables can absorb Cd rapidly and accumulate its [15].

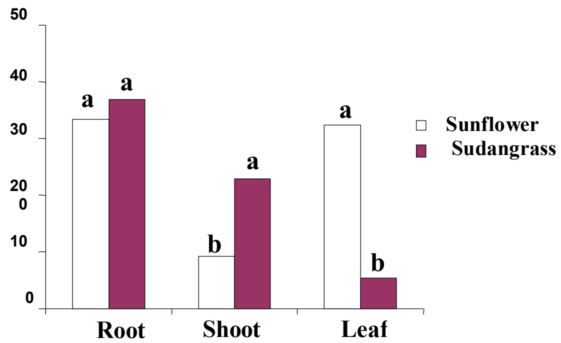

Figure 7: Comparison of absorbed Cadmium of two plant sunflowers and Sudan grass

Pb metal was absorbed in roots of both plants and its concentration in roots of both plants was same and there was no significant difference between two plants. But in stem and leaf, its amount was zero (Figure 8). Wilson et al [16] studied absorption of Pb by barely and showed that only 0.003 - 0.005 of Pb can absorb by plants and just 0.03 of its can transfer from root to above-ground organs. These statements were consistent with the results of this study.

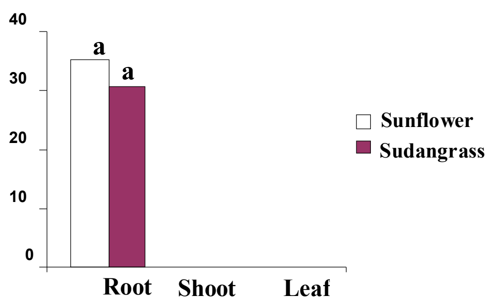

Figure 8: Comparison of absorbed lead of two plant sunflowers and Sudan grass

Ni metal was absorbed more in roots of both plants than to steam and leaf. Amount of Ni in root of sudangrass was higher than sunflower. This is because of dense and wide root of sudangrass (Figure9). Munns, [17] expressed that Sunflower and Sudangrass had differences in absorption and accumulation heavy metals that can be cause Physiologic and Morphology differences in their roots. Movahedian et al showed that capacity of plants is different in accumulate heavy metals and maize plant has higher capacity to accumulated Pb, but wheat has more ability in accumulating Cd and Ni.

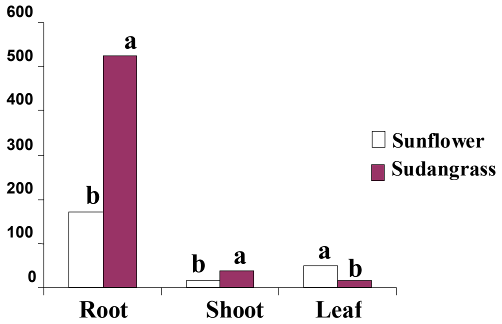

Figure 9: Comparison of absorbed Nickle of two plant sunflowers and Sudan grass

Transmission Coefficient of Cd , Pb and Ni

Transmission coefficient is the ratio of metal concentration in above-ground organ to concentration of that metal in soil. Cd transmission coefficient increased with increase salinity in soil in two plants. Comparison of both plants showed that the sunflower has higher transmission coefficient than Sudangrass. Regarding low mobility of Pb in soil and plants, absorption of this metal was low in above-ground organs of both plants. This amount was approximately zero, So this parameter was zero. By increasing salinity, Ni transmission coefficient increased of both plants But between two plants, Sunflower can transfer high Ni to above-ground organs and has higher transmitting coefficient than Sudangrass (Table 3**).**

Table 3: Different levels of salinity on the transfer coefficient of cadmium, lead and nickel in plants sunflower and Sudangrass

transfer coefficient Ni		transfer coefficient Pb		transfer coefficient Cd		(dS/m) EC
Sudangrass	**sunflower**	**Sudangrass**	**sunflower**	**Sudangrass**	**sunflower**	
0.069 b	0.0953 a	0	0	0.466 b	0.866 c	2
0.085 ab	0.115 ab	0	0	0.656 b	1.04 b	7
0.11 a	0.12 a	0	0	0.923 a	1.28 a	12

Number with the same letters in every column, there is no statistically significant difference at 5% level.

CONCLUSION

Results of plant and soil analysis showed that by increasing salinity, absorbable form of heavy metals (Cd, Pb and Ni) increased in soil, So with increasing salinity, concentration of absorbed Cd, Pb and Ni increased in all parts (root, stem, leaf) of Sunflower and Sudangrass. Comparison of two plant showed that concentration of Cd, Pb and Ni in root of Sudangrass was higher than sunflower, but its concentration in sunflower leaves was higher than sudangrass.

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