

Ulva compressa from copper-polluted sites exhibits intracellular copper accumulation, increased expression of metallothioneins and copper-containing nanoparticles in chloroplasts

- Espinoza D.^a
- González A.^a
- Pizarro J.^b
- Segura R.^b
- Laporte D.^c
- Rodríguez-Rojas F.^d
- Sáez C.A.^{d, e}
- Moenne A.^a

Abstract

In order to analyze the mechanisms involved in copper accumulation in *Ulva compressa*, algae were collected at control sites of central and northern Chile, and at two copper-polluted sites of northern Chile. The level of intracellular copper, reduced glutathione (GSH), phytochelatins (PCs), PC2 and PC4, and transcripts encoding metallothioneins (MTs) of *U. compressa*, UcMT1, UcMT2 and UcMT3, were determined. Algae of control sites contained around 20 µg of copper g⁻¹ of dry tissue (DT) whereas algae of copper-polluted sites contained 260 and 272 µg of copper g⁻¹ of DT. Algae of control sites and copper-polluted sites did not show detectable amounts of GSH, the level of PC2 did not change among sites whereas PC4 was increased in one of the copper-polluted sites. The level of transcripts of UcMT1 and UcMT2 were increased in algae of copper-polluted sites, but the level of UcMT3 did not change. Algae of a control site and a copper-polluted site were visualized by transmission electron microscopy (TEM) and the existence of copper in electron-dense particles was analyzed using energy dispersive x-ray spectroscopy (EDXS). Algae of copper-polluted sites showed electron-dense nanoparticles containing copper in the chloroplasts, whereas algae of control sites did not. Algae of a control site, Cachagua, were cultivated without copper (control) and with 10 µM copper for 5 days and they were analyzed by TEM-EDXS. Algae cultivated with copper showed copper-containing nanoparticles in the chloroplast whereas control algae did not. Thus, *U. compressa* from copper-polluted sites exhibits intracellular copper accumulation, an increase in the level of PC4 and expression of UcMTs, and the accumulation of copper-containing particles in chloroplasts. © 2021 by the authors. Licensee MDPI, Basel, Switzerland.

Author keywords

Copper; Glutathione; Marine alga; Metallothionein; Phytochelatins; *Ulva compressa*