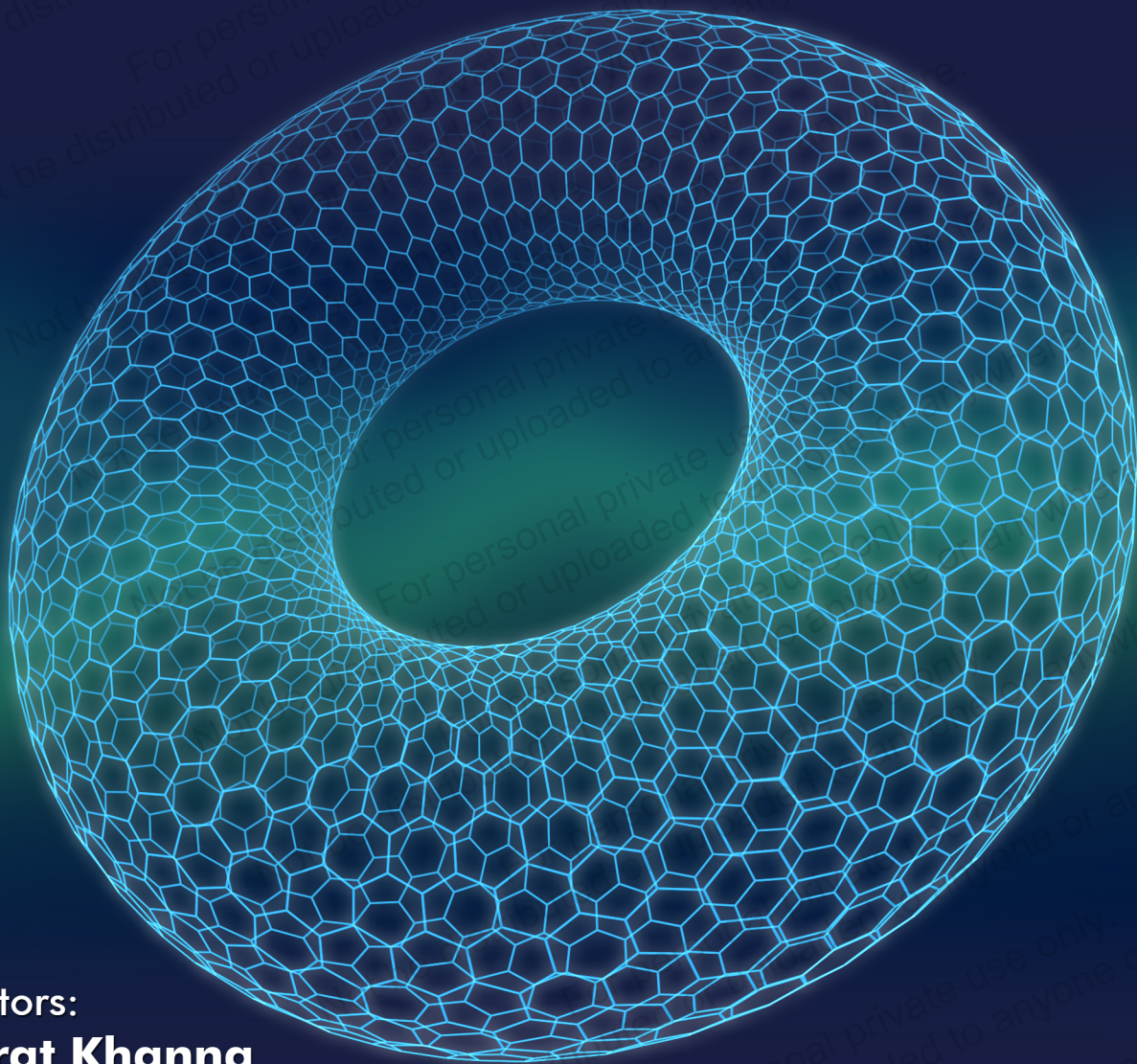


RECENT ADVANCEMENTS IN MULTIDIMENSIONAL APPLICATIONS OF NANOTECHNOLOGY



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Recent Advancements in Multidimensional Applications of Nanotechnology

(Volume 1)

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Agro-Nanotechnology: A Way Towards Sustainable Agriculture

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Abstract: Addressing the global population's dietary needs is crucial amid crop damage issues like insect infestations and adverse weather affecting one-third of conventionally farmed crops. Nanotechnology, recognized for its efficacy and environmental benefits, has gained attention in the past decade. While it has transformed medicine, its applications in agriculture are underexplored. Current research investigates the use of nanomaterials in agriculture for targeted delivery of genes, insecticides, fertilizers, and growth regulators. Nanotechnology shows promise in mitigating abiotic stress in plants by mimicking antioxidative enzymes. This chapter assesses nanoparticles' roles in plant research, highlighting their effectiveness as growth regulators, nanopesticides, nanofertilizers, antimicrobial agents, and targeted transporters. Understanding plant-nanomaterial interactions opens new avenues for enhancing agricultural practices, improving disease resistance, and crop productivity, and optimizing fertilizer use.

Keywords: Agriculture, Nanofertilizer, Nanopesticide, Production, Sustainable.

INTRODUCTION

Agriculture, the cornerstone of a thriving economy, plays a pivotal role in providing sustenance for an ever-growing global population. However, the agricultural sector faces challenges such as climate uncertainties, soil contamination from fertilizers and pesticides, and an escalating demand for food [1]. The imperative to boost food production by over 50% to meet the needs of the burgeoning population underscores the urgency of finding innovative solutions [2]. Industrialization, while contributing to economic growth, poses a significant threat to natural resources vital for sustenance, including forests and seas. Preserving ecological diversity is paramount for maintaining the delicate balance

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between food production and the environment, enhancing agriculture's resilience to environmental stresses that could lead to crop failure. In response to these challenges, the adoption of nanomaterials (NMs) represents a progressive step in revolutionizing current farming techniques [3]. Nanomaterials, with their remarkable reactivity owing to a large surface area to volume ratio and distinctive physicochemical characteristics, can be easily tailored to meet the increasing demands in agriculture. Nanoparticles (NPs) are already making strides in various consumer products, drawing keen attention from the food and agricultural industries. These NMs exhibit unique surface chemical, electrical, and optical properties, enhancing sensitivity, detection limits, and response times [4, 5].

Fertilizers, vital for increasing crop output, often disrupt soil fertility by upsetting mineral balances and can contribute to environmental pollution. Nanoparticles offer a solution by reducing production costs, minimizing the need for plant protection agents, and mitigating nutrient losses to enhance yields. Innovative applications, such as intelligent agrochemical delivery systems utilizing NMs as carriers for active chemicals, are continually evolving [5]. Moreover, agricultural waste materials, like soy hulls and grain straws, can be transformed into advanced bio-nanocomposites with enhanced mechanical and physical qualities for industrial applications. This chapter emphasizes the superior potential of nanomaterials in enhancing agriculture and food systems [6]. Despite these advancements, challenges remain, requiring improvements in procedure design, risk assessment of nanopesticides and nanofertilizers, and regulatory frameworks for the commercialization of nano-agroproducts, to fully realize the benefits of nanotechnology in agriculture.

APPLICATIONS

Agriculture is the mainstay of the developing economy, providing people with food and a better standard of living. A wide range of problems are currently affecting agriculture, including unforeseen climate change, soil contamination from harmful environmental contaminants like pesticides and fertilizers, and dramatically rising the demand for food due to an expanding world population [7]. On the other side, industrialization has an alarmingly quick detrimental effect on the ecological diversity, woods, and seas which promote the population's way of life. In order to meet the requirements of the population's unrelenting growth, it is urgent to increase agricultural output by more than 50%. It encourages the necessity of increased agricultural output and enhanced food security as a result. Environmental biodiversity strengthens agriculture's resistance to environmental pressures that could result in crop failure, which is essential for maintaining the delicate equilibrium between food production and the environment [8]. New techniques and strategies are constantly emerging to solve these significant issues.