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Phytotoxic and genotoxic effect of Aluminum to date palm (*Phoenix dactylifera* L.) *in vitro* cultures

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Abstract

Background: Al is a common metallic element found in earth's crust and is a toxic pollutant present at high concentrations in acidic soil, thus affecting plant growth. Despite being well studied as a toxic element, the effects of Al on date palm have not been investigated. This study aimed to assess the toxic effects of different Al concentrations on the development and growth of date palm callus and evaluate the biochemical and molecular response of date palm cells under Al stress.

Results: Our study revealed the phytotoxicity of Al concentrations (50, 100, 150 and 200 mg.l^{-1}) on date palm callus. The fresh and dry weight and the number of produced embryos were significantly decreased in response to Al concentration. At 150 mg.l^{-1}, the embryo number decreased to 1.66 compared with the 19.33 in the control treatment. At high Al concentration (200 mg.l^{-1}), the callus failed to produce any embryo. Biochemical analysis revealed that Al exposure had negative effect on callus. Total soluble carbohydrates, total soluble protein and free amino acids were decreased in plants receiving 200 mg.l^{-1} Al treatment compared with those in the untreated ones. A similar decline was observed in total soluble protein and free amino acid in response to Al treatment. Significant accumulations of malondialdehyde, H_2O_2 and peroxidase activity accompanied the increase in Al concentration in cultured tissues, revealing the generation of toxic reactive oxygen species in affected cultures. The genotoxic effect of Al at high concentrations (150 and 200 mg.l^{-1}) was revealed by protein patterns.

Conclusion: Our findings revealed for the first time the phytotoxicity of Al to date palm callus. At 200 mg.l^{-1}, Al prevented the embryo production of date palm callus. At 50, 100, 150 and 200 mg.l^{-1}, Al negatively affected the biochemical characteristics of date palm callus. At 150 and 200 mg.l^{-1}, Al induced changes in protein expression. These data showed that the tissue culture technique can be used as a valuable approach in heavy metal toxicity studies.

Keywords: Aluminum, biochemical analysis, date palm, pollution, protein patterns

Background

Soil acidification is a result of industrial and agricultural activities that lead to the accumulation of toxic ions, including Al, Zn, Cu, Pb and Cd [7]. Al is the third most abundant element in the earth's crust but is not considered as an essential nutrient; however, an increased plant growth is observed in soils with low Al concentrations [37]. In soil pH of 5.5 or lower, Al is a toxic factor that limits crop growth and productivity [23, 27]. Al toxicity has several consequences of, including root growth inhibition, oxidative stress as a result of reactive oxygen species (ROS) generation, alteration of cell wall and plasma membrane characteristics, nutrient unbalances, cytoplasmic Ca^{2+} efflux and induction of callose (1,3- β -D-glucan) formation [26, 37, 38, 41]. The use of *in vitro* tissue culture technique is suitable to study the physiological effects of Al and allows the application of cells with uniform growth and the investigation of physiological and biochemical Al toxicity at the cellular level [20, 39, 45]. The negative effects of Al toxicity in cultured cells for some plant species, such as tomato [28], tobacco [50], wheat [11], *Citrus* species [46] and *Lobelia*

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