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Selenium and its nanoparticles modulate the metabolism of reactive oxygen species and morpho-physiology of wheat (*Triticum aestivum* L.) to combat oxidative stress under water deficit conditions

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Abstract

Background Wheat (*Triticum aestivum* L.) is one of the most important cereal crop species worldwide, but its growth and development are adversely influenced by drought stress. However, the application of trace elements is known to improve plant physiology under water-limited conditions. In this study, the effects of drought stress on wheat plants were investigated, with a focus on potential mitigation by foliar application of selenium nanoparticles (Se(np)) and sodium selenate (Na_2SeO_4). The experiment was conducted in a net house using a completely randomized design with four replications. The treatments involved three levels of drought stress (mild, moderate, and severe) started at 30 days after sowing (DAS), with foliar sprays of Se(np) and Se (both 25 µM) initiated at 27 DAS and repeated 4 times at 7-day intervals until 55 DAS.

Results Drought stress significantly reduced plant growth, whereas Se(np) and Se sprays enhanced it. Drought stress induced chlorophyll degradation, increased malondialdehyde and hydrogen peroxide levels, impaired membrane stability, and caused electrolyte leakage. Severe drought stress reduced the levels of antioxidants (e.g., proline, ascorbate, and glutathione by 4.18-fold, 80%, and 45%) and the activities of antioxidant enzymes (ascorbate peroxidase, dehydroascorbate reductase, and others). Conversely, treatment with Se(np) and Se restored these parameters, for example, 1.23-fold higher total chlorophyll content with Se(np) treatment, 26% higher APX activity with Se treatment, 15% lower electrolyte leakage with Se treatment in wheat plants under severe drought stress. This Se-associated enhancement facilitated rapid scavenging of reactive oxygen species and reduced methylglyoxal toxicity, thereby diminishing oxidative stress and positively affecting the morphophysiological and biochemical responses of the plants under drought.

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