

Nanotechnology in the Life Sciences

Series Editor

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Nano and biotechnology are two of the 21st century's most promising technologies. Nanotechnology is demarcated as the design, development, and application of materials and devices whose least functional make up is on a nanometer scale (1 to 100 nm). Meanwhile, biotechnology deals with metabolic and other physiological developments of biological subjects including microorganisms. These microbial processes have opened up new opportunities to explore novel applications, for example, the biosynthesis of metal nanomaterials, with the implication that these two technologies (i.e., thus nanobiotechnology) can play a vital role in developing and executing many valuable tools in the study of life. Nanotechnology is very diverse, ranging from extensions of conventional device physics to completely new approaches based upon molecular self-assembly, from developing new materials with dimensions on the nanoscale, to investigating whether we can directly control matters on/in the atomic scale level. This idea entails its application to diverse fields of science such as plant biology, organic chemistry, agriculture, the food industry, and more.

Nanobiotechnology offers a wide range of uses in medicine, agriculture, and the environment. Many diseases that do not have cures today may be cured by nanotechnology in the future. Use of nanotechnology in medical therapeutics needs adequate evaluation of its risk and safety factors. Scientists who are against the use of nanotechnology also agree that advancement in nanotechnology should continue because this field promises great benefits, but testing should be carried out to ensure its safety in people. It is possible that nanomedicine in the future will play a crucial role in the treatment of human and plant diseases, and also in the enhancement of normal human physiology and plant systems, respectively. If everything proceeds as expected, nanobiotechnology will, one day, become an inevitable part of our everyday life and will help save many lives.

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Khalid Rehman Hakeem • Tanveer Bilal Pirzadah
Editors

Nanobiotechnology in Agriculture

An Approach Towards Sustainability



Springer

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This book is dedicated to



***Fatima bint Muhammad Al-Fihriya
Al-Qurashiya,***

*an Arab Muslim woman who is attributed
with founding the oldest existing, continually
operating and first degree-awarding
educational institution for natural sciences
in the world, the University of al-Qarawiyyin
in Fez, Morocco in 859 CE. She is also
known as “Umm al-Banayn”*

(Source: wikipedia.org)

Foreword



Agriculture is the backbone of developing nations and provides employment to more than half of the workforce. The agricultural land is shrinking in respect of crop productivity due to land degradation, reduced soil fertility, and low water accessibility. The excessive use of chemical fertilizers and pesticides to increase the crop yield is not safe for environment and human health. In this regard, nanobiotechnology serves as a freelancer to tackle the problems related to agricultural sector. Nowadays, nano-agribusiness is an emerging

field to enhance crop yield, rejuvenate soil health, provide precision farming, and stimulate plant growth. Thus, agri-nanobiotechnology plays a pivotal role in the agricultural sector, without possessing any pessimistic impact on the environment and biosafety issues.

This book *Nanobiotechnology in Agriculture: An Approach towards Sustainability* published by Springer includes 13 chapters. Chapter “Nanotechnology: An Overview” presents an overview on the methods of preparation of nano-engineered active ingredients of fertilizers, pesticides and their formulation of nanocarriers for their controlled release and targeted delivery. Chapter “Embodiment of Nanobiotechnology in Agriculture: An Overview” deals with the embodiment of nanobiotechnology in agriculture. Chapter “Nanotechnology: A Boost for the Urgently Needed Second Green Revolution in Indian Agriculture” focuses on the use of nanotechnology to boost the green revolution in Indian agriculture. Similarly, Chapter “Role of Nanotechnology in Crop Improvement” deals with the basis of crop improvement through nanotechnology. Chapter “Nanofertilizers: A Way Forward for Green Economy”, by the joint authorship of Indian and Saudi Arabian researchers, focuses on the various scopes and economic aspects of nano-formulations. In Chapter “Nano-enabled Agriculture Can Sustain “Farm to Fork” Chain”, the Indian author entails the vital role of nanotechnology to boost the agribusiness and food industry for their sustainable development. Chapter “Nano-Biosensors: NextGen Diagnostic Tools in Agriculture” by the Indian investigators discusses the

importance and practices of nano-biosensors as a next-generation diagnostic tool to boost the agricultural practices, while Chapter “Development of Nano-formulations via Green Synthesis Approach” deals with the development of nano-formulations via green synthesis approach. However, Chapter “Nano-agrochemicals: Economic Potential and Future Trends” focuses on the economic potentials and future trends of nano-agrochemicals. Chapter “Pros and Cons of Nanotechnology” emphasizes on the pros and cons of nanotechnology. Chapter “Nanoparticles: The Magic Bullets in Mitigating Drought Stress in Plants” describes the role of nanoparticles in mitigation of drought stress in plants. However, Chapter “Nanotechnology: An Innovative Tool to Enhance Crop Production” deals with the potential of agro-nanotechnology to transform the agricultural and agro-business sector, while significances and potentiality of CRISPR/Cas 9 as a new revolutionary science in agricultural and horticultural sciences are summarized in Chapter “CRISPR/Cas9: A New Revolutionary Science in Agricultural and Horticulture”. This volume includes various aspects of agri-nanobiotechnology to resolve the issues related to global food security, sustainability and climate change, nano-formulation, etc. to boost up the agricultural and agribusiness sectors. I congratulate Prof. Khalid Rehman Hakeem and Dr. Tanveer Bilal for their decent academic effort in bringing out this book.

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Preface

Agriculture is regarded as the backbone of the national economy of the developing countries of the world as about two-fifth of their population depends upon agriculture for their livelihood. The progress in agriculture sector plays a critical role in population growth and economic forums as it produces raw materials for food and feed industry. Currently, due to the growing population and other anthropogenic activities, global agricultural production faces many challenges such as decreased crop yield, soil fertility, soil degradation, low efficiency and labour shortages due to expulsion from agriculture. In addition, losses of bioresources are occurring at an alarming rate, with dramatic effects on people's livelihood. The population is projected to reach 9 billion by 2050, and it will be mandatory to generate at least 50–70% more production to feed such a large population. The exorbitant use of conventional fertilizers and pesticides to increase production efficiency is of course not an appropriate choice for the long term, as these fertilizers are considered as double-edged sword, which increases crop yields but at the same time, they have a detrimental effect on the soil microflora and thus reduce fertility. In addition, it irreversibly damages soil texture and disrupts the balance of the food web in the ecosystem, which can lead to genetic mutations in future generations. The increased reliance on conventional fertilizers during and after the Green Revolution has caused serious problems of sustainability and health risks.

To overcome the disadvantages of conventional fertilizers, bioformulations have been created to revolutionize the agricultural sector because of their eco-friendly nature and their cost-effectiveness. Nevertheless, this approach has also been confronted with some problems, like short life span, stability, solubility, low absorption efficiency by plants and the high dosage requirement. To combat these problems, nano-formulations have received an overwhelming response due to superiority over bioformulations. Nano-biotechnologies have thus become a promising tool to tackle the above-mentioned problems, particularly in the agricultural sector, to combat global food production and boost the agricultural sector. Nano-agribusiness is a new field that improves crop yields, regenerates soil health, ensures precision agriculture and stimulates plant growth.

In this book, we have tried to integrate literature focusing the issue related to agricultural productivity, different practices to manage these issues and then the role of the nano-biotechnology in environmental and agricultural sustainability. The chapters in this book highlight importance of nano-biotechnology as an innovative tool to enhance production yield and environmental sustainability.

We are highly grateful to all our contributors for readily accepting our invitation for not only sharing their knowledge and research, but for venerably integrating their expertise in dispersed information from diverse fields in composing the chapters and enduring editorial suggestions to finally produce this venture. We greatly appreciate their commitment.

We thank Springer-International team for their generous cooperation at every stage of the book production.

Jeddah, Saudi Arabia
Mohali, Punjab, India

Khalid Rehman Hakeem
Tanveer Bilal Pirzadah

Contents

Nanotechnology: An Overview	1
Sheikh Tanveer Salam, Tanveer Bilal Pirzadah, and Pervaiz Ahmad Dar	
Nanotechnology: A Boost for the Urgently Needed Second Green Revolution in Indian Agriculture	15
Kaizar Hossain, Syed Zaghun Abbas, Akil Ahmad, Mohd Rafatullah, Norli Ismail, Gaurav Pant, and Maruthi Avasn	
Nano-enabled Agriculture Can Sustain “Farm to Fork” Chain.	35
Deepu Pandita	
Role of Nanotechnology in Crop Improvement	63
John Mohd War, Mohammad Afaan Fazili, Waseem Mushtaq, Abdul Hamid Wani, and Mohd Yaqub Bhat	
Nanofertilizers: A Way Forward for Green Economy.	99
Bisma Pirzadah, Tanveer Bilal Pirzadah, Aarifa Jan, and Khalid Rehman Hakeem	
Embodiment of Nanobiotechnology in Agriculture: An Overview	113
Tareq A. Wani, Gulzar A. Rather, Mudasar Ahmad, and Zahoor A. Kaloo	
Nano-Biosensors: NextGen Diagnostic Tools in Agriculture.	129
Fayaz Ahmad Dar, Gazala Qazi, and Tanveer Bilal Pirzadah	
Nanoparticles: The Magic Bullets in Mitigating Drought Stress in Plants.	145
Javed Ahmad, Sadia Qamar, Nida Kausar, and M. Irfan Qureshi	
Nanotechnology: An Innovative Tool to Enhance Crop Production	163
Aarifa Jan, Tanveer Bilal Pirzadah, and Bisma Malik	

Development of Nano-formulations via Green Synthesis Approach	171
Tanveer Bilal Pirzadah, Bisma Pirzadah, Aarifa Jan, Fayaz Ahmad Dar, Khalid Rehman Hakeem, Seema Rashid, Sheikh Tanveer Salam, Pervaiz Ahmad Dar, and Mohammad Afaan Fazili	
Nano-agrochemicals: Economic Potential and Future Trends	185
Gazala Qazi and Fayaz Ahmad Dar	
CRISPR/Cas9: A New Revolutionary Science in Agricultural and Horticulture	195
Quazi Mohammad Imranul Haq and Touseef Hussain	
Pros and Cons of Nanotechnology	207
Waseem Mushtaq, Adnan Shakeel, Mohammad Afaan Fazili, Ishani Chakrabartty, and Mustafa Sevindik	
Index	223

About the Editors



Khalid Rehman Hakeem, PhD, is Professor at King Abdulaziz University, Jeddah, Saudi Arabia. After completing his doctorate (Botany; specialization in Plant Ecophysiology and Molecular Biology) from Jamia Hamdard, New Delhi, India, in 2011, he worked as a lecturer at the University of Kashmir, Srinagar, for a short period. Later, he joined Universiti Putra Malaysia, Selangor, Malaysia, and worked there as Postdoctoral Fellow in 2012 and Fellow Researcher (Associate Prof.) from 2013 to 2016. Dr. Hakeem has more than 10 years of teaching and research experience in plant ecophysiology, biotechnology and molecular

biology, medicinal plant research, plant–microbe–soil interactions as well as in environmental studies. He is the recipient of several fellowships at both national and international levels; also, he has served as the visiting scientist at Jinan University, Guangzhou, China. Currently, he is involved with a number of international research projects with different government organizations.

So far, Dr. Hakeem has authored and edited more than 36 books with international publishers, including Springer Nature, Academic Press (Elsevier), and CRC Press. He also has to his credit more than 90 research publications in peer-reviewed international journals and 55 book chapters in edited volumes with international publishers.

At present, Dr. Hakeem serves as an editorial board member and reviewer of several high-impact international scientific journals from Elsevier, Springer Nature, Taylor and Francis, Cambridge and John Wiley Publishers. He is included in the advisory board of Cambridge Scholars Publishing, UK. He is also a fellow of Plantae group of the American Society of Plant Biologists, member of the World Academy of Sciences, member of the International Society for Development and Sustainability, Japan, and member of Asian Federation of Biotechnology, Korea. Dr. Hakeem has been listed in Marquis Who's Who in the World, since 2014–2019. Currently, Dr. Hakeem is engaged in studying the plant processes at ecophysiological as well as molecular levels.



Tanveer Bilal Pirzadah, PhD, is Assistant Professor at University Centre for Research and Development (UCRD), Chandigarh University, Mohali, Punjab, India. After completing his doctorate (Bioresources; specialization in Plant Stress Physiology and Biofuels) from the University of Kashmir, Srinagar, India, in 2017, he worked as a lecturer at the Cluster University Srinagar. Dr. Tanveer has about 8 years of research and teaching experience in bioresources management, bio-fuels, plant stress physiology, biotechnology and molecular biology, medicinal plant research, plant–metal interactions as well as in environmental studies.

He also has to his credit 20 research publications in peer-reviewed international journals and 22 book chapters in edited volumes with international publishers.

At present, Dr. Tanveer serves as an editorial board member and reviewer of several international scientific journals. He is also member of the World Academy of Sciences and Plantae group of the American Society of Plant Biologists. Currently, Dr. Tanveer is engaged in studying the plant processes at proteomic, metabolomic and molecular level to better understand the dynamic plant–metal interactions.