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Modulation of salinity impact on early seedling stage via nano-priming application of zinc oxide on rapeseed (*Brassica napus* L.)

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A B S T R A C T

Salinity stress negatively affects the plant's developmental stages through micronutrient imbalance. As an essential micronutrient, ZnO can substitute Na+ absorption under saline conditions. Therefore, nanoparticles as technological innovation, improve the plant growth efficiency under biotic and abiotic stresses. Nano-priming has become widely applicable in agricultural research during the last decade. The current study was conducted to highlight the impact of ZnONPs priming on seedling biological processes under 150 mM of NaCl using two rapeseed cultivars during the early seedling stage. All concentrations of ZnONPs increased the germination parameters i.e., FG%, GR, VI (I), and VI (II). Meanwhile, the high concentration (ZnO 100%) showed the highest increase in shoot length (9.60% and 25.63%), root length (41.64% and 48.17%) for Yang You 9 and Zhong Shuang 11 over hydro-priming, respectively, as well as biomass. Additionally, nano-priming improved the proline, soluble sugar, and soluble protein contents as a result of osmotic protection modulation. Moreover, nano-priming alleviated ROS and biosynthesis pigments through the reduction of accumulated (H_2O_2) and (O_2 -), and chlorophyll degradation, respectively, also enhanced antioxidant adjustment via improving the plant defense system. Nano-priming substituted the Na+ by Zn^{2+}, K^+, and Ca^{2+}, and compensated the deficit of micronutrients, thus reduced the Na+ toxicity in the cell cytosol. To track the effects of priming during seed imbibition, it noticed that ZnO 100% and ZnO 100%+S increased the Linoleic and Linolenic acids among the studied fatty acids composition by 12.02%, 7.59%, 13.27%, and 10.38% (Yang You 9), 7.42%, 2.77%, 2.93%, and 1.49% (Zhong Shuang 11) over the hydro-priming, respectively. Moreover, the gene expression patterns of *BnCAM* and *BnPER* reflected the enhancement of germination levels, notably under the influence of ZnO 100% priming, which increased the level of *BnCAM* by 70.42% and 111.9% in Yang You 9 and Zhong Shuang 11, respectively. Consequently, ZnO nano-priming enhanced the seedling development through the biosynthesis of pigments, osmotic protection, reduction of ROS accumulation, adjustment of antioxidant enzymes, and improvement of the nutrient absorption, thus enhancing the economic yield under saline conditions.

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