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Growth and biochemical contents of *Sesuvium portulacastrum* (L.) Induced by cadmium

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Abstract
The effect of increasing concentrations (10, 20, 30, 40 and 50 mg kg-1) of soil cadmium on growth and biochemical contents in *Sesuvium portulacastrum* (L.), plants were analysed on 30th, 60th, 90th, and 120th sampling days. Control plants were maintained separately. The inner surface of pots was lined with a polythene sheet. Each pot contained 3kg of air dried soil. Ten plant cuttings were planted in each pot. All pots were watered to field capacity daily. Plants were thinned to a maximum of six per pot, after a week of planting. Each treatment including the control was replicated five times. Cadmium at all levels (10, 30 and 50 mg kg-1) tested, decreased the growth parameters such as root and shoot length, and biochemical constituents such as, protein,(except, proline) and sugar contents in plants compared to untreated plants. The shoot length of cadmium treated *Sesuvium portulacastrum* (L.) plants was higher than the root length. When compared with proline content of root of *Sesuvium portulacastrum* (L.) plants was higher than shoot.

Keywords: cadmium, *sesuvium portulacastrum* (l.), growth, biochemical

Introduction

Heavy metals presence in the atmosphere, soil and water can cause serious problems to all organisms (Das, *et al*., 1997) [3]. Heavy metals bio-accumulation in plants can be highly dangerous (Sanita di Toppi, and Gabbrielli. 1999) [20], since plant is a member of the food chain and may create a risk for man and animals, through the contamination of their food supplies (Fargasova, 1994) [6]. Food chain contamination by heavy metals has become a burning issue in recent years because of their potential accumulation in biosystem through contaminated water, soil and air. Therefore, a better understanding of the sources, accumulation, and uptake of heavy metals and their effects on plant systems seem to be an important issue of present day research on risk assessments (Sharma *et al*., 2004; Lokeshwari and Chandrappa, 2006). Cadmium enters into the environment through weathering of rocks, forest fires and volcanic eruptions. It may be naturally present in air, water, soil and foodstuffs. Rapid industrialization has increased the natural limit of cadmium to a toxic level.

The present investigations extent of changes in growth parameters such as, root and shoot length, and biochemical constituents such as, proline, protein and total sugar contents in *Sesuvium portulacastrum* (L.) Plants due to cadmium toxicity.

Materials and Methods

The experimental plant, the *Sesuvium portulacastrum* L. belongs to the family Aizoaceae which is one of the important halophytic plants of India. Plant cuttings of *Sesuvium portulacastrum* used in the experiments were collected from T.S. Pettai village nearer to Pichavaram mangrove forest [11°43′N and 79°77′E] on the south east coast of Tamil Nadu, India. Plant cutting with each 5 cm length with uniform thickness were chosen for experimental purpose. The soil used in the experiment was red 40% + sandy loam 60% in nature and pH of the soils was 7.1. It contains major nutrients of 123kg available N, 89kg P and 109kg k/ha and micronutrients of 20.76mg available Cu, 245.89mg Fe, 168mg Mn and 20.56mg Zn/kg, cadmium was not available in this experimental soil. The cadmium chloride (Cd Cl_2 ½ H_2O) was used as cadmium source.

The pot culture experiments were conducted in Botanical Garden, Annamalai University. *Sesuvium portulacastrum* (L.) Plants were grown in pots containing untreated soil (Control) and soil mixed with various levels of cadmium (*viz*., 10, 20, 30, 40 and 50 mg kg-1). The inner surfaces of pots were lined with a polythene sheet. Each pot contained 3kg of air dried soil. Ten plant cuttings were planted in each pot. All pots were watered to field capacity daily. Plants were thinned to a maximum of six per pot, after a week of planting. Each treatment including the control was replicated five times. The plant samples were collected on 30th, 60th, 90th, and 120th days after sowing. Three plants from each replicates of pot was analysed for the various growth parameter such as root and shoot length, and dry weight of root and shoot and biochemical such as, protein, proline and sugar contents. Shoot as treated and control plants were used for the estimation of total sugar as per Singleton and Rossi (1965), proline as per Bates *et al*. (1973) (Root and shoot), and protein contents as per Lowry *et al*. (1951) methods.

Results and Discussion

Physio-chemical properties of the soil

The pot cultures experiments were conducted in Botaniocal Garden, Annamalai University. The soil condition was sandy loam in nature and pH, EC, organic carbon and available macro and micro nutrients are given in table -1.

Table 1: Physio-chemical properties of the experimental soil

Soil type	pH	EC	Moisture content	Organic carbon	Available(kg/h^{-1})			DTPA-TEA extractable (mg kg^{-1})				
					N	P	K	Cu	Fe	Mn	Zn	Cd
Red+Sandy loam	7.1	0.5	23.67	0.67	123	89	109	20.76	245.89	168	20.56	-

Growth

The effect of cadmium on growth parameters such as root and shoot length of Sesuvium portulacastrum (L.) plants are presented in figure- 1 and 2. All growth parameters of cadmium treated plants (10, 20, 30, 40 and 50 mg kg-1) gradually decreased when compared to untreated plants. The maximum root (9.50, 13.45, 17.06, 19.89 cm/plant) and shoot (16.45, 23.50, 29.90, 32.65cm/plant) length were recorded in control plants on 20th, 60th, 90th and 120th sampling days. The minimum value of all growth parameters were found in 50mg kg^{-1} of cadmium treated plants. Our results are in agreement with the findings of Juwarkar and Shende (1986) [11]; Yi and Ching (2003) [24]; Xu *et al*. (2008) [23]. also suggested that the higher concentrations of cadmium may inhibit root growth directly by inhibition of cell division or cell elongation or combination of both resulting in the limited exploitation of the soil volume for uptake and translocation of nutrients and water and induced mineral deficiency. Schutzendubel *et al*. (2001) who reported that the cadmium also induced the generation of reactive oxygen species (ROS) and affected various toxicities in the cells, resulting in inhibition of plant growth and severely suppressed root elongation. The morphological and structural effects caused by metal toxicity in plants was due to decrease in root elongation, root tip damage, decrease in formation, suppression of elongation, growth rate of cells, affecting the ultracellular structure of meristamatic cells and inhibition of the size of plant cells and inter cellular spaces were also observed by Hagemeyer and Breckle (2002) [7]. and Marcano *et al*., (2002).

Biochemical Estimations

Protein Content

Perusal of data in figure-3, 6, reveal that shoot of the plants raised in cadmium treated soils were poorer in protein and sugar contents as compared to control plants in on 30th, 60th, 90th and 120th sampling days. Higher the cadmium contents lesser the values. The above results were in agreement with the findings of Costa and Spitz (1997) [1] in *Lupinus albus*, Costa and Morel (1994) [2] in lettuce, Satyakala (1997) [21] in *Pistia stratiotes* and Dinakar *et al*. (2008) [5] in *Arachis hypogaea*. The decrease in protein and sugar content can be compared with the work of Dietz *et al*. (1999) [4] who suggested that the binding of heavy metals to sulphydryl groups in proteins, which leads to an inhibition of activity or a disruption of a structure, or the displacement of an essential element, or the production of free radicals and reactive oxygen species are the possible ways for heavy metals to disrupt normal physiological and biochemical functions of cells. Cadmium induced reduction of protein content may be due to leak or diffuse out of the plant material or possibly catabolic enzymes get induced and destroyed proteins as suggested by Jana (1987) [9]. The inhibitory action of cadmium on amino acid, total sugar and protein content may be due to binding of metals with sulphydryl group of protein, causing deleterious effect in the normal protein form (Manahan, 1990) [19].

Proline Content

The results showed in figure-4,5. Indicated that the minimum proline content of root and shoot of *Sesuvium portulacastrum* (L.) was occurred in control (Root, 2.23, 2.44, 3.40 and 2.88.. Shoot, 1.59, 2.26, 3.09 and2.34) plants. With further increase of cadmium level (10, 20, 30, 40 and 50 mg kg-1in soil), the proline content of *Sesuvium portulacastrum* (L.) was strongly increased 30th, 60th, 90th and 120th sampling days. Maximum proline content of root and shoot was observed at 50mg kg^{-1} cadmium level (Root, 3.56, 3.80, 4.67, 4.32 and Shoot, 3.35, 3.90, 4.44, 4.25) of soil. This can be compared with earlier reports of Dinakar *et al*. (2008) [5] in *Arachis hypogaea*, Mishra and Agrawal (2006) [16] in spinach. Sun *et al*. (2007) in Solanum nigrum and Hasan *et al*. (2008) [8] in chickpea. This investigation lends support to the findings of Schat *et al*. (1997) suggested that proline accumulation in plants under cadmium stress is due to the decrease of the plant water potential and the functional significance of this accumulation could be related to the water balance. It may be argued that proline accumulation helps to conserve nitrogenous compounds and protect the plant against heavy metal stress. These results also support the view that proline acts as a membrane stabilizing agent under stress conditions (Poschenrieder and Barcelo, 2004).

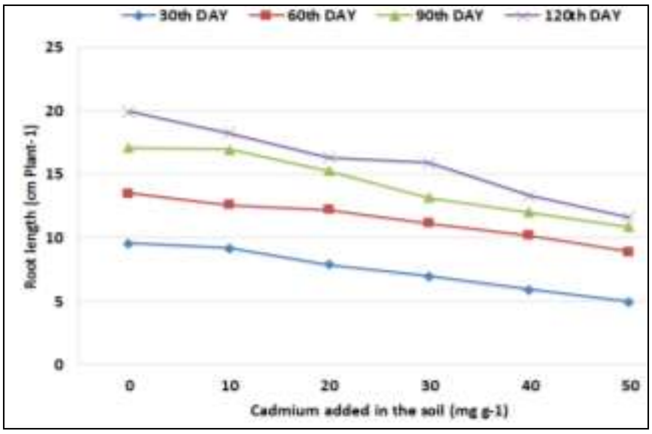

Fig 1: Effect of cadmium on root length (cm plant^{-1}) of *Sesuvium portulacastrum* L.

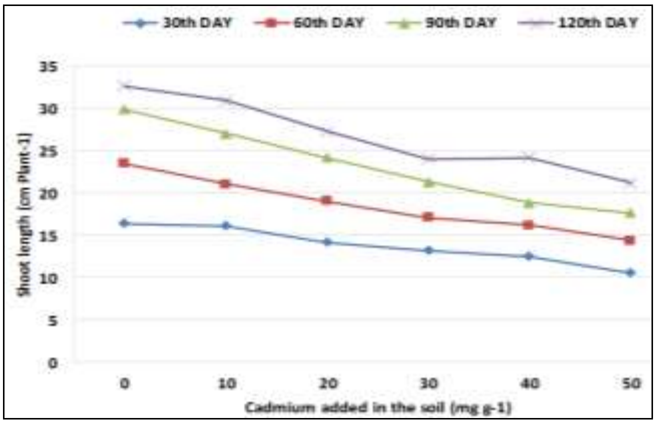

Fig 2: Effect of cadmium on shoot length (cm plant^{-1}) of *Sesuvium portulacastrum* L.

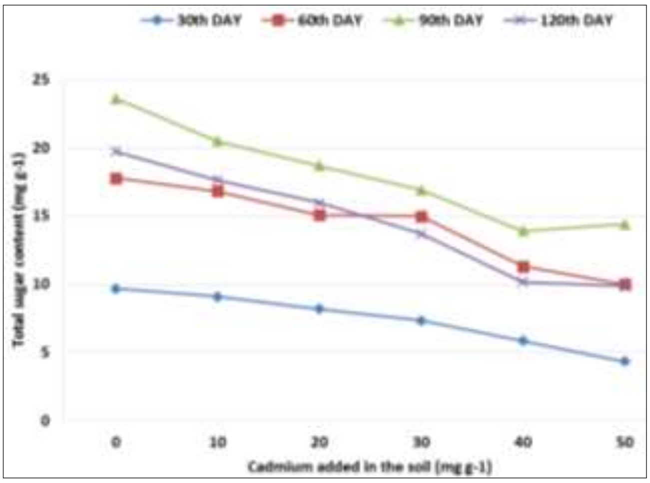

Fig 3: Effect of cadmium on Total sugar content of shoot of Sesuvium portulacastrum (L.) plants.

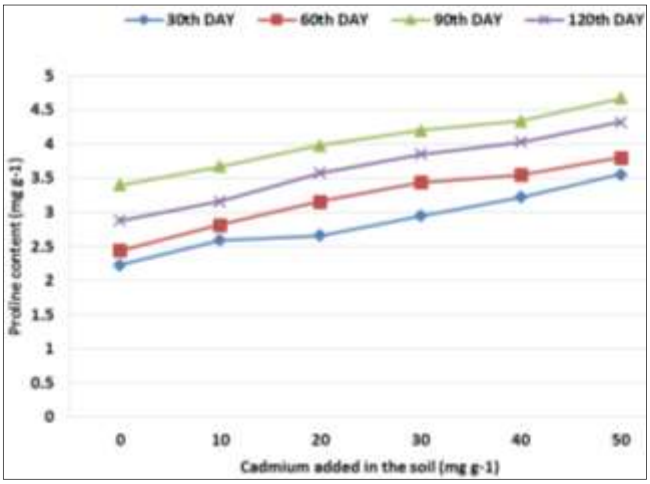

Fig 4: Effect of cadmium on proline content of Root of *Sesuvium portulacastrum* (L.) plants.

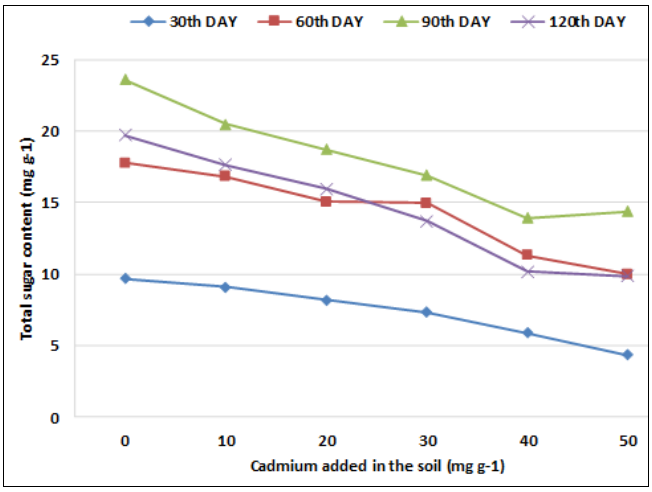

Fig 5: Effect of cadmium on proline content of shoot (mg g^{-1} fresh weight) of *Sesuvium portulacastrum* L.

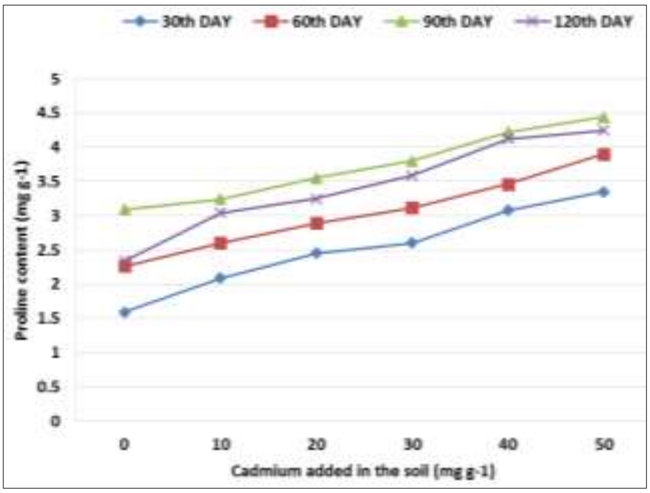

Fig 6: Effect of cadmium on protein content of shoot of Sesuvium portulacastrum (L.) plants

Table 1: Effect of cadmium on root length (cm $plant^{-1}$) of *Sesuvium portulacastrum* L.

Cadmium added in the soil (mg kg^{-1})	**Cadmium**			
	Sampling days			
	30	**60**	**90**	**120**
Control	9.50	13.45	17.06	19.89
10	9.11	12.56	16.92	18.20
20	7.82	12.15	15.23	16.27
30	6.90	11.10	13.10	15.85
40	5.86	10.12	11.98	13.25
50	4.90	8.84	10.80	11.60

Table 2: Effect of cadmium on shoot length (cm $plant^{-1}$) of *Sesuvium portulacastrum* L.

Cadmium added in the soil (mg kg^{-1})	**Cadmium**			
	Sampling days			
	30	**60**	**90**	**120**
Control	16.45	23.50	29.90	32.65
10	16.15	21.10	27.06	30.90
20	14.21	19.06	24.18	27.30
30	13.20	17.13	21.32	24.06
40	12.50	16.23	18.84	24.18
50	10.60	14.42	17.67	21.23

Table 3: Effect of cadmium on total sugar content (mg g^{-1} fresh weight) of *Sesuvium portulacastrum* L.

Cadmium added in the soil (mg kg^{-1})	**Cadmium**			
	Sampling days			
	30	**60**	**90**	**120**
Control	9.67	17.78	23.62	19.72
10	9.09	16.80	20.48	17.64
20	8.18	15.06	18.69	15.96
30	7.33	14.96	16.89	13.68
40	5.86	11.30	13.90	10.15
50	4.34	9.98	14.38	9.84

Table 4: Effect of cadmium on proline content of root (mg g^{-1} fresh weight) of *Sesuvium portulacastrum* L.

Cadmium added in the soil (mg kg^{-1})	Cadmium Sampling days			
	30	60	90	120
Control	2.23	2.44	3.40	2.88
10	2.59	2.82	3.67	3.16
20	2.66	3.16	3.98	3.58
30	2.95	3.44	4.20	3.85
40	3.22	3.55	4.34	4.03
50	3.56	3.80	4.67	4.32

Table 5: Effect of cadmium on proline content of shoot (mg g^{-1} fresh weight) of *Sesuvium portulacastrum* L.

Cadmium added in the soil (mg kg^{-1})	Cadmium Sampling days			
	30	60	90	120
Control	1.59	2.26	3.09	2.34
10	2.09	2.60	3.24	3.04
20	2.45	2.89	3.55	3.25
30	2.60	3.12	3.80	3.59
40	3.08	3.46	4.22	4.12
50	3.35	3.90	4.44	4.25

Table 6: Effect of cadmium on protein content (mg g^{-1} fresh weight) of *Sesuvium portulacastrum* L.

Cadmium added in the soil (mg kg^{-1})	Cadmium Sampling days			
	30	60	90	120
Control	12.16	14.67	17.89	14.56
10	9.80	11.36	14.61	11.78
20	8.52	10.32	12.99	10.28
30	7.76	9.10	10.96	9.16
40	6.72	8.10	10.19	08.67
50	5.67	6.90	09.60	07.45

Conclusion

The present investigation shows decrease in growth and protein and sugar constituent of Sesuvium portulacastrum (L.) Plants, when compared to control plants. The loss of these may be due to inhibition of displacement of an essential element, or the production of free radicals and reactive oxygen species are the possible ways for cadmium to disrupt normal physiological and biochemical functions of cells and cell division, increasing stomatal resistance or through such process as chlorophyll degradation, decrease of the plant water potential, poor translocations of sugar and other metabolites to the growing parts,. The proline contents increase may be due to the decrease of the plant water potential and the functional significance of this accumulation could be related to the water balance. So there was a consequents reduction in the growth of root shoot, protein, (increased the prolinel) content of *Sesuvium portulacastrum* (L.) Plants. The shoot length of cadmium treated *Sesuvium portulacastrum* (L.) Plants was higher than the root length. When compared with proline content of root of *Sesuvium portulacastrum* (L.) Plants was higher than the shoot.

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