

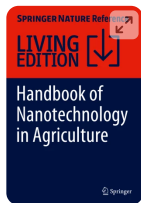
**SPRINGER NATURE** Reference

**LIVING  
EDITION**



# Handbook of Nanotechnology in Agriculture

Home > Living reference work



# Handbook of Nanotechnology in Agriculture

| Living reference work | © 2025

| Latest edition

[Accessibility Information](#)

## Overview

Editors: [Azamal Husen](#)

Provides a comprehensive review of the rapidly expanding discipline of nanotechnology in agricultural sectors  
Includes in-depth discussions, a vast array of special topics and explore wide range applications  
Represents an indispensable reference for nano-based professionals, academic researchers, and upper level of students

367 Accesses 1 [Altmetric](#)

This is a preview of subscription content, [log in via an institution](#) to check access.

### Access this book

[Log in via an institution](#)

### Other ways to access

[Licence this eBook for your library](#) →

[Institutional subscriptions](#) →

# About this book

This handbook provides a comprehensive overview of the application of nanotechnology in agricultural sectors to boost sustainable agriculture with the use of these modern age nanomaterials and nanodevices that are empowering to attain maximum output from limited resources. The application of nanotechnology includes, enhancing plant growth and protection through the use of nanoparticles, the management of plant diseases and pest management through nano herbicides nanofungicides, nano/smart fertilizers for controlled and target release of nutrients, food processing and preservation with polymers nanocomposites. Further, in agriculture sectors nanosensors seem to be a promising tool for detection of fertilizers, herbicides, pesticides, and insecticides as well as pathogens, moisture, soil pH, soil contaminants, contaminants, and other parameters to improve crop health and sustainability. Moreover, nanosensors have also a significant role in precision agriculture activity, satellite farming or site-specific crop plants management in terms of detecting, calculating, and responding to inter and intra-field variability of crop plants. This handbook summarizes the recent findings, in-depth discussions and a wide range applications associated with smart nano research and technology for overall agricultural sectors and represents an indispensable reference for nano-based professionals, academic researchers, and upper level of students.

## Similar content being viewed by others



### [Nanotechnology in Crop Protection: Innovations for Sustainable Agriculture](#)

Chapter | © 2025



### [Nanoparticles for Crop Protection](#)

Chapter | © 2025



### [Nanobiotechnology](#)

Chapter | © 2021

## Explore related subjects

Discover the latest articles, books and news in related subjects.

[Agricultural Biotechnology](#)

[Food Nanotechnology](#)

[Nanobiotechnology](#)

## Search within this book

## Table of contents (30 entries)

---

### **Biochar and Nanotechnology for Sustainable Crop Growth and Soil Conservation**

Shahram Torabian, Salar Farhangi-Abriz

---

### **Carbon Nanomaterials: Fullerenes, Graphene, and Nanotubes in Agriculture**

Iram Gul, Syeda Irsa Mazhar Kazmi, Muhammad Arshad

---

### **Harnessing Magnetic Nanomaterials for Sustainable Plant Growth: Mechanisms, Benefits, and Challenges**

Shweta Sharma, Dilbag Singh, Varsha Malik, Kiran Kiran, Deepak Beniwal, Divya Kapoor et al.

---

### **Nano-Encapsulated Pesticides for Targeted Pest Control**

Ravinder Kumar, Baljeet Singh Saharan, Surekha, Jyoti Rani, Joginder Singh Duhan

---

### **Nano-enhanced Organic Farming: A Sustainable Approach**

Lakshika Arya, Nishtha Chawla, Hina Alim, Nimisha Patel

---

### **Nano-Pesticides: Sustainable Alternatives to Traditional Pest Control**

Hassan Nawaz, Zia Ud Din, Hamza Irshad, Muhammad Shahid

---

### **Nanoclays and Nanocomposites for Agricultural Use**

Mohamed A. Amin, Mahmoud A. Eldiehy, Abdelatti I. Nowwar

---

### **Nanofertilizers: Revolutionizing Nutrient Delivery in Crops**

Misba Khan, Nisha Ali, Mariyam Rafi, Archana Vimal, Reena Vishvakarma

---

### **Nanomaterials for Enhanced Crop Protection and Growth**

Weria Weisany

---

### **Nanomaterials for Increasing Photosynthesis Efficiency**

Hamzeh Amiri, Parvaneh Hemmati Hassan Gavyar, Yusuf Farrokhzad

---

## **Nanosensors and Their Role in Fertilizers, Herbicides, Pesticides, and Insecticides Detection**

Rishi Raj, Deepika Chauhan, Ranjana Verma, Jay Singh

---

## **Nanosensors in Agricultural Applications: An Overview**

Reena Vishvakarma, Mohammad Areeb Siddiqui, Nida Ansari, Pooja Kumari, Fiza Batool, Zoha Parvez et al.

---

## **Nanotechnology and Sustainable Agriculture: Transforming Global Farming**

Shivani Garg

---

## **Nanotechnology for Climate Change Mitigation in Agriculture**

Shifa Shaffique, Muhammad Aaqil Khan, Anis Ali Shah, Muhammad Saleem Khan, Javier Trujillo Rogmas, Sang-Mo Kang et al.

---

## **Nanotechnology for Sustainable Agriculture and Global Food Systems**

Avijit Biswas, Subhadwip Ghorai, Sahely Kanthal, Avishek Chatterjee, Madhusri Pramanick, Pabitra Kumar Ghosh et al.

---

## **Nanotechnology for Sustainable Water Management in Precision Agriculture**

Weria Weisany

---

## **Nanotechnology in Agriculture: Principles and Applications**

Sandra Fabiola Velasco Ramírez

---

## **Nanotechnology in Biocontrol Agents for Sustainable Pest Management**

Subhadwip Ghorai, Ankur Mukhopadhyay, Sk Md. Asif, Rajdeep Mohanta, Sourav Roy, Soham Hazra et al.

---

## **Nanotechnology in Irrigation Systems: Enhancing Water Use Efficiency**

Vikas Sharma, Vedika Dhingra

---

## **Nanotechnology in Plant-Based Agricultural Innovations**

Pooja V. Nagime, Vaishali S. Chandak

---

## Editors and Affiliations

---

**Wolaita Sodo University, Wolaita, Ethiopia**

Azamal Husen

## About the editor

---

**Professor Azamal Husen** research and teaching experience of 25 years encompasses nanobiotechnology, plant physiology, environmental botany, medicinal plants and plant propagation. He has contributed to R&D projects of the World Bank, the National Agricultural Technology Project, the Indian Council of Agriculture Research, the Indian Council of Forest Research Education, the Japan Bank for International Cooperation, and so on. Husen has published extensively (>300) and served on the Editorial Board, worked as Special Issue Guest Editor and reviewer of reputed journals published by Elsevier, Frontiers Media, Taylor & Francis, Springer Nature, RSC, Oxford University Press, Sciendo, the Royal Society, CSIRO, PLOS, MDPI, John Wiley & Sons, and UPM Journals. He is on the advisory board of Cambridge Scholars Publishing, UK. He is a fellow of the Plantae group of the American Society of Plant Biologists, and a member of the International Society of Root Research, Asian Council of Science Editors, and International Natural Product Sciences. He has given numerous talks and presentations in many conferences and workshops. Prof. Husen has also given various orientation courses for academic staff, prepared different modules, developed BSc, MSc and PhD curriculum. Moreover, he has received a recognition award from University of Gondar, Ethiopia for a decade of service in teaching, research and community services.

## Accessibility Information

---

### PDF accessibility summary

This PDF has been created in accordance with the PDF/UA-1 standard to enhance accessibility, including screen reader support, described non-text content (images, graphs), bookmarks for easy navigation, keyboard-friendly links and forms and searchable, selectable text. We recognize the importance of accessibility, and we welcome queries about accessibility for any of our products. If you have a question or an access need, please get in touch with us at [accessibilitysupport@springernature.com](mailto:accessibilitysupport@springernature.com). Please note that a more accessible version of this eBook is available as ePub.

### EPUB accessibility summary

This ebook is designed with accessibility in mind, aiming to meet the ePub Accessibility 1.0 AA and WCAG 2.2 Level AA standards. It features a navigable table of contents, structured headings, and alternative text for images, ensuring smooth, intuitive navigation and comprehension. The text is reflowable and resizable, with sufficient contrast. We recognize the importance of accessibility, and we welcome queries about

accessibility for any of our products. If you have a question or an access need, please get in touch with us at [accessibilitysupport@springernature.com](mailto:accessibilitysupport@springernature.com).

## Bibliographic Information

---

<b>Book Title</b> Handbook of Nanotechnology in Agriculture	<b>Editors</b> Azamal Husen	<b>DOI</b> <a href="https://doi.org/10.1007/978-981-96-4489-6">https://doi.org/10.1007/978-981-96-4489-6</a>
<b>Publisher</b> Springer Singapore	<b>eBook Packages</b> Living Reference Engineering, Reference Module Computer Science and Engineering	<b>eBook ISBN</b> 978-981-96-4489-6
<b>Number of Pages</b> X, 1190	<b>Topics</b> <a href="#">Food Microbiology</a> , <a href="#">Agriculture</a> , <a href="#">Biotechnology</a> , <a href="#">Materials Science</a> , <a href="#">general</a>	

## Keywords

---

[Agricultural Crop Production](#)

[Soil Protection](#)

[Precision Farming](#)

[Food Processing](#)

[Enhanced Plant Growth](#)

[Formulation of Nanofertilizers](#)

[Plant Disease and Pest Management](#)

[Agricultural Nanosensors](#)

[Plant Genetic Engineering](#)

[Agricultural Waste Management](#)

## Publish with us

---

[Policies and ethics](#) 

[Back to top](#) 

[Home](#) > [Handbook of Nanotechnology in Agriculture](#) > Living reference work entry

# Nanofertilizers: Revolutionizing Nutrient Delivery in Crops


| Living reference work entry | First Online: 25 October 2025

| pp 1–33 | [Cite this living reference work entry](#)



## Handbook of Nanotechnology in Agriculture

[Misba Khan](#), [Nisha Ali](#), [Mariyam Rafi](#), [Archana Vimal](#) & [Reena Vishvakarma](#)

 13 Accesses

## Abstract

Nanofertilizers, as an efficient alternative to traditional fertilizers, have transformed the agricultural scenario by demonstrating precise, targeted, and controlled delivery of nutrients to the crops. Such efficiency has boosted sustainability through reduced nutrient losses and contamination in the environment. These attributes have arisen due to their specific features, such as enhanced nutrient absorption efficiency, due to high surface area-to-volume ratio, better reactivity with reduced leaching, and tendency to interact at cellular and molecular levels, which ultimately culminate in enhanced plant growth. Moreover, these have a minimal ecological footprint and contribute substantially to the improvement of soil fertility through their customized nutrient availability approach. Though a revolutionary step in sustainable agriculture, the application and utility of nanofertilizers still face regulatory hurdles, a lack of proper frameworks for large-scale production, and substantial knowledge, hindering their extensive usage. This chapter, which deals with nanofertilizers, their classifications, mechanism of action, applications, and limitations, is therefore an attempt to enlighten readers about the innovative and sustainable approach to utilizing nanofertilizers in agriculture for efficient farming practices that cater to growing food demands.