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Biochemical Responses of Date Palm *Phoenix dactylifera* L. to Combined Stress of Salinity and Nickel

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Abstract: This study examined the effects of nickel (Ni) at 0, 25, and 50 mg.L^{-1} concentrations, applied alone or in combination with salinity (represented by NaCl at 0, 100, and 200 mM concentrations), on the biochemical traits of date palm. Hydrogen peroxide (H_2O_2), malondialdehyde (MDA), membrane stability index (MSI), peroxidase (POD) activity, superoxide dismutase (SOD), and proline content were among the parameters evaluated. The results revealed significant effects of nickel and salinity on the studied biochemical markers. Nickel at 50 mg.L^{-1} significantly increased H_2O_2 (0.87 µmol. L^{-1}) and MDA (2.46 nmol.g^{-1}) levels, while decreasing MSI (75.85%). Moreover, it enhanced POD (25.09 U.min^{-1}.g^{-1}) and SOD (3.78 U. min^{-1}.g^{-1}) activity, as well as proline content (4.35 µmol.g^{-1}). Salinity at 200 mM significantly increased H_2O_2 (0.90 µmol L^{-1}) and MDA (2.54 nmol.g^{-1}) levels, decreased MSI (77.69%), and increased POD (27.61 U. min^{-1}.g^{-1}) and SOD (3.77 U.min^{-1}.g^{-1}) activity, along with increased proline content (4.54 µmol.g^{-1}). Additionally, the combined application of nickel and salinity, particularly at higher concentrations, resulted in significantly increased biochemical responses compared to individual treatments. The findings highlight the interactive effects of nickel and salinity on the oxidative and antioxidant mechanisms in date palm plants. This study contributes to our understanding of plant responses to abiotic stressors and provides insights for optimizing date palm cultivation under challenging environmental conditions.

Keywords: Antioxidants, hydrogen peroxide, Malondialdehyde, Membrane stability index, Peroxidase, Proline, Superoxide dismutase.

Introduction

Date palm (*Phoenix dactylifera* L.) is an economically significant crop cultivated in arid and semiarid regions worldwide due to its nutritional value and commercial importance (Al-Alawi *et al*., 2017; Al-Aradi *et al*., 2020). However, date palm growth and productivity are often hindered by various abiotic stresses, including salinity and heavy metal contamination (Akensous *et al*., 2022). Among heavy metals, nickel (Ni) is known to