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Mercury-tolerance of *Chloris barbata* Sw. and *Cyperus rotundus* L. isolated from contaminated sites

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Abstract

Chloris barbata Sw. and *Cyperus rotundus* L. from a mercury contaminated site near a chloralkali plant were tested for relative tolerance to Hg by root-elongation method. The above two species from the Hg-contaminated site exhibited high tolerance to Hg compared to the same species from a non-contaminated site. Tolerance to Hg was higher in *Chloris barbata* than in *Cyperus rotundus*.

Introduction

The phenomenon of adaptation or tolerance to metal pollution by organisms including plants is well known, the mechanism of which may be physiological or genetic (Klerks and Weis 1987). Individual organisms may have acquired a degree of tolerance by physiological acclimatization during exposure to sublethal concentration at some prior periods of their lives. Populations may also have evolved genetic tolerance through the action of natural selection. Invariably, pollution stress generates new selection pressure that may not only decrease species diversity (Martin and Caughtrey 1981) but also induce additional adaptive genetic changes in the organisms of a population that alone survive in a polluted environment. Tolerance to metals, particularly to mercury, has been reported for bacteria (Nakamura *et al.* 1986) and gastropods (Baker *et al.* 1985). Tolerance by plant populations to metals *e.g.* cadmium, copper, lead and zinc has been well documented (Antonovics *et al.* 1971, Baker 1987). Tolerance to Hg by higher plants is however less known (Chaney and Strickland 1984, Godbold and Huttermann 1985). In a recent biomonitoring study undertaken at a Hg polluted locality near a chloralkali plant at Ganjam, India, two grasses namely, *Chloris barbata* Sw. and *Cynodon dactylon* (L.) Pers. and a sedge, *Cyperus rotundus* L. have been found growing at abandoned solid-waste dump sites that contained Hg level as high as 557 mg (kg^{-1})soil (Lenka *et al.* 1992). In the present paper clones of two plant species *C. barbata* and *C. rotundus* were

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tested to assess their relative tolerance to Hg as compared to the same plants from a non-contaminated site.

Materials and methods

Plants of *Chloris barbata* Sw. and *Cyperus rotundus* L. from a Hg-contaminated site near a chloralkali plant at Ganjam, Orissa, India as well as from a non-contaminated site at Berhampur University campus were brought to laboratory for testing of tolerance to Hg. The Hg concentration in soil at the contaminated site ranges between 200 and 600 mg kg^{-1}, whereas that for the non-contaminated site was less than 1 mg kg^{-1}. Hg-tolerance was estimated by the root elongation method (Wilkins 1978). 20 tillers of uniform size from either plant species from Hg-contaminated and non-contaminated sites were trimed off roots from the lowest node, washed in running tap water and then allowed to sprout fresh roots in water for 2 d under Hg concentrations 0, 1, 50, 100 and 500 μg l^{-1} made by adding appropriate volumes of stock solution of mercuric chloride (*BDH*, Bombay) into a 50 ml of calcium nitrate solution at concentration 1 g l^{-1} and pH 5.5. All the experiments were conducted under continuous cool fluorescent light and at a temperature of 24 ± 1 °C for a period of 5 d. The treatment as well as control solutions were replaced with fresh solutions every day. The length of the longest root (first root) from each tiller was measured both at the beginning (day 0) as well as at the end (day 5) of the experiment. The relative root elongation (R) for each treatment was determined by subtracting the length of the root on day 0 from that of day 5. Tolerance index (TI) for the tested plants was calculated using the formula:

$$\text{TI } [\%] = \frac{\text{mean R in solution with Hg}}{\text{mean R in solution without Hg}} \times 100$$

Students' *t*-test was used to test significance.

Results and discussion

Root growth diminished with an increase of Hg-concentration irrespective of either plant species or site (Fig. 1). Inhibition of root growth for non-contaminated plants were comparatively more pronounced, significant at $P \leq 0.01$ or $P \leq 0.05$ at all the concentrations of Hg tested. The inhibition of root growth for plants of *C. barbata* from the Hg-contaminated site though apparent was found to be significant ($P \leq 0.01$) only at 500 μg l^{-1}. The lowest Hg-concentration 1 μg l^{-1} induced increased root growth in plants of *C. rotundus* from the Hg-contaminated site, resulting in a TI > 100. The concentration of Hg that significantly inhibited root growth for plants of *C. barbata* from Hg-contaminated site was 500 μg l^{-1}, whereas that for *C. rotundus* from the contaminated site was 100 μg l^{-1}, indicating the former to be relatively more

tolerant to Hg (Fig. 1). Based on TI values calculated for Hg-contaminated and non-contaminated plants, those from the Hg-contaminated site were more tolerant to Hg.

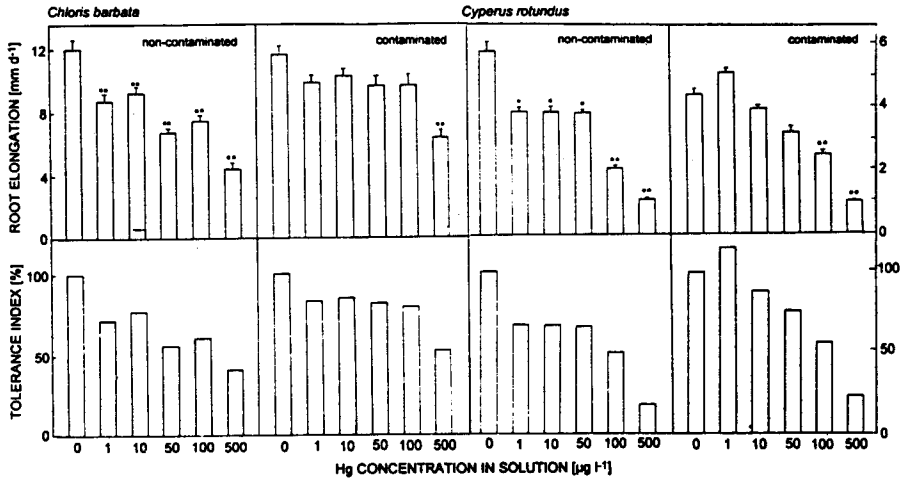

Fig. 1. Root elongation and tolerance index (TI) of plants of *C. barbata* and *C. rotundus* from non-contaminated and Hg-contaminated sites determined for a range of concentrations of $HgCl_2$.

The root elongation method developed by Wilkins (1978) to quantify the inhibitory effect of metal ions on root growth, has been used widely in ecological studies for testing of tolerance of plants to metals. The method is simple, rapid and easy to perform, thus far outweighing its limitations (Baker and Walker 1989). TI derived from ratios between data for treatment and control solutions have been useful to characterize individual populations for metal tolerance. The plants of *C. barbata* and *C. rotundus* from non-contaminated and Hg-contaminated sites may be considered as sensitive and tolerant to Hg pollution, respectively (Fig. 1). Analysis of Hg in root and shoot in relation to soil with respect to the plants of *C. barbata* and *C. rotundus* at Hg-contaminated site indicated that *C. barbata* was relatively more efficient in avoiding or restricting Hg uptake from soil than *C. rotundus* (Lenka *et al.* 1992). The present observation therefore lends further evidence in support of our contention that of the two species from the Hg-contaminated site *C. barbata* is more tolerant to Hg than *C. rotundus*. Furthermore, the observed stimulation to root growth in tolerant plants of *C. rotundus* particularly by the Hg concentration at 1 µg l^{-1} in the present study is not surprising for such a response has been reported for a number of metal-tolerant plants with TIs even higher than 100 % (Antonovics *et al.* 1971, Baker 1987). It may, however, be kept in mind that since the ability of plants to evolve metal tolerance is species-specific (Gartside and McNeilly 1974), the present findings cannot be extrapolated to other plant species growing at the contaminated site unless tested specifically. Several mechanisms of heavy metal tolerance in plants have been proposed which include *a*) production of intracellular metal binding compounds, *b*) alteration of metal compartmentation patterns,

c) alteration of cellular metabolism and *d*) alteration of membrane structure (Verkleij and Schat 1990). Hg is the third member of the group IIb triad of the periodic table of elements along with zinc and cadmium. Whereas a vacuolar compartmentalization mechanism has been suggested for Zn-tolerance in certain plants (Davis *et al.* 1991), the mechanism of Cd-tolerance has been attributed to induction of metal binding phytochelatins (Steffens 1990). Either one of the above mechanisms or both might be responsible for the presently reported Hg-tolerance in *C. barbata* and *C. rotundus* which however remain obscured at this moment warranting further investigation.

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