www.nature.com/scientificreports

scientific reports

OPEN

Nano-enhanced storage of American cotton using metal-oxide nanoparticles for improving seed quality traits

Nirmal Singh[1], Axay Bhuker[1], Vineeta Pandey[2], Himani Punia[3], Sourabh[4], Bhupender Singh[5], Ajaz Ahmad[6], Anshika Tyagi[7] & Anurag Malik[1,8]✉

Cotton seeds have poorer germination than other crops because of their high sensitivity towards insect pests and other biotic and abiotic stresses during the germination process. In the present study, inorganic bulk and nano nutrients of zinc oxide (ZnO) and titanium oxide (TiO_2) nanoparticles were synthesized using the chemical reduction method and invigourated with cotton seeds. The characterization of nanoparticles was done by FESEM, HRTEM, UV/Vis analysis and FTIR. The delinted and fuzzy seeds of two American cotton varieties (H 1300 and H 1098-i) were nano-primed for 10 h with zinc oxide nanoparticles (ZnONPs) @ 400 ppm and titanium dioxide nanoparticles (TiO_2NPs) @ 100 ppm. After nanoparticle invigouration, the seeds were analyzed for various parameters at different intervals (0 months, 3 months, 6 months, 9 months and 12 months) such as germination percentage, seedling length, seedling dry weight, electrical conductivity, dehydrogenase activity, antioxidant enzyme activity. The results indicated that that different storage periods and nanopriming treatments had significant effects on all seed quality parameters except the effect of nanopriming treatments on germination percentage (excluding delinted seeds of H 1098-i). It is also revealed that the interaction effect of nanopriming treatment and storage period was non-significant on all parameters except EC. Maximum reduction in seed quality parameters was observed in control treatment and minimum was found when seeds were nanoprimed with ZnONPs @ 400 ppm. The differences in the response for both NPs can be attributed to their surface charge, and concentration used. Overall, ZnONPs and TiO_2NPs could hold seed quality and vigour during the storage of cotton seeds of American varieties (H 1300 and H 1098-i).

Keywords Nanoparticles, Nanopriming, Seed quality parameters, Cotton, Seed storage

Seeds represent the reproductive stage of the plant's life cycle. It serves as a primary seedling material for the subsequent season's crop, thereby significant productivity and an abundance of healthy and robust seeds is needed[1]. Cotton (*Gossypium* sp.), a member of the family *Malvaceae* is the foremost natural fibre crop, the sixth-largest source of vegetable oil, and the third most cultivated crop worldwide[2]. The main producing countries are India, China, the United States, Brazil, and Pakistan. This growth will come from an expansion of the cotton area (0.5% p.a.) and growth in average global yields (1% p.a.)[3]. India will continue to be the world's largest cotton producer, with the increase in production resting mostly on higher yields, while area expansion is expected to be limited in line with recent trends[4]. Cotton productivity in India is low because of low seed germination and the incidence of insect pests[5]. The poor seed storage practices result in the production of free radicals causing lipid peroxidation and leading to a rapid deterioration process[6]. Production of high-quality seeds of cotton which could hold

[1]Department of Seed Science and Technology, College of Agriculture, CCS Haryana Agricultural University, Hisar, Haryana 125004, India. [2]Faculty of Agricultural Sciences, GLA University, Mathura, Uttar Pradesh, India. [3]Department of Sciences, Chandigarh School of Business, Chandigarh Group of Colleges, Jhanjeri, Mohali, Punjab 140307, India. [4]Division of Integrated Farming Systems, ICAR-Central Arid Zone Research Institute, Jodhpur 342003, India. [5]Department of Horticulture, Training Assistant Farm, CCS Haryana Agricultural University, Hisar 125 004, Haryana, India. [6]Department of Clinical Pharmacy, College of Pharmacy, King Saud University, 11451 Riyadh, Saudi Arabia. [7]Department of Biotechnology, Yeungnam University, Gyeongsan, Republic of Korea. [8]Division of Research and Innovation, Uttaranchal University, Dehradun, Uttarakhand 248007, India. ✉email: anuragmalikseed@hau.ac.in

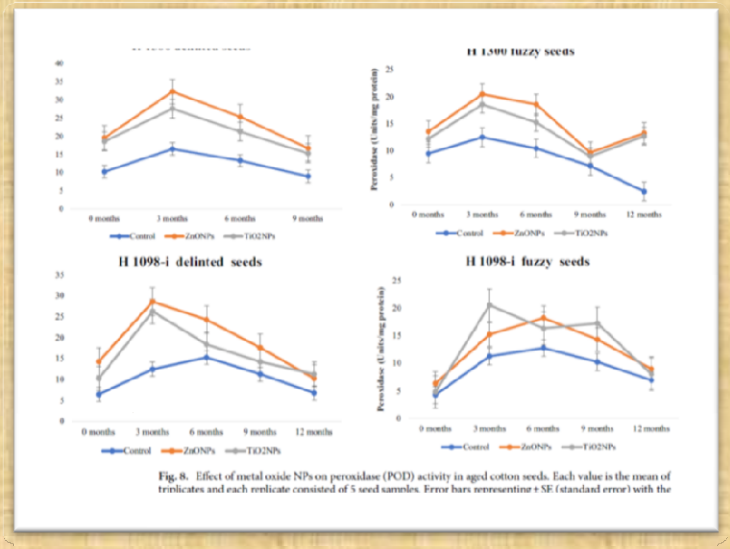

Fig. 8. Effect of metal oxide NPs on peroxidase (POD) activity in aged cotton seeds. Each value is the mean of triplicates and each replicate consisted of 5 seed samples. Error bars representing ± SE (standard error) with the

Nano-enhanced storage of American cotton using metal-oxide nanoparticles for improving seed quality traits

Nirmal Singh, Axay Bhuker, Vineeta Pandey, Himani Punia, Sourabh, Bhupender Singh, Ajaz Ahmad, Anshika Tyagi & Anurag Malik

DOI: https://doi.org/10.1038/s41598-024-71179-8