PHYSIOLOGICAL EFFECTS OF CERIUM NANOPARTICLES ON SORGHUM UNDER DROUGHT STRESS

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Rationale and Objectives

In crops, drought increases tissue oxidative damage, which could decrease the photosynthetic rate and grain yield. Nanocerium (CeO_2) has an inherent antioxidant property due to its mixed valence states on its surface.

Hence, it is hypothesized that CeO_2 nanoparticles could decrease drought-induced oxidative damage by its inherent antioxidant property resulting in enhanced photosynthetic rate and reproductive success.

The objectives were to quantify the (i) ecotoxicity potential of nanoceria and (ii) effects of nanoceria on the alleviation of drought-induced oxidative damage in sorghum.

Materials and Methods

Cerium nanoparticles were synthesized through the hydrothermal process. The CeO_2 nanoparticles were characterized through AFM, SEM, TEM, and XRD. The ecotoxicity potential of CeO_2 nanoparticles was evaluated using model organisms. The effect of CeO_2 nanoparticles on drought-induced oxidative damage in sorghum was assessed by indicated by Djanaguiraman et al. (2018).

Results

Characterization

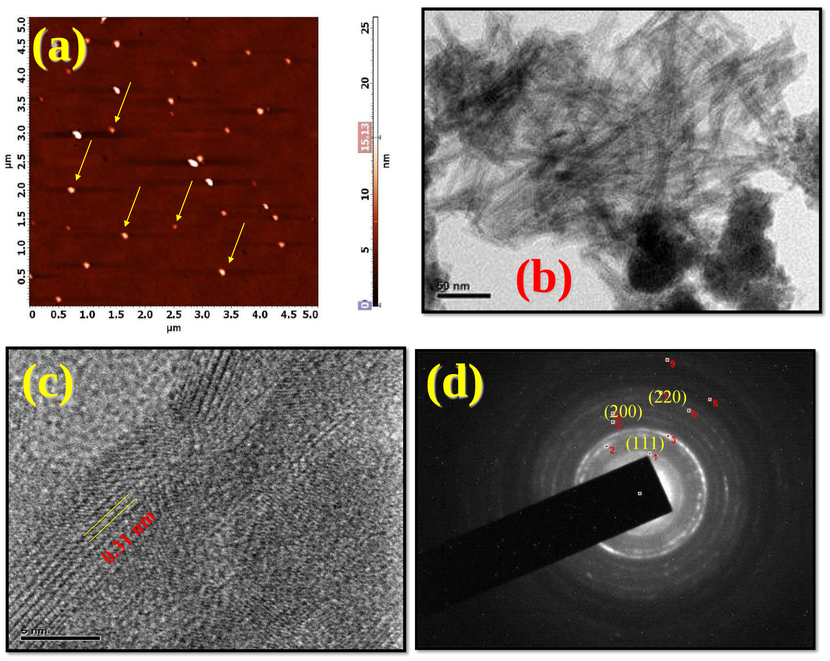


Figure 1. (a) AFM, (b), TEM, (c) HRTEM, and (d) SAED diffraction image.

The average size of rod-shaped CeO_2 NPs is 10.2 nm. Diffraction peaks indicate pure cubic fluorite structure with high crystallinity. The interplanar spacing of 0.31 nm indicates the dominant presence of the (111) plane for the CeO_2 NPs.

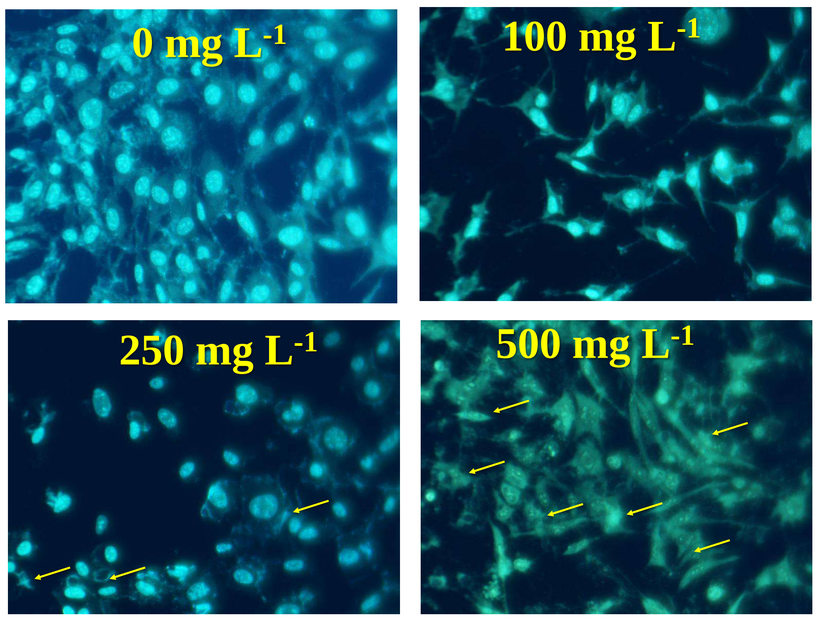
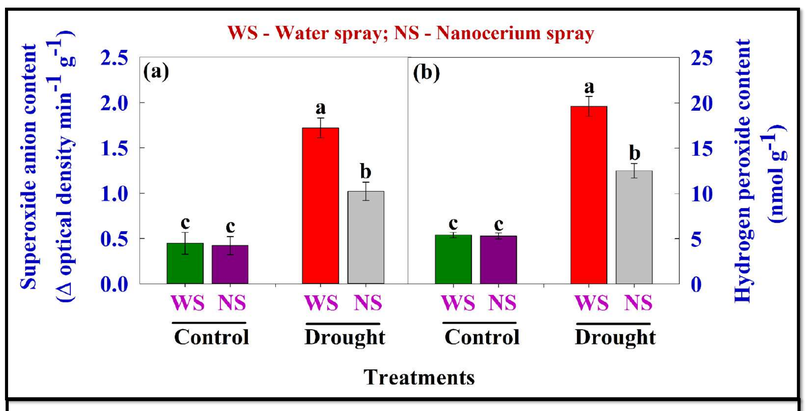


Figure 2. Toxicity of nanoceria to murine fibroblast cell line. Cell and nuclear membrane damage of murine cell line assessed through DAPI. Arrows indicates damage.

EC_{50} of Ce-NPs was > 250 mg L^{-1} for fibroblast L929 cell line.

Confirming the Antioxidant Property



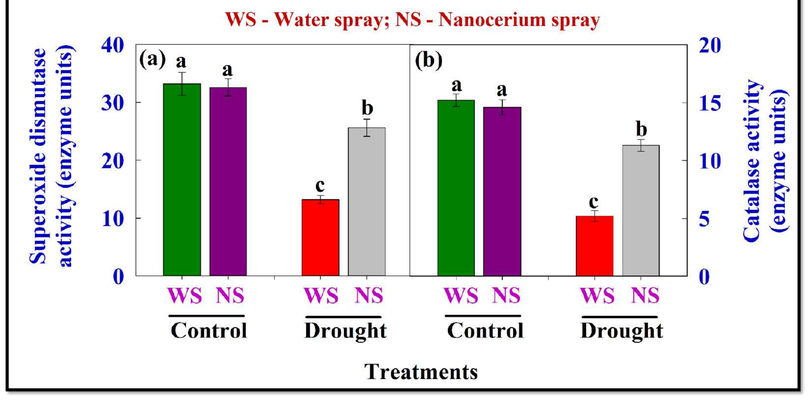


Figure 3. Interaction of irrigation regime [control (C): irrigation once in 7 days; drought (D): water withheld for 21 d] and foliar spray of nanoceria [water spray (WS) and nanoceria (NC) @ 25 mg L^{-1}] during booting stage on oxidants and antioxidant enzymes.

The decrease in oxidant content and increase in antioxidant enzymes activity in the presence of nanoceria indicates nanoceria possess antioxidant activity.

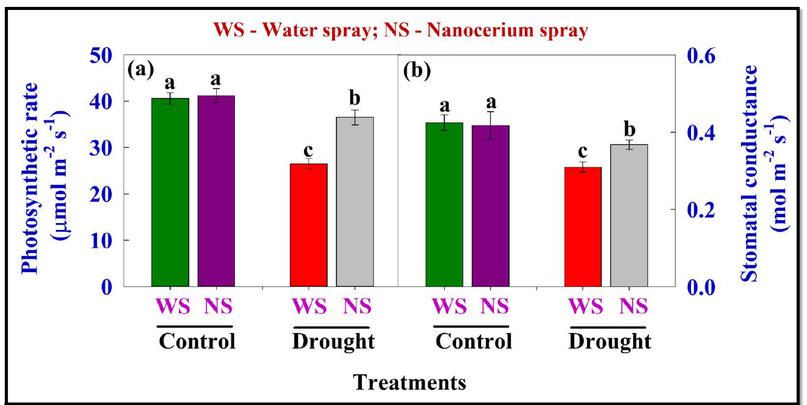


Figure 3. Interaction of irrigation regime and foliar spray of nanoceria during booting stage on photosynthesis and stomatal conductance and response of sorghum to foliar application of nanoceria and decreasing FTSW under drying soil.

Drought stress decreases photosynthetic rate and foliar spray of nanoceria increased photosynthesis by increasing the stomatal conductance, which was confirmed in dry-down experiment. Also, the membrane integrity is maintained by foliar application of nanoceria.

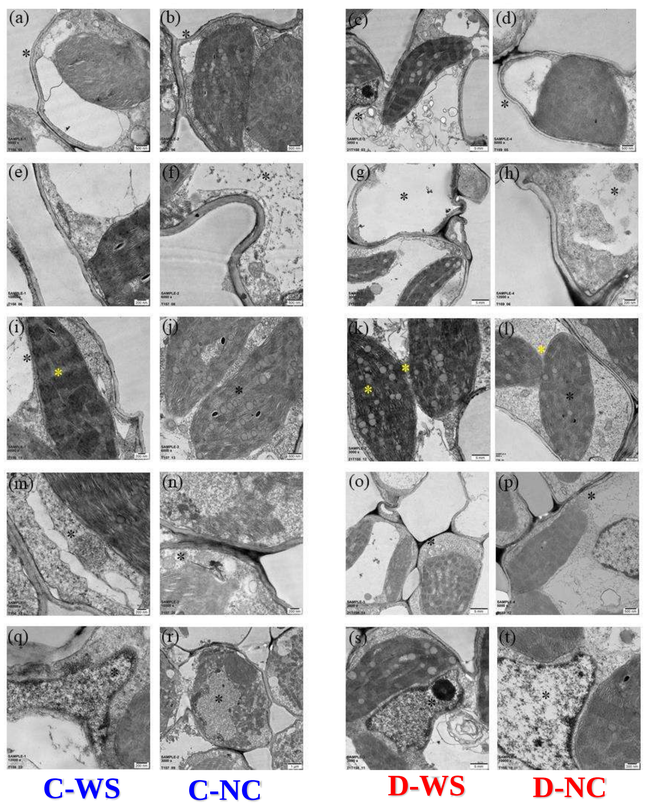


Figure 3. Interaction of irrigation regime [control (C): irrigation once in 7 days; drought (D): water withheld for 21 d] and foliar spray of nanoceria [water spray (WS) and nanoceria (NC) @ 25 mg L^{-1}] during seed-filling stage on leaf ultrastructure. The leaf images were showing the normal (*) and abnormal or damaged (arrow) cell organelles are indicated.

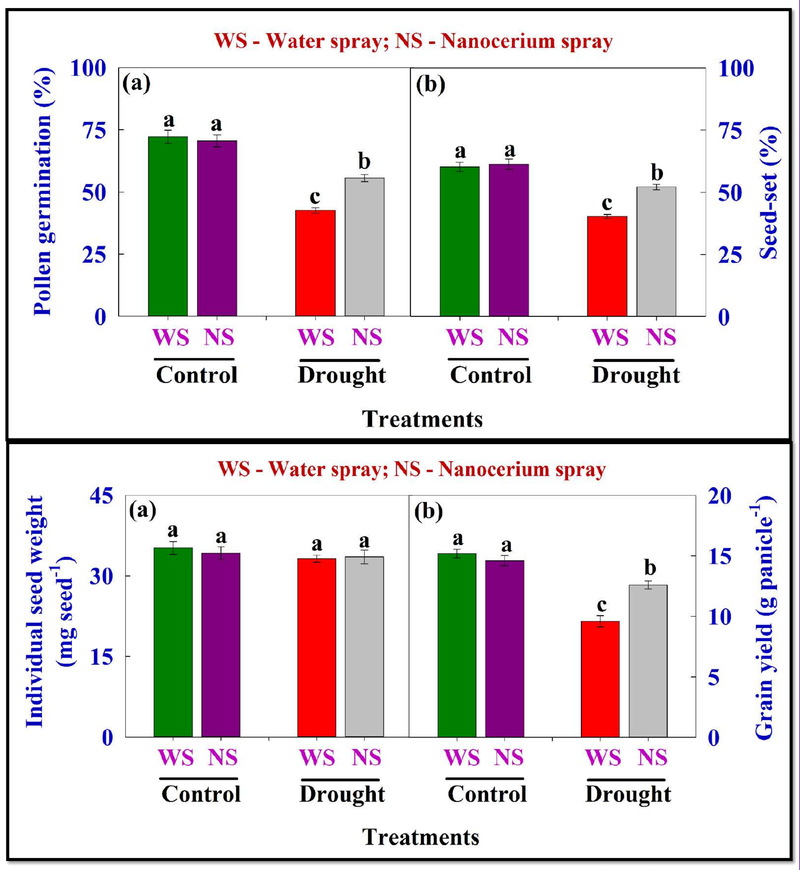
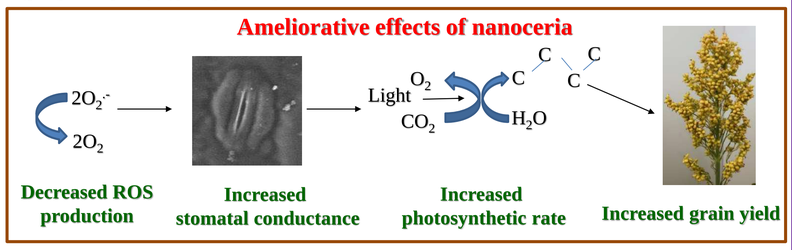


Figure 3. Interaction of irrigation regime and foliar spray of nanoceria during booting stage on yield components of sorghum.

Drought stress decreases grain yield and foliar spray of nanoceria increased grain yield by protecting the pollen function resulting in increased seed-set percentage.

Conclusion



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