Fourth Article: (with another inside and outside the specialization -Published).

Article title	Integrative application of licorice root extract and melatonin improves faba bean growth and production in Cd-contaminated saline soil.
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Article status	Sharing with another inside and outside the specialization- Published in an international specialized journal
The Journal	BMC Plant Biology, 25, 1–18
Impact factor	4.3

Abstract

Globally, salinity poses a threat to crop productivity by hindering plant growth and development via osmotic stress and ionic cytotoxicity. Plant extracts have lately been employed as exogenous adjuvants to improve endogenous plant defense mechanisms when grown under various environmental stresses, such as salinity. This study investigated the potential of melatonin (Mt; 0, 50, and 100 mM) as an antioxidant and licorice root extract (LRE; 0.0 and 3%) as an organic biostimulant applied sequentially as a foliar spray on faba bean (*Vicia faba* L.) grown in cadmium (Cd)-contaminated saline soil conditions [Cd=4.71 (mg kg^{-1} soil) and ECe=7.84 (dS m^{-1})]. Plants not receive any treatment and sprayed with H_2O were considered controls. The experimental treatments were laid out in strip plot in a randomized complete block design replicated thrice, where the LRE and Mt were considered as vertical and horizontal strips, respectively. Growth characteristics, photosynthetic pigments, nutrient uptake, physiology and metabolic responses, anatomical features, and yield were assessed. Cadmium (Cd) and salinity-induced stress significantly altered leaf integrity, photosynthetic efficiency, total soluble sugars (TSS), free proline (FPro), total phenolic, DPPH, and total soluble proteins (TSP), non-enzymatic and enzymatic antioxidants, growth characteristics and yield-related traits. However, the application of LRE+Mt considerably improved these negative effects, with higher improvements were observed due to application of LRE+Mt_{100}. Application of LRE+Mt significantly reduced hydrogen peroxide (H_2O_2) accumulation, lipid peroxidation and Cd content in leaves and seeds, all of which had increased due to Cd stress. Application of LRE+Mt significantly mitigated the Cd-induced oxidative damage by increasing the activity of reactive oxygen species (ROS) scavenging enzymes such as superoxide dismutase, catalase, ascorbate peroxidase, and glutathione reductase, in parallel with enhanced ascorbate and reducing glutathione content. Exogenous application of LRE+Mt significantly increased osmolyte content, including FPro, TSS, and total phenols and mitigated Cd-induced reduction to considerable levels. Our findings showed that LRE+Mt increased *V.* faba plants' morphological, physiological, and biochemical properties, reducing Cd stress toxicity, and promoting sustainable agricultural practices.