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CADMIUM TOLERANCE BY AN AQUATIC FERN *SALVINIA MOLESTA* MITCHELL

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Tolerance to cadmium toxicity by the hydrophytic fern *Salvinia molesta* was tested with different concentrations of cadmium ranging from 0.5μM to 5.0μM for four weeks under natural conditions. Dry matter accumulation and chlorophyll contents increased gradually from first week to fourth week at 0.5μM concentration and decreased gradually from 1.0μM concentration onwards. On the otherhand, protein content was affected by cadmium from 2.5μM to 5.0μM concentration. At 0.1 uM and 1.0μM of cadmium caused increased levels of protein upto fourth week. Accumulation of cadmium enhanced to a levelof 58 n mol g^{-1} dry weight especially by submerged leaves. Higher levels of proline content was maintained under heavy metal stress. Therefore, the results of the present sduty indicate that this water fern is highly tolerant for cadmium pollution in water since it maintained higher levels of chlorophyll, proteins and proline contents.

Keywords : Cadmium; *Salvinia molesta*; Tolerance; Toxicity.

Introduction

Toxicity of cadmium is well documented in plants[1-3]. Cadmium abosrbed by the plants through roots and leaves[4] and depress the growth by affecting the photosynthesis and nutrient uptake[5]. Cadmium also effects the chlorophyll and protein synthesis[6]. Uptake and tolerance of cadmium in terrestrial plants has been extensively investigated, but information on aquatic macrophytes is scanty. *Salvinia molesta* an invasive water fern is considered as one of the worlds worst weed occurs in water of warm climates. Its high photosynthetic efficiency, rapid dry matter production and an explosive growth rate makes it an ideal fresh water macrophyte for investigating some of its physiological aspects under heavy metal stress. Therefore, the present study is aimed at understanding the effect of different concentrations of cadmium on chlorophyll, protein and proline accumulation as well as uptake of cadmium by *Salvinia molesta*.

Materials and Methods

Cadmium chloride ($CdCl_2$) solutions (0.5, 1.0, 2.5 and 5.0 μM) were prepared with tap water and 10 litres aliquots transferred to large plastic troughs. 50 nodel segments from adult plants of *Salvinia* were placed in each solution. The control plants were allowed to grow in tap water containing all minerals except cadmium. Each nodel segment consisted of 2 pairs of floating leaves and a pair of submerged leaves. Three replicates of each concentration were used. Cadmium uptake and other physiological parameters were carried out for four weeks at an interval of one week.

Dry weight of floating leaves and submerged leaves were determined separately for each concentration by weighing one gram of fresh material kept in oven at 85° C until constant dry weight was obtained. The total chlorophyll, protein and proline contents were measured[7-9]. The cadmium content was determined by using the method of Piper[10]. The plants were washed thoroughly in distilled water and the dry powder was kept overnight in triacid mixture (Perchloric acid; Sulphuric acid; Nitric acid in the ratio of 4:2:20) and heated at 180° C until clear solution was obtained then diluted with double distilled water for determination of cadmium content in Atomic Absorption Spectrophotometer (Perkin-Elmer Model 2380).

Results and Discussion

An increase in dry weight was observed in both floating and submerged leaves treated with 0.5 µM and 1.0 µM concentrations from first week to fourth week. The concentrations of 2.5 µM and 5.0 µM of cadmium causes drastic reduction of dry matter accumulation (Table 1).

Cadmium 0.5 µM concentration maintained higher level of chlorophyll over the control. At 1.0 µM concentration the level of chlorophyll content was almost constant neither decreased nor increased but other two concentrations enhanced the chlorophyll degradation upto 75% over the control with increasing time (Fig. 1).

Protein content was affected by 2.5 µM concentration of cadmium, which was most pronounced at 5.0 µM. The 0.5 µM and 1 µM cadmium treatment enhanced 18% and 10% of protein over the control respectively (Fig. 2).

Accumulation of cadmium was more in submerged leaves than floating leaves (Table 2). The absorption of cadmium was increased in both floating and sumberged leaves with time and concentration.

The proline content in *Salvinia* is directly related to the cadmium accumulation (Fig.3). However, higher level of proline content was observed at 5.0 µM concentration and the content of proline was increased with increasing concentrations of cadmium.

Different concentrations of cadmium reduced dry matter accumulation in *Salvinia*. At the lower concentrations the cadmium enhanced the dry matter production in *Salvinia*. Similar result was observed in *Pinus pinea* by Arduini *et al*[11]. Lower levels of cadmium enhanced the growth by increasing some enzyme activities or transpiration. Effect of cadmium on uptake of other ions like Ca^{2+}, Mg^{2+} and Fe^{2+} leads to the development of light green leaves that becomes progressively lighter with age and the growth was strongly reduced[12].

The result showed that the levels of chlorophyll was decreased at higher concentrations, the same result was observed in bean plant[13] and in *Hydrilla*[3]. Long time treatment of cadmium affects photosynthetic apparatus of the plants and led to decrease in the content of plastid pigments and net photosynthesis[14] by inhibiting of some steps of photosynthetic electron transport chain[15]. Cadmium acts on chlorophyll synthesis earlier than photosynthetic functions and induced decline in Mg^{2+} content which leads to the degradation of chlorophyll and increases the chlorophyllase activity in higher plants[12,16]. The chlorophyll content was

Table 1. The effect of different concentrations of cadmium on the changes in dry weight of floating leave (F.L.) and submerged leaves (S.L.) of *Salvinia molesta* (mg g^{-1} Fr. Wt.). Figures in the parentheses indicate percent increase or decrease over control. (Values are mean ± SE of 3 replications).

Cadmium Concentrations µ	I week		II week		III week		IV wiik	
	F.L.	S.L.	F.L.	S.L.	F.L.	S.L.	F.L.	S.L.
Control	102 ±1.4	129 ±1.9	113 ±2.0	135 ±1.9	136 ±0.9	157 ±1.2	153 ±2.5	220 ±1.9
0.5	112 ±1.2 (9.8)	136 ±2.5 (5.4)	125 ±1.9 (10.6)	138 ±2.0 (2.2)	143 ±1.9 (5.1)	159 ±1.8 (1.2)	171 ±2.0 (11.7)	230 ±3.0 (4.5)
1.0	130 ±3.1 (27.4)	138 ±2.5 (6.9)	127 ±1.0 (12.3)	140 ±1.0 (3.7)	124 ±2.1 (-8.8)	131 ±3.2 (-16.5)	120 ±4.0 (-21.5)	122 ±3.5 (-44.5)
2.5	128 ±2.9 (25.4)	132 ±1.8 (2.3)	120 ±1.29 (6.2)	130 ±3.0 (-3.7)	119 ±2.8 (-12.5)	120 ±3.1 (-23.5)	105 ±2.5 (-31.3)	110 ±1.2 (-5.0)
5.0	118 ±1.9 (15.6)	120 ±2.1 (-6.9)	110 ±1.8 (-2.6)	118 ±2.1 (-12.5)	85 ±0.9 (-37.5)	108 ±1.9 (-23.5)	65 ±0.9 (-57.5)	90 ±1.9 (-59.0)

Table 2. Uptake of cadmium by floating leaves (F.L) and submerged leaves (S.L.) of *Salvinia molesta* at different concentrations of $CdCL_2$ (n moles g^{-1} Dry wt.) (Values are mean ± SE of 3 replications).

Treatment of Cd^{2+} µM	I week		II week		III week		IV wiik	
	F.L.	S.L.	F.L.	S.L.	F.L.	S.L.	F.L.	S.L.
Control	-	-	-	-	-	-	-	-
0.5	10.64 ±0.16	20.3 ±0.8	13.76 ±1.10	23.12 ±0.97	16.72 ±1.19	28.16 ±1.55	19.12 ±0.56	32.32 ±1.18
1.0	12.08 ±0.90	23.92 ±1.10	14.96 ±1.51	28.00 ±0.88	20.32 ±0.78	33.32 ±0.94	27.16 ±1.62	37.76 ±2.01
2.5	12.56 ±1.00	27.04 ±1.50	18.4 ±1.2	35.6 ±1.7	27.52 ±1.21	43.12 ±0.71	34.72 ±0.96	50.32 ±1.75
5.0	18.24 ±0.89	38.32 ±0.95	27.2 ±0.7	42.56 ±0.99	37.12 ±0.98	50.32 ±1.59	42.56 ±0.89	58.16 ±0.92

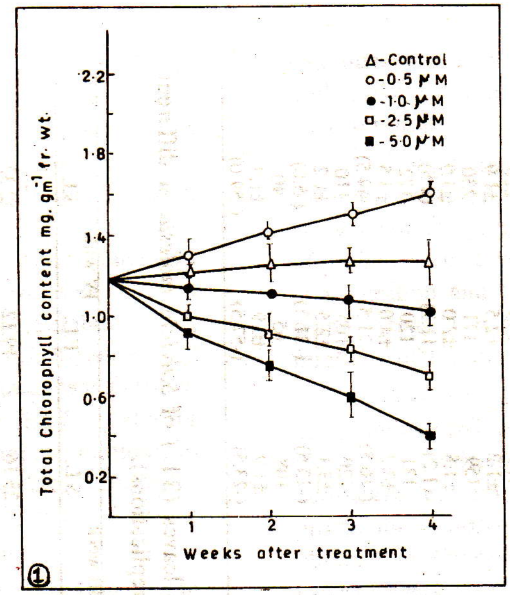

Fig. 1 Effect of cadmium on changes in total chlorophyll content of *Salvinia molestaa*. Each value represents the mean ± SE of 3 replications.

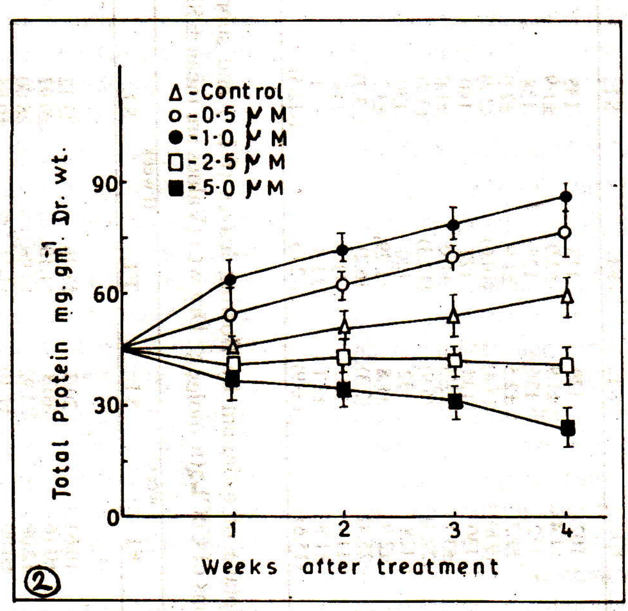

Fig. 2 Effect of cadmium on changes in total protein content of *Salvinia molesta*. Each value represents the mean ± SE of 3 replications.

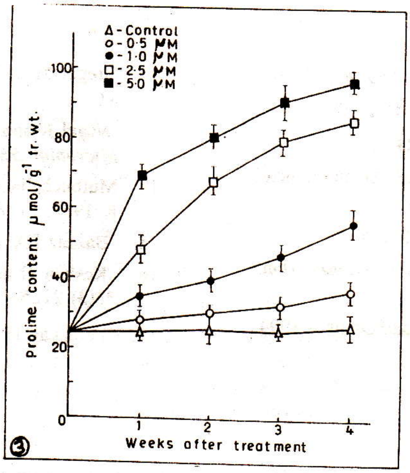

Fig. 3 Effect of cadmium on changes in proline content of *Salvinia molesta*.. Each value represents the mean ± SE of 3 replications.

increased at lower levels of cadmium (Fig.1) and similar result was found in cadmium treated pea and wheat seedlings[2] .

The data reveals that 2.5 and 5.0 μM cadmium concentrations caused degradation of protein. Bhattacharya and Choudhuri[3] observed similar result in *Hydrilla* with cadmium treatment. It is due to the activity of protease enhanced by the cadmium and the heavy metal stress induced early senscence through enhancement of catabolism of the key metabolite such as chlorophyll and protein.

Submerged leaves of *Salvinia molesta* accumulates more cadmium than the floating leaves. There was a rapid loss of turgidity in the cell and proline level increased significantly with increasing concentrations. Accumulation of inorganic ions in cytosol for balancing the concentrations, proline content increased[17]. Proline accumulation helps to conserve nitrogenous compounds and protect the plant against heavy metal stress[3].

In the conclusion of the present study shows that the 0.5 and 1.0 μM cadmium treatment caused marked stimulation in chlorophyll, protein and dry weight accumulation in plant. The *Salvinia molesta* therefore appears as bio-indicator for cadmium pollution and it can tolerate high level of cadmium concentration upto 5.0 μM over a long period. Moreover, the plant can tolerate the cadmium toxicity atleast in part, may be by maintaining higher levels of proline content. This tropical hydrophytic fern can eliminate the cadmium from polluted water and reduced the toxicity.

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