

Zinc Modulates Reactive Oxygen Species and Protects the Structural Integrity of DNA in Cadmium-Exposed *Ceratophyllum demersum* L., a Free Floating Aquatic Macrophyte

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INTRODUCTION

Free radical reactions through various mechanisms involving electron transfer have often been implicated in heavy metal toxicity to a biological system. Zinc is an essential micronutrient while Cd is non-essential for plants. Published reports indicate that Zn can antagonise and alleviate Cd-induced stress (Aravind and Prasad 2003, 2004; Cakmak 2000; Koleli et al. 2004). Here, evidence for Zn protection of DNA integrity from Cd-induced reactive oxygen species in *Ceratophyllum demersum* L. is presented.

METHODS

Ceratophyllum demersum L. is subjected to various treatments: 10 μM Cd, and 10 μM Cd treatments supplemented with Zn (10, 50, 100 and 200 μM).

RESULTS AND DISCUSSION

The results are presented in the following figures: NADPH dependent superoxide ($\text{O}_2^{\cdot-}$) generation in Fig. 1., cellular levels of superoxide ($\text{O}_2^{\cdot-}$) radicals and measurement of hydrogen peroxide (H_2O_2) in Fig. 2, electron spin resonance spectra of hydroxyl (OH^{\cdot}) radicals and measurement of hydroxyl (OH^{\cdot}) radical levels in Fig. 3 and 4, total protein and carbonyl content as a measure of protein oxidation in Fig. 5, and analysis of the structural integrity of DNA and measurement of DNA damage by ethidium bromide (EB) binding assay and gel mobility of DNA in Fig. 6.

According to the presented results, it is more likely that Zn-induced structural protection of DNA is a consequence of the elimination of Cd-induced free radical species.

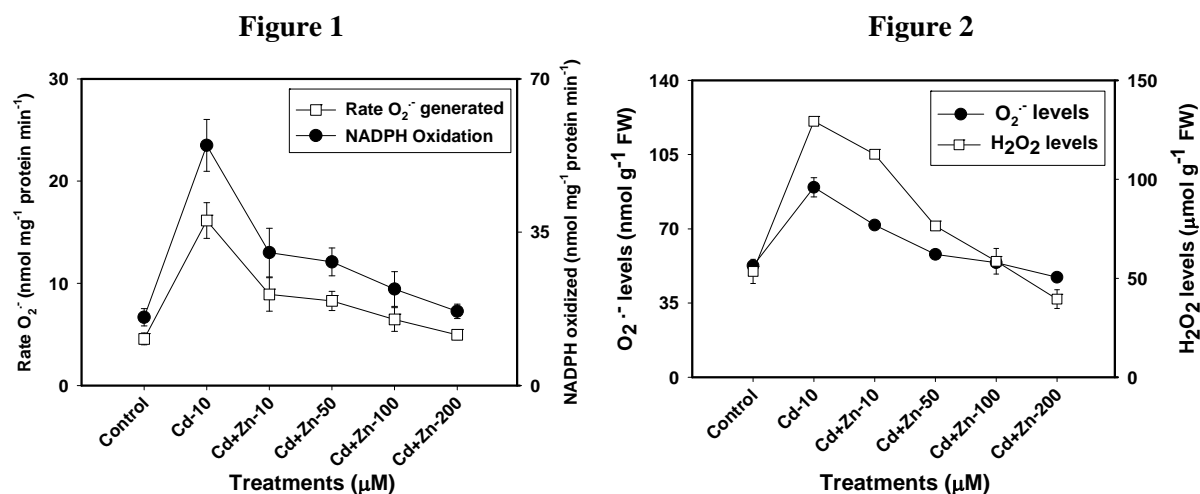


Fig. 1. NADPH dependent superoxide generation and rate of NADPH oxidation.

Fig. 2. Superoxide radical levels and levels of hydrogen peroxide. Error bars represent standard errors for all figures.

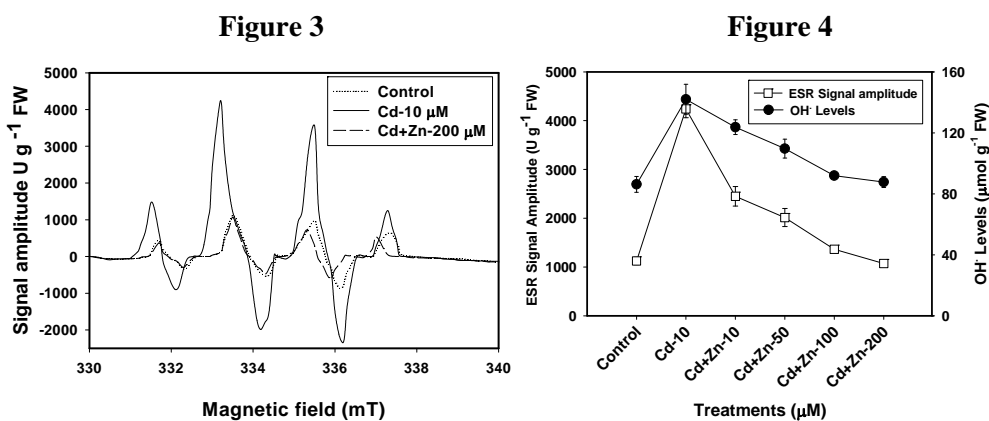


Fig. 3. Electron spin resonance spectra showing the typical 1:2:2:1 quartet of the DMPO-OH adduct in control as well as treated plants.

Fig. 4. ESR signal amplitude changes recorded for DMPO-OH adducts and hydroxyl radical levels.

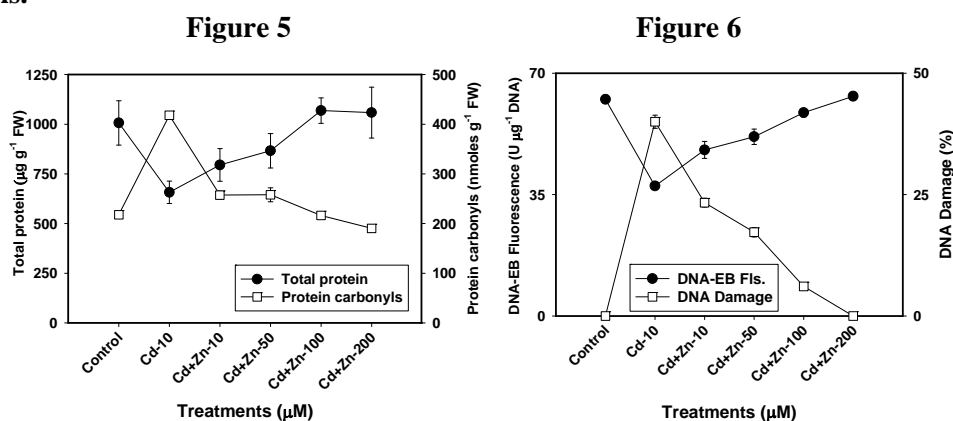


Fig. 5. Total protein and protein carbonyls content.

Fig. 6. Ethidium bromide-DNA fluorescence as a measure of DNA damage.

CONCLUSIONS

The presented results suggest the *in vitro* antioxidant action of Zn and the *in vivo* association of oxidative stress with Zn deficiency. The Zn-Cd interactions in crops under different soil conditions including Zn-deficient and Cd-rich conditions need attention for research.

REFERENCES

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