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Seed Priming with Nanoparticles and 24-Epibrassinolide Improved Seed Germination and Enzymatic Performance of *Zea mays* L. in Salt-Stressed Soil

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Abstract: Saline stress is one of the most critical abiotic stress factors that can lessen crops' productivity. However, emerging nanotechnology, nano-fertilizers, and developing knowledge of phytochromes can potentially mitigate the negative effects of saline stress on seed germination. Therefore, the aim of this study was to investigate the effects of seed priming either with zinc oxide nanoparticles (ZnO-NPs; 50 and 100 mg L^{-1}) or 24-epibrassinolide (EBL; 0.2 and 0.4 μM) and their combinations on maize (*Zea mays* L.) grains sown in salt-stressed soil (50 and 100 mM NaCl). Saline stress treatments significantly affected all germination traits and chemical analysis of seeds as well as α-amylase activity. Compared to un-primed seeds, seed priming with ZnO-NPs or EBL and their combinations significantly increased the cumulative germination percentage, germination energy, imbibition rate, increase in grain weight, K^+ content, and α-amylase activity, and significantly reduced germination time, days to 50% emergence, Na^+ uptake, and Na^+/K^+ ratio of maize sown in salt-stressed-soil (50 or 100 mM NaCl). The combination of 100 mg ZnO-NPs L^{-1} + 0.2 μM EBL resulted in the highest improvements for most of the studied traits of maize seeds sown in salt-stressed soil in comparison to all other individual and combined treatments.

Keywords: ZnO NPs; 24-Epibrassinolide; phytochromes; germination; metabolic activity; maize

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1. Introduction

The growing human population, climate change, natural disasters, anthropogenic activities, agricultural land degradation, and salinity are posing extra pressure on food security and agricultural sustainability worldwide [1,2]. Maize (*Zea mays* L.) is ranked third after wheat (*Triticum aestivum* L.) and rice as a staple food for humankind and has become a potential vital cereal crop due to its diversified uses, wide adaptability, and low cost of production [3]. It contributes 30% of the daily calories of 4.5 billion people globally [4]. Despite important genetic developments, maize is still susceptible to environmental stresses such as salinity [5].

Soil salinity, among the abiotic stresses, is considered a major factor that can significantly affect the germination, physiology, and productivity of strategic crops [6–8]. At present, about 7% of the global land surface (approximately 1 billion ha) is salt-affected. Even though most of this has resulted from quite consistent and slow natural geochemical processes, nearly 30% of it was categorized as human-induced salinization, including 189 M ha in the Middle East [9,10].