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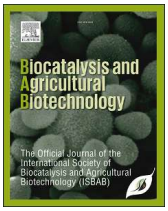

Advancements in bionanotechnological applications for climate-smart agriculture and food production

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ABSTRACT

Due to the significant challenges of growing global population and climate change, the agriculture and food industries are facing a continued demand for improving productivity. The integration of nanotechnology in food and agriculture has been envisioned to supply abundant alternative avenues for the crop improvement and food security. To meet these challenges, nanotechnology has made remarkable advancements in agricultural sciences, resulting in numerous beneficial impacts on crop yield and productivity. The key areas of nano-based agriculture aim to enhance food quality, optimized fertilizer doses, reduced agricultural inputs, and improved nutrient uptake by plants from the soil. Additionally, employing minimal hazardous agrochemicals, lowering fertilizer losses, solidification of soil and water quality, and managing nutrient supply efficiently are attributed to the advantages of nanomaterials. In future, the continued efforts and convergence of agriculture and nanotechnology offers promising benefits such as equipping plants with cutting-edge nanotools to combat abiotic (drought, salt, and temperature) and biotic (insects and diseases) stresses, precise and rapid diagnostics, and maximizing utilization of available resources. The ultimate goal in agricultural sciences is to achieve sustainable food production, which forms the backdrop for harnessing the properties of nanomaterials to enhance crop productivity and address widening growing climate challenges. In summary, the extensive applications of nanotechnology in agriculture are anticipated to support climate-smart crop cultivation.

1. Introduction

With the burgeoning global population pressures, the demand for food has expanded dramatically. By 2050, the load on the agricultural sector will rise by 70% as a result of rising incomes, improved lifestyles, and dietary changes (Bindraban et al., 2018). To meet the demands of the growing population, the output of food and other agricultural products should be boosted by at least 50% in comparison to existing production. In order to meet demand with the least operating cost and safeguard the crops from biotic and abiotic influences, yield improvement and soil protection have become increasingly important. Pesticides and fertilizers have demon-

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