


Chapter 10

Revolutionizing Agriculture: Harnessing Nanotechnology for Sustainable Crop Enhancement

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ABSTRACT

Agricultural systems, water resources and many other fields could all be revolutionized by nanotechnology. Because nanotechnology can work with the smallest particles possible, it may be able to solve issues that traditional methods have not been able to, which could increase agricultural productivity. The synthesis of chemical pesticides, fertilizers, and other nanomaterials that enhance plant health, growth, and yield is just one application of nanotechnology in agriculture. Nanosensors are the most

DOI: 10.4018/979-8-3693-3061-6.ch010

important tools in recent agriculture for the advance detection of plant diseases, and nanomaterials (NMs) have the power to change the soil quality and get rid of pollutants like heavy metals and unwanted microbes. However, nanotechnological approaches are beneficial for revolutionizing the sustainability of agriculture.

INTRODUCTION

Nanotechnology can be defined as the design, characterization, manufacturing, and application of devices, structures and systems by controlling shape and size at the nanoscale (Mousavi and Rezaei, 2011). Nano is a Greek word that means “very small”; it indicates one billion (10^{-9}) of something. Ex: 1 Nanometer = 1 billion meters. Nanotechnology's interdisciplinary approach has been applied to several industries, including electronics, cosmetics, pharmaceuticals, and agriculture. Compared to its application in drug delivery and pharmaceuticals, nanotechnology has only recently been used in the food and agriculture industries. About 50 years ago, the idea of using nanotechnology in agriculture first emerged, and now agriculture has benefited greatly from nanotechnology in a variety of ways. For example, agrochemical use is decreased because of the small delivery system; nano pesticides kill phytopathogens; bio-nanocomposites are created; nanosensors are used as intelligent detection tools, and so on. To lessen runoff and loss that comes with using synthetic fertilizers, nano-fertilizers are also being utilized. The increasing patterns of publications in various agri-nanotechnology fields show the excellent results of ongoing research, and agri-nanotechnology research trends are predicted to have a huge positive impact on society and the agriculture industry globally (Altabbaa et al., 2023).

Nanotechnology is used in agriculture in many ways, including the synthesis of chemical pesticides, fertilizers, and other nanomaterials that promote better plant health, growth, and yield. This is achieved through the production and application of nanomaterials, which contribute to enhanced output efficiency and decreased relevant losses. Furthermore, nanomaterials not only improve crop development and management but also act as unique fertilizer and pesticide carriers, which facilitate the intentional and supervised on-site transportation of nutrients. However, the effective operation and application of agricultural inputs, such as different pesticides and fertilizers, depend on nanotools like nano biosensors. (Hussain et al., 2023). Therefore, nanotechnology is used to cultivate transgenic plants, nanoparticles, nanosensors, nanoparticles, and nanomaterials substances at the nanoscale, which used for crop improvement, protection, precision farming, stress tolerance, and soil enhancement, ensure global food demand projections by the extensive development of sustainable agriculture, because sustainable agriculture must prioritize environ-

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