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Impact of Heavy Metal Cadmium on Leaf Physiology of Grass (Sedges)

Research Article

Pritesh Parmar, Ketankumar Panchal, Khushbu Raj, R.B. Subramanian*

B R D School of Biosciences, Sardar Patel University, VallbhVidya Nagar- (Gujarat), India

***Corresponding author:** RB Subramanian, B R D School of Biosciences, Sardar Patel University, Post Box no. 39, Vallbh Vidya Nagar- 388120 (Gujarat) India. Tel.:+91-2692-234402/234412, Fax: +91-2692-236475/237258, E-mail: asp.fus@gmail.com

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Abstract

Remediation of heavy metal is crucial which can be efficiently achieved by biological treatment compared to chemical and physico-chemical techniques. The best among the biological is application of plants for the uptake of heavy metals from contaminated sites though it has certain limitation but it is economical and environmental safe technique. In order to apply, it is critical to identify the hyperaccumulator plant amongst the population in terms of heavy metals uptake, the present study reconfirms the finding of the grass as a hyperaccumulator by anatomical changes pertaining the heavy metal stress. Anatomical changes can be applied to identify hyperaccumulator at preliminary stage but it needs to be confirmed by metal localization or metal uptake study.

Keywords: Sedges; Starch granules; Vascular bundle.

Introduction

The contamination of the environment by toxic metals poses a threat for "Man and Biosphere", dropping agricultural yield and detrimental to the health of ecosystem. Heavy metal pollution is a serious threat to both man and plants. Living organisms have developed a variety of mechanisms to counteract the toxic effects of heavy metal ions [1]. In order to maintain the concentration of essential metals within the physiological limits and to minimize the detrimental effect of nonessential metals, plants like all other organisms, comprise a composite system of homeostatic mechanisms that provide to manage the uptake, buildup, transport and detoxification of metals.

Uptake and accumulation of heavy metals at higher concentration can be cytotoxic in some plants species, causing structural and ultrastructural changes affecting the growth and physiological well being of the plants [2,3].

The phytotoxic effect of heavy metals in plants manifests itself through visual symptoms such as wilting and reduced augmentation and biomass accumulation [4,5]. Physiological changes have also been noted in plants exposed to contamination at various levels of the photosynthetic process, including the chlorophyll biosynthesis [6], the consequences of photochemical reaction [7] and the action of Calvin cycle enzymes [8].

In this study anatomy of the grass leaves in terms of starch content and vascular bundle was observed to check the consequences of the heavy metal cadmium stress in leaves which reconfirms that it is a hyperaccumulator.

Materials and Methods

Plant sample

Mature sedge (grass) which was reported as a hyperaccumulator by Parmar et al. [9], taken for the study of anatomical differentiation after two months of treatment with 100 mM cadmium nitrate.

Free hand sectioning

A new double edge razor blade was rinsed with warm tap water to remove traces of grease from the surface of the blade. The plant material was hold firmly for sectioning and razor blade flooded with tap water to minimize the friction was drowned at right angle to and fro across the top of the material. Several sections were cut at a time which varied in thickness. The thinnest sections (the more transparent ones) were selected and transfer sections on a glass slide using a brush.

For delicate and hard to hold specimens such as thin leaves and tiny roots, additional support such as potato slice was used to facilitate hand sectioning. Tissue pieces were inserted in between potato slice. Once the tissue was firmly in place, the hand section was taken as describe above.

Micro morphological changes (Vascular bundle)

Sections were placed on a clean glass slide and flooded with an aqueous solution of 0.2 % safranin solution for one minute. Stain was then removed by flooding the sections with tap water, washing with tape water was repeated number of times till there was no excess stain around the sections. A drop of clean water over the sections was applied and a cover glass was placed on it to mount the section under light microscope.

Starch content

A drop of IKI solution was positioned directly on the section and a cover glass was mounted and observed under the light microscope.

Results

Anatomical response

Vascular bundle: Observation of the safranin stained transverse sections of control and treated leaves after two months of heavy metals stress under light microscope showed significant changes in the number of the vascular bundles. The number of vascular bundles in the leaves of control plant ranged from 45-46 while in metal treated plants it was from 51-52. The width of vascular bundles also showed a change in size from 4-12 µm in control plant and 3-9 µm in treated plants as shown in Figure 1.

Starch content: Evaluation of starch content under heavy metal stress using IKI stain, revealed increase in the starch content in treated plant compared to the control plant as shown in Figure 2.

Discussion

Gomes et al. [10] observed that the number of tracheary elements in the vascular bundle was less in the plants exposed to high

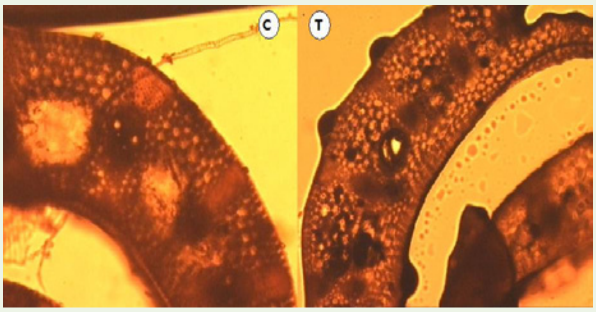

Figure 1: T.S. of leaf which shows increase in the number and decrease in the size of vascular bundles. C: control, T: Treated

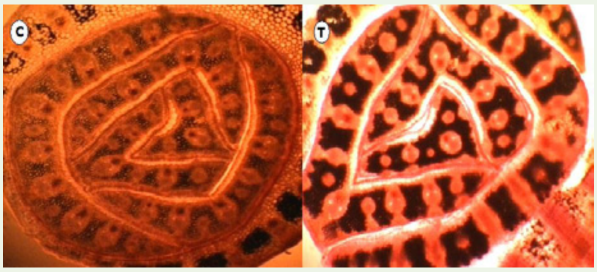

Figure 2: T.S of leaf which shows changes in the starch accumulation. C: Control T: Treated

concentrations of heavy metal. The area of metaxylem elements was smaller in the treatment by 15%. In the present investigation also a decrease in vessel size accompanied by an increase in the number of vascular bundles was observed in treated plants compared to the untreated plants. Reduction in the number of conducting elements has been reported in literature as being an adaptive measure to secure water flow [11]. Reduction in size and number of conducting elements of the xylem in response to heavy metals has been reported by Sandalio et al. [12].

Moya et al. [13] performed experiments on rice plants that were grown 5 or 10 days in a nutrient solution with Nickel (0.1 and 0.5 mM). Nickel reduced carbohydrate transport by inhibition of starch conversion into sucrose, and its translocation to the roots resulting into reduced carbohydrate supply for roots and in consequence depressed mitotic activity in root meristems. In the present study too, the starch content in the leaves of *Sedges* showed an increase in treated plant than in control. However, the above results are not in agreement with the findings of Espen et al. [14,15] who suggested that increased concentration of Nickel in radish seedlings strongly affected reactivation of oxygen uptake and increased the energy change, the transportation of sugar, phosphor-organic compounds, and inhibited the synthesis of DNA, RNA and protein of soluble and microsomal fractions.

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