# Cadmium and Plants

<table>
<thead>
<tr>
<th>Title</th>
<th>Cadmium Toxicity in Plants and Role of Mineral Nutrients in Its Alleviation</th>
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<tbody>
<tr>
<td>Author Name</td>
<td>Rahat Nazar, Noushina Iqbal, Asim Masood, M. Iqbal R. Khan, Shabina Syeed, Nafees A. Khan</td>
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<tr>
<td>Journal Name</td>
<td>American Journal of Plant Sciences</td>
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<tr>
<td>Year</td>
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<tr>
<td>Volume and Issue</td>
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<tr>
<td>Pages</td>
<td>1476-1489</td>
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<tr>
<td>Abstracts</td>
<td>Cadmium (Cd) is a toxic heavy metal that enters the environment through various anthropogenic sources, and inhibits plant growth and development. Cadmium toxicity may result from disturbance in plant metabolism as a consequence of disturbance in the uptake and translocation of mineral nutrients. Plant nutrients and Cd compete for the same transport-ers and, therefore, presence of Cd results in mineral nutrients deficiency. The optimization of mineral nutrients under Cd stress could reduce Cd toxicity by greater availability at the transport site resulting in reduced accumulation of Cd, and could also alleviate Cd-induced toxic effects by enhancing biochemical reactions and physiological processes in plants. In the present review the role of plant macro, micro and beneficial elements in alleviating Cd stress in crop plants is discussed.</td>
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<tr>
<td>Keywords</td>
<td>Antioxidant Enzymes; Cadmium Toxicity; Mineral Nutrition; Oxidative Stress</td>
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<tr>
<th>Title</th>
<th>Unravelling cadmium toxicity and tolerance in plants: Insight into regulatory mechanisms</th>
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<tr>
<td>Author Name</td>
<td>Susana M. Gallego, Liliana B. Penaa,b, Roberto A. Barciaa, Claudia E. Azpilicueta, Maria F. Iannonea, Eliana P. Rosalesa, Myriam S. Zawoznika, Maria D. Groppa, Maria P. Benavides</td>
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<tr>
<td>Journal Name</td>
<td>Environmental and experimental botany</td>
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<tr>
<td>Year</td>
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</tr>
<tr>
<td>Pages</td>
<td>33–46</td>
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<tr>
<td>Abstracts</td>
<td>The occurrence of heavy metals in soils may be beneficial or toxic to the environment. The biota may require some of these elements considered essentials (like Fe, Zn, Cu or Mo) in trace quantities, but at higher concentrations they may be poisonous. Due to the difficulty in controlling environmental metal accumulation, organisms have to cope with exposure to unwanted chemical elements, specially those considered biologically nonessential. Cadmium (Cd) belongs to this latter group. The effect of Cd toxicity on plants has been largely explored regarding inhibition of growth processes and decrease of photosynthetic apparatus activity. This article reviews current knowledge of uptake, transport and accumulation of Cd in plants and gives an overview of Cd-detoxification mechanisms, Cd-induced oxidative damage and antioxidant defenses in plants. It also presents a picture of the role of reactive oxygen and nitrogen species in Cd toxicity; signalling and gene</td>
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regulation are topics critically discussed.

**Keywords** Cadmium; Heavy metals; Oxidative stress; Metal toxicity; Signalling; Gene regulation

<table>
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<tr>
<th>Title</th>
<th>Interactions of zinc and cadmium toxicity in their effects on growth and in antioxidative systems in tomato plants (Solarium lycopersicum)</th>
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<tr>
<td>Author Name</td>
<td>Jaouhra Cherif, Chamseddine Mediouni, Wided Ben Ammar, Fatma Jemal</td>
</tr>
<tr>
<td>Journal Name</td>
<td>Journal of Environmental science</td>
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<tr>
<td>Year</td>
<td>2011</td>
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<td>Volume and Issue</td>
<td>23, 5</td>
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<tr>
<td>Pages</td>
<td>837 - 844</td>
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<tr>
<td>Abstracts</td>
<td>The interaction between zinc and cadmium was investigated in tomato plants (Solarium lycopersicum). Ten-day-old seedlings were treated with 10 μmol/L CdCl2 associated to different concentrations of ZnCl2 (10, 50, 100, and 150 μmol/L). Zn supply clearly reduced Cd accumulation in leaves and simultaneously increased Zn concentration. Cd induced oxidative stress in leaves as indicated by an increase in thiobarbituric acid-reactive substances (TBARS) level and chlorophyll breakdown. Furthermore, compared with control, Cd-treated plants had significantly higher activities of Superoxide dismutase (SOD, EC 1.15.1.1), whereas, catalase (CAT, EC 1.11.1.6), ascorbate peroxidase (APX, EC 1.11.1.11), and glutathione reductase (GR, EC 1.6.4.2) activities were significantly suppressed by Cd addition. Zn supplementation, at low level, restored and enhanced the functional activity of these enzymes (SOD, CAT, APX and GR) as compared to Cd-alone-treated plants. The beneficial effect of adequate Zn level on Cd toxicity was confirmed by a significant decrease in TBARS level and restoration of chlorophyll content. However, when Zn was added at high level in combination with Cd there was an accumulation of oxidative stress, which was higher than that for Cd or excess Zn alone treatments. These results suggested that higher Zn concentrations and Cd are synergistic in their effect on plant growth parameters and oxidative stress.</td>
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<tr>
<td>Keywords</td>
<td>Solarium lycopersicum; cadmium; zinc; oxidative stress; antagonism; synergism</td>
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<tr>
<th>Title</th>
<th>Oxidative post translational modifications of proteins related to cell cycle are involved in cadmium toxicity in wheat seedlings</th>
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<tr>
<td>Author Name</td>
<td>Liliana B. Pena, Roberto A. Barcia, Claudia E. Azpilicueta, Andrea A.E. Méndez, Susana M. Gallego</td>
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<tr>
<td>Journal Name</td>
<td>Plant Science</td>
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<td>Year</td>
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<tr>
<td>Pages</td>
<td>1 - 7</td>
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<tr>
<td>Abstracts</td>
<td>Abiotic stress is greatly associated with plant growth inhibition and redox cell imbalance. In the present work, we have investigated in which way oxidative posttranslational modifications (PTM) of proteins related to cell cycle may be implicated in post-germinative root growth reduction caused by cadmium, by methyl viologen (MV) and by</td>
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hydrogen peroxide (H2O2) in wheat seedlings. Although cadmium is considered a redox inactive metal, reactive oxygen species were detected in the apex root of metal-treated seedlings. Oxidative stress hastened cells displacement from the cell division zone to elongation/differentiation zone, resulting in a shortened meristem. The number of cells in the proliferation zone was lower after MV, H2O2 and 10 μM Cd2+ treatments compared to control. All treatments increased protein carbonylation. Although no modification in total Ub-conjugated proteins was detected, oxidative treatments reduced cyclin D and CDKA protein ubiquitination, concomitantly with a decrease in expression of cyclin D/CDKA/Rb/E2F-regulated genes.

**Keywords**
Cadmium; Cell cycle; Oxidative stress; Triticum aestivum; Root growth inhibition

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<tr>
<th>Title</th>
<th>Polynuclear aromatic hydrocarbons (PAHs) mediate cadmium toxicity to an emergent wetland species</th>
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<tr>
<td>Author Name</td>
<td>Zhenhua Zhang, Zed Rengel, Kathy Meney, Ljiljana Pantelic, Radmila Tomanovic</td>
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<tr>
<td>Journal Name</td>
<td>Journal of Hazardous Materials</td>
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<tr>
<td>Year</td>
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<td>Volume and Issue</td>
<td>189, 1-2</td>
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<tr>
<td>Pages</td>
<td>119 - 126</td>
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**Abstracts**
Growth and pollutant removal by emergent wetland plants may be influenced by interactions among mixed pollutants in constructed wetlands. A glasshouse experiment was conducted to investigate interactive effects of cadmium (Cd) × polynuclear aromatic hydrocarbons (PAHs) × plant treatments on growth of Juncus subsecundus, Cd and PAH removal from soil and the total number of microorganisms in soil. Growth and biomass of J. subsecundus were significantly influenced by interaction of Cd and PAHs, significantly decreasing with either Cd or PAH additions, but with the effect of Cd on plant growth being stronger than that of PAHs. The mixture of low Cd and low PAH lessened Cd toxicity to plants, resulting in improved plant growth and increased Cd accumulation in plant tissues, thus enhancing Cd removal by plants. The dissipation of PAHs in soils was significantly influenced by interactions of Cd, PAH and plant presence or absence. The total number of microorganisms in soils was significantly increased by the PAH additions. The interactive effect of Cd and PAHs on plant growth may be linked to the changes in the abundance of microorganisms in the rhizosphere, probably via a positive effect of PAH metabolites and/or phytohormones produced by microorganisms on plant growth.

**Keywords**
Co-contamination, Constructed wetland, Juncus subsecundus, Metal, Organic pollutant, Polynuclear aromatic hydrocarbons