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The Role of Nano-selenium in Alleviating the Effects of Salt Stress in Date Palm Trees (*Phoenix dactylifera* L.): a Fourier Transform Infrared (FTIR) Spectroscopy Study

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Abstract
Fourier transform infrared (FTIR) spectroscopy was used to determine the biochemical changes in date palm leaves which induced different NaCl concentrations (2.5 (control), 5, 10 and 20 dS m^{-1}). It was also used to determine the potential role of selenium nanoparticles (Se NPs) at concentrations of 80 and 160 ppm in alleviating salinity stress of date palm (*Phoenix dactylifera L.*) trees. Results showed the appearance of a new peak at 2850 cm^{-1} in the lipid region (2800–3000 cm^{-1}) when date palm trees were exposed to salinity stress. This peak was not observed in the control treatment or when salinity was combined with foliar spraying of Se NPs. Furthermore, a clear and distinct peak at 1735 cm^{-1} was only seen in plants exposed at 10 or 20 dS m^{-1} salinity. This peak was attributed to membrane lipid compounds that contain carbonyl ester groups. In addition, the findings demonstrated that the treatments affected the secondary structure of proteins (1500–1800 cm^{-1}) and carbohydrates (1200–1500 cm^{-1}). This was evident by the appearance and disappearance of some characteristic peaks in these regions.

Keywords Abiotic stress · FTIR · Functional group · Nanoparticles · Vibrational spectroscopy

1 Introduction

Date palm is one of the oldest and most valuable trees grown mainly in the southern part of Iraq. It has nutritional, economic and social importance and is also used as a design for landscape decoration [1]. Salinity in the southern part of Iraq is caused by insufficient rainfall and over-irrigation with brackish or salty water [2]. Date palm can resist high soil salt concentrations. However, irrigation with brackish water results in high salt levels that significantly reduce fruit production and decrease the number of date palm trees that are still alive [3]. The soil salinity tolerance varies amongst date palm cultivars. Certain date palm cultivars can tolerate a high soil salt level of 12.8 dS m^{-1} (1 dS m^{-1} = 640 mg l^{-1}) without any discernible effects on the seedling phenotype [4]. Meanwhile, some cultivars can tolerate soil salt levels of up to 9 dS m^{-1} [5]. Salt stress is a harmful environmental stressor because it simultaneously produces ionic toxicity and osmotic and oxidative stress [6]. The metabolic equilibrium of plants is interrupted and altered when they are grown in stressful environments. For example, the activities of several genes and proteins are drastically altered when the salt level is increases, thus altering plant metabolism [7]. With the existence of nanoparticles (NPs), nanotechnology has attracted the interest of scientists across various fields. It plays a vital role in various areas of our lives, including health, manufacturing, agriculture, electronics, energy and the environment [8]. Recently, nano-compound materials have attracted the interest of agricultural experts because of their unique features [9]. As NPs have a larger surface area than bulk materials, they have greater solubility and surface reactivity [10]. Despite being an essential element of animal and human nutrition, selenium (Se) is not regarded as a necessary element for higher plants. [11]. Recently, selenium nanoparticles (Se NPs) have been employed as a foliar treatment to protect plants from extreme stress by improving antioxidant defence systems, photosynthetic indices and secondary metabolism [12]. Some studies have conducted foliar spraying of nano-selenium on coriander [13]

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