THE ENERGY AND RESOURCES INSTITUTE
Creating Innovative Solutions for a Sustainable Future

जैव प्रौद्योगिकी विभाग
Department of Biotechnology
Ministry of Science & Technology
Government of India
सत्यमेव जयते

DEAKIN UNIVERSITY
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NANOFORAGRI 2021

Technology readiness and overcoming regulatory barriers to implement nanotechnology-enabled agriculture for sustainable future

8th-9th December 2021

TERI-Deakin Nanobiotechnology Research Centre, New Delhi, India

Welcome Note

It is my pleasure to welcome you to the **5th International Conference on Nano-biotechnology for Agriculture: "Technology Readiness and Overcoming Regulatory Barriers to Implement Nanotechnology-Enabled Agriculture for Sustainable Future"** organized by TERI Deakin Nanobiotechnology Centre, TERI in partnership with Department of Biotechnology, Government of India.

'NANOFORAGRI 2021' is an opportunity to participate in a dynamic, international, interdisciplinary platform for sharing knowledge and taking part in scientific discussions on Nanobiotechnology advances in agri- and food-based sectors. The interactive sessions will help scientific fraternity in the field of nanobiotechnology with the knowledge to ease them into translational research. This 5th successive conference will focus on the world's readiness for achieving the "UN's sustainable Development Goal: End hunger, achieve food security, and promote sustainable agriculture" through the application of nanotechnology. The event will be of high importance to all stakeholders involved in NanoAgriculture encompassing the researchers and industries having recently developed nanotechnologies, and regulators and farmers. The meeting will bring together highly-accomplished experts with diversified backgrounds across the globe and showcase breakthrough research towards nano-driven shift in agriculture practices. Amid the many uncertainties and restrictions due to COVID19, the conference will be organized in a hybrid mode with possibility for both in-person and virtual experience for participants from India and only virtual meeting for international participants. The 'NANOFORAGRI 2021' meeting is promising to be the strong, robust scientific forum that participants have enjoyed in the past, while making sure the content is accessible to the greater NanoAgriculture research community.

I hope that knowledge exchange and significant brainstorming held during the conference will advance your understanding and would also draw consensus on some of the key issues related to applications of nanoscience and nanotechnologies in the field of food and agriculture. The conference will also provide an interactive platform for young and established researchers by showcasing posters, and selected oral presentations in the focused thematic sessions to understand the innovation space and scope for nanobiotechnology interventions to address issues in food and agriculture areas. Partnership between TERI-Deakin Nanobiotechnology Centre, India, Deakin University, Australia and Department of Biotechnology, Government of India led to the joint organization of this conference through DBT -TDNBC - DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA) network(https://www.teriin.org/projects/dtd-rna/) ; Centre of Excellence for Advanced Research in Agricultural Nanotechnology (CEARAN) Programme (https://www.teriin.org/projects/coe-ncearan/)

funded by DBT. We are in an era where research has to be of use to somebody. Within the Government of India, DBT have been a pioneer, leader and a path breaker in translational research. TERI-Deakin Nanobiotechnology is standing at the frontier of Nanobiotechnology, which allows us to be lot more effective in agriculture and environment sectors. Deakin University, Australia are leaders in material sciences. These three institutes, DBT, TDNBC and Deakin have jointly created DTD-RNA network. The challenge would be to create right mechanisms that allow us to capture these opportunities. I am extremely delighted in welcoming you all as you are leaders who can make the change happen. I believe that partnership matters greatly to shape the future and therefore great teams must come together whether they are multi-disciplinary or multi-cultural to make a change that can create impact. Our world is much smaller place but the need for scientific solutions is more pressing.

In this context, "DTD-RNA network platform is very relevant. This platform will bring together the nanobiotechnology community and translate lab-based research into practical applications that benefit society. This network platform is one of the key steps in bringing the community together to collaborate and share resources, information, knowledge, facilities, ideas, and infrastructure to create impactful and strategy driven research. All of you are invited to join this network and do mail us at DTDRNA@teri.res.in if you want to join our journey. I also encourage you to visit our NCEARAN web page for the technologies developed by TERI. All these technologies are developed using a biogenic approach and therefore highly efficacious and are safe for environment and human.

I sincerely hope that the conference will be both pleasant and productive for all of you. My colleagues and I take this opportunity to thank all the individuals, institutions and sponsors who have contributed towards the conference. I hope you will not only able to advance your thinking through the lively exchange of information and the significant brainstorming that should take place, but also develop consensus positions on some of the key issues that characterize the different fields of application of nanoscience and nanotechnologies. Further, I express my gratitude and appreciation to all the members of the local organizing committee, without whose hard work and dedication the conference would have not been possible. I sincerely wish you a very productive conference, one that will support the safe, integrated, and responsible development of nano-biotechnology for agriculture.

Dr. Pushplata Singh
Conference President

Conference at a glance

Twenty-first century is witnessing a scientific and industrial revolution as a consequence of the manipulation of matter at the nanometric level. This rising discipline (i.e. nanotechnology), is expounded to the practices for planning, fabricating, measuring and manipulating matter at the nanometre (nm) scale, grows at a thoughtless pace and unique phenomena enable novel applications.

In agriculture, nanotechnology is very relevant as worldwide demand for food has urged for increase in production and better protection of agricultural crops and this in turn demanded excessive use of chemicals. This is creating nutrient imbalance in soil, leaching losses, consequent reduced productivity, and associated environmental problems. Nanobiotechnology offers state-of-the-art solutions for precision farming, targeted/ controlled delivery of inputs, improving soil and plant health, and more importantly need-based application of inputs for improved productivity and efficiency.

The international conference on 'NANOFORAGRI 2021': "Technology Readiness and Overcoming Regulatory Barriers to Implement Nanotechnology-Enabled Agriculture for Sustainable Future" organized by TERI Deakin Nanobiotechnology Centre, TERI in partnership with Department of Biotechnology, Government of India, will be a unique Virtual International meeting exclusively dedicated to the application of nanoscale science and technology in re-engineering the quality, quantity and safety of agricultural and food systems. Due to the current global situation with the COVID-19 pandemic, the conference will be a hybrid event bringing together highly accomplished experts with diversified backgrounds across the globe. The event will be of truly interdisciplinary in nature and encompassing basic studies, applications, global challenges and globally harmonized systems for nano solutions for agriculture and food systems. Domain experts from across the globe will deliver talks on the session themes. Day 1 will host three thematic scientific sessions on Advances in Nano-fertilizers and Nano-pesticides Systems; Smart Delivery, Sensing and Precision Engineering; Perceptions amongst farmers, Industries and Field Trials followed by Oral pitch by young scientists. Day 2 will include three thematic sessions followed by panel discussion and e-poster presentations. The second day sessions will further focus on regulatory aspects of nanotechnology, advancement in seed treatments and bio-derived nanoagri-products. This conference aims to provide a potential platform for the young researcher and budding scientist to keep pace with the latest developments in the emerging areas of Agri-Nanotechnology. The event will cover the Science-Society-Policy Interface for Agriculture and Food Nanotechnology. This conference will also involve thought-provoking panel discussions in the related fields and also focus of developing technologies and fostering innovation in agricultural research.

Foreword

Web www.teriin.org

The Energy and Resources Institute
Darbari Seth Block
I H C Complex
Lodhi Road
New Delhi – 110 003
Tel. 2468 2100 or 7110 2100
E-mail mailbox@teri.res.in
Fax 2468 2144 or 2468 2145
India +91 • Delhi (0) 11

Regional centres within India

North-Eastern Regional Centre
Guwahati
Tel. (361) 233 4790
E-mail terine@teri.res.in
Fax (361) 233 4869

Southern Regional Centre
Bangalore
Tel. (80) 2535 6590 (5 lines)
E-mail terisrc@teri.res.in
Fax (80) 2535 6589

Goa
Tel. (832) 245 9306 or 245 9328
E-mail terisrc@teri.res.in
Fax (832) 245 9338

Western Regional Centre
Mumbai
Tel. (22) 2758 0021 or 4024 1615
E-mail terimumbai@teri.res.in
Fax (22) 2758 0022

Himalayan Centre
Mukteshwar
Tel. (5942) 286 433
E-mail praveen.sharma@teri.res.in
Fax (5942) 286 460/433

TERI worldwide

TERI **North America**
Tel. (+91) 9811150290
E-mail
annapurna.vancheswaran@terina.org

TERI **Japan**
Tokyo
Tel. (+81 3) 3519 8970
E-mail teri@iges.or.jp
Fax +81 33 5195 1084

Dr. Vibha Dhawan

The agriculture sector is not immune to the challenges posed by an ever-increasing population and deteriorating ecosystems. There is a pressing need to develop technologies that harmonize with nature, value diversity, and provide resilience in critical times of rapid climate change. TERI was recently well-represented at COP26 in Glasgow, where it was strongly implied that "while agriculture is a victim of climate change, it also contributes to it." This personifies the challenges associated with agriculture's current state, even more necessitating the development of more sustainable alternatives to current practices.

Aligning with the United Nations Sustainable Development Goals, TERI seeks to aid transitions to a more sustainable future by implementing novel methods of increasing agricultural productivity. In pursuit of this goal, we are using nanotechnology to improve agricultural inputs. Our path to success in developing nano-enabled agriculture is a result of interdisciplinary and integrated research and analyses; lab to field transitions; decision making, policy advisory and consultancy; capacity building, and collaboration with national and international stakeholders.

Our sustainable agriculture division is dedicated to provide novel solutions to existing agricultural practices. The TERI Deakin Nanobiotechnology Centre (TDNBC) is actively involved in developing innovative nanobiotechnology-based solutions to address current challenges in agriculture and the environment. The activities of the centre are supported by researchers from TERI in India and Deakin University in Australia. The TDNBC has developed capabilities in research, policy, consultation, and large-scale production of nano-based agricultural products. The centre has fostered several national and international collaborations to achieve sustainable agricultural solutions using nanotechnology by establishing several platforms and fora. The TDNBC has cutting-edge infrastructure for the research, development, and translation of nano-products for fertilizer, pesticide, and technology for seed coating and slow nutrient delivery.

The 5th annual International Conference 'NANOFORAGRI 2021' having its nodal head as TDNBC is based on 'Technology readiness and overcoming regulatory barriers to implement nanotechnology-enabled agriculture for sustainable future'. The conference focuses on the "UN Sustainable Development Goal: End hunger, achieve food security, and promote sustainable agriculture". This conference brings policymakers, funding agencies, regulators, researchers, and industries under one roof to discuss ground breaking research towards a nano-driven shift in agricultural practices.

I would like to take this opportunity to thank all the funding agencies, collaborators, industrial partners, and colleagues who helped to organise this important event. I extend my best wishes to all the speakers and young researchers. I look forward to the success of NANOFORAGRI 2021.

Dr. Namrata Pathak
Sci – F & Associate Head
Senior Director, Nano Mission
Ministry of Science & Technology
Department of Science & Technology
Technology Bhavan, New Mehrauli Road
New Delhi-110016

प्रौद्योगिकी मिशन प्रभाग
विज्ञान और प्रौद्योगिकी विभाग,
विज्ञानं एवं प्रौद्योगिकी मंत्रालय
भारत सरकार, नई दिल्ली – ११००१६

Foreword

One of the United Nations' sustainable development goals is "***Zero Hunger***," which can be achieved through sustainable agriculture. At present, agricultural practices consume a staggering number of resources and are under tremendous stress, compromising food quality and quantity. This situation necessitates significant changes in the global food production systems. Currently, crop production and protection with a focus on nanofertilizers, nanopesticides, nanobiosensors, and nano-enabled remediation strategies for contaminated soils, is among one of the most recent developments in **nano based technological applications** in this sector. Undoubtedly, **Nanotechnology** holds an enormous potential in promoting sustainable agriculture.

DST's Nano Mission (NM) is an umbrella program for overall development of research in the field of nanotechnology in the country. It has established numerous Centers of Excellence, cutting-edge facilities & infrastructure and facilitated international collaborations towards advancement of Nano science and technology. Recently, NM through a special thematic call invited proposals on, **'NANO in Agriculture'** and received an overwhelming response from across the country.

To facilitate application/ translation of Nano technology , through rigorous efforts and contributions from scientific experts , researchers, ministerial members, regulators and other stakeholders , '***Guidelines for evaluating nano-based agri-inputs and food products in India',*** was successfully brought out, Year 2020 .TERI's contribution to the same was commendable. I applause TERI Deakin Nanobiotechnology Center for conceptualizing development of novel nano agri-inputs, assessing their efficacies and environmental behavior and working to translate these products to support the overburdened agricultural sector.

This event, 'Nanoforagri-21' is an excellent interface for national and international scientists/academicians, budding researchers, industrialists, funding agencies, and regulatory bodies working towards application of nano biotechnology to support and promote agriculture. Let us avail this opportunity to build and strengthen our collaborations to further advance the transdisciplinary field of nano-based agriculture. I wish this conference a stupendous success.

नमृता पाठक

(Namrata Pathak)

Tele : 011-26590367 , 26522815 Email : namrata.pathak@gov.in

Foreword

Web www.teriin.org

The Energy and Resources Institute
Darbari Seth Block
I H C Complex
Lodhi Road
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Tel. 2468 2100 or 7110 2100
E-mail mailbox@teri.res.in
Fax 2468 2144 or 2468 2145
India +91 • Delhi (0) 11

Regional centres within India

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Guwahati
Tel. (361) 233 4790
E-mail terine@teri.res.in
Fax (361) 233 4869

Southern Regional Centre
Bangalore
Tel. (80) 2535 6590 (5 lines)
E-mail terisrc@teri.res.in
Fax (80) 2535 6589

Goa
Tel. (832) 245 9306 or 245 9328
E-mail terisrc@teri.res.in
Fax (832) 245 9338

Western Regional Centre
Mumbai
Tel. (22) 2758 0021 or 4024 1615
E-mail terimumbai@teri.res.in
Fax (22) 2758 0022

Himalayan Centre
Mukteshwar
Tel. (5942) 286 433
E-mail praveen.sharma@teri.res.in
Fax (5942) 286 460/433

TERI worldwide

TERI **North America**
Tel. (+91) 9811150290
E-mail
annapurna.vancheswaran@terina.org

TERI **Japan**
Tokyo
Tel. (+81 3) 3519 8970
E-mail teri@iges.or.jp
Fax +81 33 5195 1084

Dr Pushplata Singh, Director, TERI-Deakin Nanobiotechnology Centre (TDNBC) & Conference President

On behalf of the TERI Deakin Nanobiotechnology Centre, I express my delight to address the 5th Annual International Conference NanoforAgri2021. This year, the conference focuses on Technology readiness and overcoming regulatory barriers to implement nanotechnology-enabled agriculture for sustainable future. The two-day International Conference will focus on the world's readiness for achieving the UN's Sustainable Development Goal: End hunger, achieve food security, and promote sustainable agriculture, through the application of nanotechnology.

Minimum input agrochemicals should be considered as one of the bases for adapting sustainable technologies. To minimise the inputs and maximise outputs, nanotechnology based solutions can be used. Nanotechnology in agriculture can considerably improve the efficiency of agricultural inputs, and so nanoparticles offer a key means to maintain the long-term development of agroecosystems. Nanofertilisers, nano-pesticides, nano-herbicides, agrochemical encapsulated smart nanocarrier systems, and other agricultural nanotechnologies can contribute to higher crop output by reducing abiotic and biotic stress. These low agri-inputs will result in reduced production costs and higher net returns. Further to add to safer production, novel methods of biosynthesis of nano agri-inputs can result in reduced carbon footprints.

With the brainstorming sessions, this conference will bring together highly accomplished experts with diversified backgrounds across the globe and showcase breakthrough research towards nano-driven shift in agriculture practices. The event will be of high importance to all stakeholders involved in NanoAgriculture encompassing the researchers and industries having recently developed nanotechnologies, and regulators and farmers. I look forward to the success of the 'NANOFORAGRI 2021' in providing a robust scientific platform to the most proficient scientists, industrial representatives, and motivated young researchers in the field of nano-enabled agriculture.

Foreword

The 5th International NanoforAgri2021 continues the series of annual conferences convened by the TERI-Deakin Nanobiotechnology Centre, dedicated to discovering novel ways to improve agricultural practices and enhance crop productivity. Given climate change impacts, our growing world population and a disease pandemic there is probably no other time in our recent history that has been more important for the development and application of nanobiotechnology to address agricultural problems.

Through the conference theme of 'Technology readiness and overcoming regulatory barriers to implement nanotechnology-enabled agriculture for sustainable future' NanoforAgri2021 brings together a wide range of scientists and practitioners from Universities, Industry and Government. Nano-approaches and applications for sustainable agriculture have been showcased across a rich program of presentations and discussion sessions. Integral to the program are those presentations by our next and younger generation of researchers through specific interactive oral and poster sessions.

The major topics that are explored at the conference this year centre around nano-fertilisers and nano-pesticides, smart delivery, sensing and precision engineering, stakeholder perceptions, advances in seed treatment and bio-derived nano-agri products.

I commend this NanoforAgri2021 e-abstract book to all those who have an interest in new and novel ways that nanotechnology can be used for a more productive, sustainable and healthier agriculture future.

Professor David Cahill

Deakin University

Rakesh Daultabad
MLA Badshahpur
Chairman, Haryana Agro Industries Corporation

राकेश दौलताबाद
विधायक बादशाहपुर विधानसभा
चेयरमैन, हरियाणा कृषि उद्योग निगम

Office :
Z-1, New Palam Vihar, Gurugram
Haryana 122017

कार्यालय :
जेड-1, न्यू पालम विहार, गुरुग्राम
हरियाणा 122017
मों. 9873646621

Ref. No.: 2020-21/506

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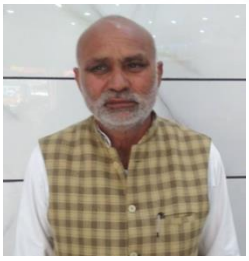
प्रस्तावना

कृषि देश की अर्थ वयवस्था के समग्र विकास की कुंजी है । विज्ञान और प्राध्योगिक के परिवर्तन के वाहक है और नैनो तकनीक दुनिया भर में स्थायी कृषि चिंताओ को दूर करने का एक वैकल्पिक समाधान है। भारत नैनो टेक्नोलॉजी के शेत्र में तीसरे नंबर पर है और कृषि और खाद्य के विकास में महत्वपूर्ण प्रगति कर रहा है। नैनो बायोटेक्नोलॉजी में उत्पादकता में वृदि और बेहतर फसल सुरक्षा के माध्यम से कृषि उत्पादन में सुधार करने की क्षमता है , जिससे ना केवल जलवायु परिवर्तन के कारण बदलती जरूरतों को पूरा किया जा सकता है बल्कि बढती आबादी को भोजन उपलब्ध कराने की भी आवश्यकता भी है और इस प्रकार भारत में सामाजिक विकास ,अर्थ व्यवस्था और व्यापार को प्रभावित करता है.

मुझे ये जानकार प्रसन्नता हो रही है की कृषि और खाद्य में नैनो आधारित उत्पादों के महत्व को ध्यान में रखते हुए टेरी-डीकिन नैनो बायोटेक्नोलॉजी सेंटर 5वें अन्तरराष्ट्रीय सम्मेलन नैनो फॉर एग्री 2021 का आयोजन कर रहा है जो निश्चित रूप से नैनो - आधारित उपन्यास उत्पादों,प्रक्रियाओं के विकास की दिशा में अनुवाद संबंधी अनुसन्धान की सुविधा प्रदान करेगा और कृषि और खाद्य शेत्र के लिए समाधान करेगा।

मैं उन सभी को बधाई देता हूँ जो वैश्विक स्तर पर इस महवपूर्ण कार्यक्रम के आयोजन में शामिल रहे है और योगदान दिया है ।

राकेश दौलताबाद
विधायक बादशाहपुर
चेयरमैन - हरियाणा कृषि उधोग निगम
Rakesh Daultabad
MLA, Badshahpur, Gurugram
Chairman, Haryana Agro
Industries Corporation



प्रस्तावना

नैनोबायोटेक्नोलॉजी में स्थायी खाद्य और कृषि के संबंधित उपयोग से स्पष्ट बदलाव की क्षमता है जो मानव जाति के लिए अत्यंत महत्वपूर्ण है। हरित क्रांति का युग, अधिक उपज देने वाली किस्में और इनपुट गहन प्रौद्योगिकियां बेहतर इनपुट और वितरण प्रबंधन के लिए स्मार्ट और सटीक कृषि का मार्ग प्रशस्त कर रही हैं, जो वर्तमान और भविष्य की पीढ़ी की खाद्य प्रणालियों की उत्पादकता: और सुरक्षा सुनिश्चित करती हैं। इस संदर्भ में, नैनो तकनीक प्रासंगिक प्रतीत होती है।

मैं टेरी-डीकिन नैनोबायोटेक्नोलॉजी सेंटर को नैनोफोराग्रि 2021सम्मेलन के आयोजन के लिए पहल करने के लिए बधाई देता हूं, जिसका उद्देश्य कृषि के क्षेत्र में नई नैनो-तकनीकी प्रगति पर चर्चा और बढ़ावा देने के लिए एक मंच प्रदान करना है। इसके अलावा नीति निर्माताओं और नियामक प्राधिकरणों को उन चुनौतियों को समझने में मदद करने के लिए जिन्हें इस तरह के तकनीकी हस्तक्षेपों की प्रभावकारिता और सुरक्षा सुनिश्चित करने के लिए संबोधित करने की आवश्यकता है। नैनोटेक्नोलॉजिकल प्रगति के प्रति अपनी अंतर्दृष्टि साझा करने के लिए योगदानकर्ताओं की उदारता की बहुत सराहना की जाती है। इस तरह के हस्तक्षेप से राष्ट्रों को आर्थिक विकास और कृषि उत्पादकता में सुधार करने में मदद मिलेगी।

कंवल सिंह चौहान

Biological Agri Solutions Association of India
Mailing Address: 263, Sector-28, Faridabad
121008 (Haryana) INDIA
Website: www.basai.org
Email: ceo@basai.org
Cell no. +91 9910700583

Vipin Saini
CEO-BASAI

FOREWORD

The recent pandemic of this century has left the world devastated in all phases of economical, socio-political, and geopolitics in any or all terms associated with National Security. This has added up to our ongoing concerns with respect to climate change with similar concerns. Agriculture as per se plays an important role not just in terms of achieving food & nutritional security but overall, in raising the economic power of any nation as a whole. Anticipating that the world may have to address the challenge of feeding a population that may reach 11 billion or so by 2100 from the current 7.9 billion mark. Nanotechnology is yet another technological tool raving to address such concerns. Production of sufficient food to feed the ever-growing population posed amongst the challenges of the impact of climate change in attaining sustainable agriculture, but of the critical safety concerns too.

New technological introductions, once proven to be commercially advantageous & viable in its own right, the challenges of its judicious risk assessment arise. The need to regulate such technological advances with respect safety, efficacy and environmental impact proves to be a challenging task due to its multi-dimensional aspects.

This 5th NANOFORAGRI 2021(Innovations for Future e-abstract book is a reflection of TERI Deakin Nanobiotechnology Centre's tradition of optimism in providing a platform to discuss and promote new nanotechnological advancements in the field of agriculture. Further to help the policy makers and regulatory authorities to understand the challenges that need be addressed to ensure efficacy & safety of such technological interventions. Generosity of the contributors to share their insights towards nanotechnological advancements is much appreciated. Such interventions will help nations in economic growth and improved agricultural productivity.

Vipin Saini

Thematic Sessions

PART-A

Session 1

Advances in Nano-fertilizers and Nano-pesticides

Session 2

Smart Delivery, Sensing and Precision Engineering

Session 3

Perceptions amongst farmers, Industries and Field Trials

Scientists Oral Pitch

PART-B

Session 4

Regulatory Aspects of Nanotechnology

Students Oral Pitch Presentations

Session 5

Advances in seed treatment

Session 6

Bio derived nano-Agri input products

ABOUT TERI

We are an independent, multi-dimensional organization, with capabilities in research, policy, consultancy and implementation. We are innovators and agents of change in the energy, environment, climate change and sustainability space, having pioneered conversations and action in these areas for over four decades.

We believe that resource efficiency and waste management are the keys to smart, sustainable and inclusive development. Our work across sectors is focused on

- Promoting efficient use of resources
- Increasing access and uptake of sustainable inputs and practices
- Reducing the impact on environment and climate

Our research, and research based solutions have had a transformative impact on industry as well as communities. We have fostered international collaboration on sustainability action by creating a number of platforms and forums. We do this by translating our research into technology products, technical services, as well as policy advisory and outreach.

Headquartered in New Delhi, we have regional centres and campuses in Gurugram, Bengaluru, Guwahati, Mumbai, Panaji, and Nainital. Our 1200-plus team of scientists, sociologists, economists and engineers delivers insightful, high quality action-oriented research and transformative solutions supported by state- of-the-art infrastructure.

Our Mission

Our mission is to usher transitions to a cleaner and sustainable future through the conservation and efficient use of Earth's resources and innovative ways of minimizing and reusing waste.

Our Goals

We pursue our mission by working towards the following key goals:

- Enhancing access to clean energy for all
- Helping a global transition to renewable energy pathways
- Enhance energy efficiency, especially in industries, public utilities and buildings
- Facilitating more efficient use of materials, especially iron and cement
- Enhancing conservation, utilization of and access to water, including watershed management

- Enabling the planning and governance of environmentally sustainable cities through green buildings and through management of solid waste, sewage, sanitation, mobility and air quality
- Building resilience to adverse impacts of climate change due to cyclones and variations in hydrology and temperature
- Accelerating pollution abatement through innovative policies and environment treatment products
- Enhancing ecosystem services, especially in forestry and biodiversity
- Developing green mobility solutions
- Enabling sustainable food production and nutritional security through quality planting material, bio-based agricultural inputs and crop diversification
- Developing innovative solutions for clean air, regionally and in cities

Our Methods

Our success of over four decades is a result of a multitude of approaches:

- Interdisciplinary and integrated research and analyses
- Evidence and data based decision making
- Taking solutions from lab to pilot and field scale
- Early validation of business models
- Enhancing livelihood through new technologies and practices
- Policy advisory and consultancy
- Education and outreach to influence decisions and consumer behavior
- Capacity building and handholding of stakeholders
- Partnerships across stakeholders, nationally and internationally

Our Promise

In all the work that we do, we fulfil one or more of the following promises:

- Increasing sustainable inputs
- Promoting resource use efficiency
- Reducing adverse impacts on environment and climate
- Increasing access to basic services
- Upscaling and enhancing uptake of resource efficient and waste management solutions

ABOUT SUSTAINABLE AGRICULTURE PROGRAM

A number of global trends are influencing food security, poverty and the overall sustainability of food and agricultural systems. The world's population is expected to grow to almost 10 billion by 2050, boosting agricultural demand – in a scenario of modest economic growth – by some 50 percent compared to 2013. Income growth in low- and middle-income countries would hasten a dietary transition towards higher consumption of meat, fruits and vegetables, relative to that of cereals, requiring commensurate shifts in output and adding pressure on natural resources. The decline in the share of agriculture in total production and employment is taking place at different speeds and poses different challenges across regions. Satisfying increased demands on agriculture with existing farming practices is likely to lead to more intense competition for natural resources, increased greenhouse gas emissions, and further deforestation and land degradation.

High-input, resource-intensive farming systems, which have caused massive deforestation, water scarcities, soil depletion and high levels of greenhouse gas emissions, cannot deliver sustainable food and agricultural production. Needed are innovative systems that protect and enhance the natural resource base, while increasing productivity and reducing losses (post-harvest, disease/pest, storage, transportation etc). Needed is a transformative process towards 'holistic' approaches, such as agroecology, agro-forestry, climate-smart agriculture and conservation agriculture, which also build upon indigenous and traditional knowledge. Technological improvements, along with drastic cuts in economy-wide and agricultural fossil fuel use, would help address climate change and the intensification of natural hazards, which affect all ecosystems and every aspect of human life. Greater international collaboration is needed to prevent emerging transboundary agriculture and food system threats, such as pests and diseases.

Agriculture accounts for 46% of land use in India with more than 54% of the workforce being dependent on agriculture for their livelihoods and sustenance. The Indian Government has three objectives: food security, food self-sufficiency, and income support for farmers and thus Government missions like Doubling farmer's income by 2022. National Mission for Sustainable Agriculture (NMSA) and Women in Agriculture are giving a major agriculture impetus to the country. With Make in India initiative, agri-industries are also on rise. Thus, Indian agriculture has the potential to impact global agriculture.

Sustainable Agriculture Program of TERI has a vision to identify and develop new ways of farm profitably while conserving natural resources. As a programme, we have a solid and optimally robust foundation to deliver on our ambitions for defined streams. We have optimally diverse expertise to address contemporary problems in most of the main themes of Agriculture, Environment and Bioenergy. We have most opportunistic and diverse superior gene pools (World's biggest mycorrhizal germplasm and functionally superior bacterial cultures, superior quality planting material from micro propagation, molecular assisted breeding and genetic modification) and world class infrastructure with globally acceptable accreditations and that too, under a single roof. Our capabilities and skills for local and global networking with industry and academia are also very strong to accomplish programme goals. We have successful, sustained and credible technology transfer, end to end services offered, 300 + publications, 11 patents, National and international awards, product validations by most credible stake holders POPs and FCO inclusion of products and processes, farmers field demonstrations across different agro-climatic regions of India, Europe, and North America.

We are Global Leading Technology developer/partner and Centre of Excellence for Future and Next Generation Innovations/Innovators in Sustainable Agriculture,

- with a mandate of focused research in frontier areas of precision and smart agriculture, bio-inputs, plant science, synthetic biology and nanotechnology
- to innovate smart materials and formulations from untapped natural/waste resources and green technologies
- for food and nutritional security, eco-compatible climate resilient farming, nutrient, water and energy use efficiency, carbon minimal energy, contribution to bio-economy, develop future food ingredients and nutraceuticals with economic feasibilities, convert wasteland/environmentally degraded land into productive land with added product, enhancing livelihood opportunities
- to contribute to the bio-based economy in the agriculture sector, with a view to expanding local, regional, national and export markets.

ABOUT TERI DEAKIN NANOBIOTECHNOLOGY CENTRE (TDNBC)

TERI-Deakin Nano-biotechnology Centre (TDNBC) was established through the joint venture between India's research think-tank TERI and Australia's Deakin University. TDNBC came into existence in 2010 at TERI's green campus in Gurugram, Haryana with the aim to establish world-class facilities for Nanobiotechnology research using Next Generation Methodologies to create innovative and green solutions to challenges and pressing problems in the field of agriculture, environment, bioenergy and human health with a common vein "Nano-science". The Centre has been making significant strides in developing nanonutrients, nanopesticides and nanoformulations. Keeping in mind deteriorating soil health, growing demand of food, water safety are the biggest challenges, the Centre is uniquely poised to develop path breaking technologies using biological interwoven with nanotechnologies and biocompatible materials. Such activities are being pursued jointly through strategic collaborations with Deakin University and partners worldwide.

Research Areas

- Bioinformatics, computational and statistical approaches in biology
- Nanomaterials in Agriculture
- Regulatory tools and biosafety
- Future Bioformulations
- Seed coating of high value crops
- Nanomaterial based diagnostics and early detection of diseases
- Mycorrhizal elicitation of medicinal molecules from plants
- Post-harvest management
- Utilizing algae as bio factories for novel products, bioactives, biofuel and
- Improving algal biomass
- Plant-made pharmaceuticals
- Toxicity and Impact assessment of Nanoparticles

ABOUT NATIONAL CENTRE OF EXCELLENCE FOR ADVANCED RESEARCH IN AGRICULTURAL NANOTECHNOLOGY (CoE)

The National Centre of Excellence (CoE) for Advanced Research in Agricultural Nanotechnology is the first of its kind in India, which endeavors to carry out end-to-end research to develop next generation nano-fertilizer, nano-pesticide and nanocarrier products and technologies. The developed products would hold promise for significantly higher efficacy and reduced risk to human health and environment. Research for complete development of novel agricultural products along with their toxicity estimation in human and environmental systems and multiple field-trials would enable meeting regulatory compliance and acceptance among stakeholders for these novel products.

The Centre aims to lead the country in Agricultural Nanotechnology and to innovate nanoagriproducts of national importance. The nano-agriproducts developed under the core theme of the CoE project would hold promise for significantly higher efficacy and reduced risk to human health and environment in comparison to their bulk-counterparts. The DBT supported “National facility for Nanotoxicology Research of Nano-Agriproducts ” as a part of the CoE project further complements the end-to-end research activities for complete product development. Toxicity estimation in human and environmental systems and multiple field-trials of the nano-agriproduct as a part of this CoE mission would enable complete development of novel agricultural products that are ready for farmers and other stakeholders.

About DBT -TDNBC - DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA)

TERI-Deakin Nanobiotechnology Centre (TDNBC), Gurugram, India and Deakin University, Australia, in association with Department of Biotechnology, Govt. of India has created “DBT -TDNBC - DEAKIN – Research Network Across continents for learning and innovation (DTD-RNA)”. This network was launched at TERI Gram, Gurugram, Haryana, on September 3, 2019 (https://www.teriin.org/projects/dtd-rna/). This newly developed network is creating joint labs as country hubs and network of research institutions across all continents with the view integrating strengths from TDNBC India and Deakin University, Australia to develop International Centre for Translational Research for research training and education in biological synthesis of Nano materials. Different institutes and countries have been contacted for joining the network for jointly undertaking cutting edge research projects to train young global students, postdoctoral fellows for collaborative research, high end technologies for basic to advanced level of research (joint research publications), to impart education and training (joint research mentorship), workshops and networking (joint workshop/ training).

LOCAL ORGANIZING COMMITTEE

Nanoforagri 2021 President: Dr Pushplata Singh

Organizing Secretaries: Dr Palash K Manna, Dr Rita Choudhary, Dr Shruti Shukla, Dr Amritpreet Kaur, Dr Ruchi Agarwal, Dr Suneeti Singh

Registration and Product Display Management: Ms Suraksha Dhingra, Dr Ankit Kumar Mehta, Mr Chandrakant Tripathi, Mr Vikas Bhati, Ms Divya Srivastava, Mr Robin Thomas, Mr. Lalu Prasad, Mr Yeshpal Sharma

Abstract book and Brochures: Dr Rita Choudhary, Dr Amritpreet Kaur, Dr Shovon Mandal, Dr Mandira Kochar

Logistics, Speaker Coordination and Facility Management: Mr Chandrakant Tripathi, Mr Deepak Kumar, Mr Wilfred Dias, Mr Vinay Pathak, Mr Suresh Dev, Mr Vikas Bhati, Dr Sangram Keshari Lenka, Dr Mukul Kumar Dubey, Dr Neeraj Dwivedi, Dr Shayam Sundar Sharma, Dr Leena Johny, Ms Ayushi Priyam, Ms Suraksha Dhingra, Ms Neha Khandelwal, Ms Sadhna Shukla, Dr Pallavolu Maheswara Reddy, Dr Vatsala Koul, Mr Indra Singh, Mr Raj Kamal Jha, Mr Rahul Chandra Mishra, Mr Hetram, Mr Purna Chandra Prusty, Ms Deep Rajini, Ms. Suchitra Gaur, Mr Vir Bhadur, Mr Rahul Kumar, Mr Arvind, Ms. Sonal Bajaj, Ms Ritu Ghai, Mr. I I Jose, Ms Ruby Banerjee,

Website: Ms Dolly Sangle

NANOFORAGRI 2021:

Technology Readiness and Overcoming Regulatory Barriers to Implement Nanotechnology-Enabled Agriculture for Sustainable Future

8th December, 2021

Day 1	8th December 2021
08:30 AM – 09:30 AM	REGISTRATION
09:00AM – 09:05 AM	**OPENING OF NANOFORAGRI - 2021** Welcome – Dr Pushplata Singh, Director, TERI-Deakin Nanobiotechnology Centre (TDNBC), TERI, Gurugram Haryana, India
09:05 AM – 10:15 AM	**Session I - Advances in Nano-fertilizers and Nano-pesticides**
	Chair – Prof. David Cahill, Personal Chair, Deakin University, Australia Rapporteur – Dr. Ruchi Agrawal, TDNBC, Gurugram Haryana, India
09:05 AM – 09:20 AM	**Keynote Speaker** **Nanonutrients for crop production and plant protection** Dr J C Tarafdar, Former ICAR Emeritus Scientist, Central Arid Zone Research Institute (CAZRI), Jodhpur, India.
09:20 AM – 09:35 AM	**Agri Nanomaterials for sustainable agriculture: Advantages and limitations** Dr Pushplata Singh, Director, TDNBC, TERI, Gurugram, Haryana, India
09:35 AM – 09:50 AM	**Indo-Norway Scientific Collaboration: Activities and Opportunities** Dr Maan Singh Sidhu, Science and Technology Counsellor, Royal Norwegian Embassy, New Delhi, India
09:50 AM – 10:05 AM	**Efficacy-Biosafety-Toxicity of Nanofertilizers – IFFCO's Experience** Dr Tarunendu Singh, Head (Agriculture Services), IFFCO Sadan, New Delhi, India
10:05 AM – 10:20 AM	**Nano-driven Farm Inputs** Shri Sagar Kaushik, UPL Limited, Mumbai, India
10:20 AM – 10:30 AM Panel Discussion	**Advances in Nano-fertilizers and Nano-pesticides** Panelists: Speakers from the session Moderator: Dr Anand Gole, Coromandel International Limited, Hyderabad, India

10:30 AM – 11:35 AM	**INAUGURAL SESSION**
10:30 AM – 10:35 AM	Arrival of Dignitaries, Felicitation and Lamp Lighting
10:35 AM – 10:40 AM	Welcome Address Dr Vibha Dhawan, Director General, TERI, India
10:40 AM – 10:45 AM	Keynote Address Dr Namrata Pathak, Technology Mission Division (Nano Mission), Department of Science & Technology, India
10:45 AM – 10:50 AM	Relevance of the Conference Dr A. K. Singh , Director IARI, India
10:50 AM- 10:55 AM	Special Address Dr S.K.Malhotra, Agriculture Commissioner, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture and Farmers Welfare, India
10:55 AM - 11:00 AM	Special Address Prof Julie Owens(Virtual), Deputy Vice-Chancellor Research and Alfred Deakin Professor, Deakin University, Australia
11:00 AM- 11:05 AM	Special Address Prof Bas Baskaran(Virtual), Pro Vice Chancellor International Research Partnerships, Deakin University, Australia
11:05 AM- 11:10 AM	Chief Guest Mr Mathew Johnston, Minister-Counsellor (Education & Research) for South Asia, Australian High Commission, India
11:10 AM- 11:15 AM	Special Address Mr Rakesh Daultabad, MLA, Chairman of Haryana Agro Industries Corporation, India
11:15 AM – 11:20 AM	Dr Rashmi Sharma, Department of Science & Technology, Technology Bhawan, India
11:20 AM – 11:25 AM	Special Address Mr. Kanwal Singh Chauhan, Padma Shri Awardee, Haryana, India
11:25 AM – 11:30 AM	Vote of Thanks Dr Pushplata Singh, Director, TDNBC,TERI, Gurugram, Haryana India

11:30 AM – 12:00 AM	HIGH TEA

12:00 PM – 02:10 PM	**Session II – Smart Delivery, Sensing and Precision Engineering**
Chair: Prof H.B. Bohidar, TDNBC,TERI, Gurugram, Haryana, India Rapporteur : Dr Rita Choudhary, TDNBC, TERI, Gurugram, Haryana, India	
12:00 PM – 12:15 PM	**Nanomaterials for enhanced photosynthesis, drought tolerance and plant protection** Prof David Cahill, Personal Chair, Deakin University, Australia
12:15 PM – 12:30 PM	**Nanopolymers for agri-input delivery: advances and future outlook** Dr Dhruba Jyoti Sarkar, Scientist, ICAR-Central Inland Fisheries Research Institute, Kolkata, India
12:30 PM – 12:45 PM	**Development Of Doped Calcium Phosphate Nanofertilizers: From the Chemical Bench to Field Tests** Prof Norberto Masciocchi, Università Degli Studi dell'Insubria, Italy
12:45 PM – 01:00 PM	**Production And Utilization of Nanocellulose and Nanochitosan for Edible Coating** Dr Erwann Guénin, Professor, Université de Technologie de Compiègne, ESCOM, France
01:00 PM – 01:15 PM	**Nanomaterials and nanotechnology – enabling technology for a sustainable agriculture future** Dr Lingxue Kong, Professor, Institute of Frontier Materials, Deakin University, Australia
01:15 PM – 01:30 PM	**Developing Nano-Delivery Systems for Agriculture and Food Applications** Prof Neena Mitter, Director, Centre for Horticultural Science at Queensland Alliance for Agriculture and Food Innovation, University of Queensland, Australia
01:30 PM – 01:45 PM	**Sensing makes Sense using AI and Nano-range Sensors for Precision Agriculture** Dr Arun Banerjee, Team Lead, Reliance Industries Limited, Mumbai, India
01:45 PM – 02:00 PM	**Development of an intelligent geo-spatio temporal decision platform for farmer collectives** Dr Sarabjot Singh Anand, Co-founder and Chief Data Scientist, TATRAS, New Delhi, India
02:00 PM – 02:10 PM Panel Discussion	**Delivery Systems for agrochemicals** Panellist: Shri Sagar Kaushik, UPL Limited, Mumbai, India, Dr Manoj Varma, Indian Institute of Science, Bangalore, India, India and Speakers from the Session Moderator: Dr Shruti Shukla, TDNBC, TERI, Gurugram, Haryana, India
02:10 PM – 03:00 PM	**LUNCH**
03:00 PM – 04:25 PM	**Session III : Perceptions amongst farmers, Industries and Field Trials**
Chair: Dr Mandira Kochar, TDNBC, TERI, Gurugram, Haryana, India Rapporteur: Dr Palash K Manna, TDNBC, TERI, Gurugram, Haryana, India	
03:00 PM – 03:15 PM	**Bio-Agriculture in India-An industry perspective** Shri Dhananjay Edakhe, Senior VP-Sales & Marketing (Agri Solutions), Zydex Industries, Pune, India
03:15 PM – 03:30 PM	**Carbon based agriculture nano-technologies- regulatory limitations and ways to overcome** Dr P S Vijayakumar, Scientist, INST, Mohali, India

03:30 PM – 03:45 PM	Dr Anand Gole, GM R&D - Fertilizers & Speciality Nutrients, Coromandel International Limited, Secunderabad, Telengana, India
03:45 PM – 04:00 PM	Dr Naresh Prasad, Deputy General Manager, Chambal Fertilizers & Chemicals Limited, Ghaziabad, India
04:00 PM – 04:15 PM	**Inspirational talk for agricultural community** Mr Kanwal Singh Chauhan, Padma Shri Awardee, Haryana, India
04:15 PM – 04:25 PM Panel Discussion	**Perceptions amongst farmers, Industry and Field Trials** Panellists: Dr Jim Rookes, Deakin, Australia; Dr Sandeep Lal, IARI, Ms Nidhi Mathur, Investment Professional (Venture Capital), Axilor Ventures, Pvt Ltd, Bengaluru, India; Mr Vipin Saini, CEO-BASAI, Haryana, INDIA Speakers from the Session Moderator: Dr Palash K Manna, TDNBC, TERI, Gurugram, Haryana, India

04:30 PM – 05:30 PM	**Oral presentations by young researchers with Award (8 selected presentations)**
Each Presenter will get 5 mins to present in 3 slides each followed by a 3 mins discussion	• Preparation and characterization of nanolignins: towards supports for nanocatalysts- **Mr Zhao Zhang, Université de Technologie de Compiègne, France** • Investigation for eco-safety and transformation of potential Phosphorus based nanofertilisers by using Caenorhabditis elegans as a terrestrial model- **Ms. Ayushi Priyam, TDNBC,TERI, Gurugram, Haryana, India** • Zinc Nano- fertilization enhances wheat grain yield and zinc concentration- **Dr Achchhelal Yadav, ICAR-Indian Agricultural Research Institute, Delhi, India** • Effect of galvanotaxic graphene oxide on chloroplast activity: Interaction quantified with Biolayer-Interferometry coupled confocal microscopy- **Ms Bandana Kumari, Institute of Nano Science and Technology, Punjab, India** • Synthesis of Nano-zeolites as delivery vehicles for nutrients- **Ms Ashita Anand, TDNBC, TERI, Gurugram, Haryana, India** • Nanomaze Lure: Pheromone Sandwich in Graphene Oxide Interlayers for Sustainable Targeted Pest Control- **Ms Mahima Chandel, Institute of Nano Science and Technology, Punjab, India** • Influence of essential oils on xanthan gum-based nano-formulated edible film- **Mr Nishant Kumar, NIFTEM, Haryana, India** • Self- readable Metal Organic Framework based Immuno-probe for detection of Aflatoxin B1-**Ms Rashi, Amity University, Uttar Pradesh, India**

06:00 PM onwards	**Cocktail & Networking and Banquet Dinner at Retreat Lawns (TERI Gram)**

Day 2	9th December 2021
09:30 AM – 11:40 AM	**Session IV – Regulatory Aspects of Nanotechnology**
Chair: Dr Pushplata Singh, TDNBC, TERI, Gurugram, Haryana, India Rapporteur: Dr Leena Johny, TDNBC, TERI, Gurugram, Haryana, India	
09:30 AM – 09:45 AM	**Overview of recent Nanosafety activities for industry in Thailand** Dr Waluree Thongkam, Director, Nanosafety Alliance Department, National Nanotechnology Center (NANOTEC), Thailand
09:45 AM – 10:00 AM	**Functional Foods and Advances in Nano Delivery Systems** Dr C. Anandharamakrishnan, Director, National Institute of Food Technology, Entrepreneurship & Management (NIFTEM), Thanjavur, India
10:00 AM – 10:15 AM	**Nanopesticides: Regulatory Evaluation of Environmental Risks** Dr Rai S. Kookana, Chief Research Scientist, Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
10:15 AM – 10:30 AM	**Is there a flip side of Nano? How to limit it?** Prof Amit K Dinda, Professor and Chief Coordinator, Centre for Medical Innovation and Entrepreneurship, AIIMS, Delhi, India
10:30 AM – 10:45 AM	**Sustainable Nano fertilizers: A "Lab to field" Approach** Prof Amitava Mukherjee, Director, Centre for Nanobiotechnology (CNBT), VIT, Vellore, India
10:45 AM – 11:00 AM	**'Nano Regulations' - DST Initiatives** Dr Namrata Pathak, Associate Head and Scientist, Technology Mission Division (Nano Mission), Department of Science & Technology, New Delhi, India
11:00 AM – 11:15 AM	**Effective Co-creation Methods for Developing Nanotechnology Applications** Dr Paul Wright, FIUPAC FACTRA Associate Professor in Toxicology and Head of RMIT Nanosafety Research Group, School of Health and Biomedical Sciences, RMIT University, Melbourne, Australia Co-chair of the Asia Nano Forum (ANF) Working Group on Nanosafety & Risk Management President of the Australasian College of Toxicology and Risk Assessment
11:15 AM – 11:30 AM	**Interdisciplinary Complexities of implementing Nano Agri-input regulations in Agriculture** Mr Vipin Saini, CEO-BASAI, Haryana, India
11:30 AM – 11:40 AM Panel discussion	**Regulatory Aspects of Nanotechnology** Panellists: Dr Richard Williams, Associate Professor, Deakin University, Australia; Mr A. Kulandaivel, Rallies India Limited, Dr Dhruba Jyoti Sarkar, Scientist, ICAR-Central Inland Fisheries Research Institute; Speakers from the Session Moderator: Dr Aaron Schultz, Deakin University, Australia
11:40 AM – 12:00 PM	**Tea Break**
12:00 PM – 01:15 PM	**Session V – Advances in seed treatment**
Chair : Dr Arvind Kapur, MD, ACSEN HIVEG, Pvt Ltd, Haryana, India Rapporteur: Dr Suneeti Singh, TDNBC, TERI, Gurugram, Haryana, India	

12:00 PM – 12:15 PM	**Overview of Engineered Nanomaterials for Seed Quality Enhancement** Dr Udaya Bhaskar K., Senior Scientist, Seed Science and Technology, ICAR , MAU, India
12:15 PM – 12:30 PM	**Biopolymer- Based Nanofiber Seed Coatings** Dr Sandeep Lal, Principal Scientist, Seed Division, IARI, New Delhi, India
12:30 PM – 12:45 PM	**Integrating Nanotechnology in Seed Treatment** Mrs Ranita Das, Chief Technical Officer-International Business, Geolife Agritech India Pvt. Ltd., Maharashtra, India
12:45 PM - 01:00 PM	**Scope of Nano technology in Seed Enhancement** Dr Manish Patel, Executive Director, Incotec India Pvt Ltd., Gujarat, India
01:00 PM – 01:15 PM Panel Discussion	**Advances in seed treatment** Panellists: and Speakers from the Session Moderator: Dr Rita Choudhary, TDNBC, TERI, Gurugram, Haryana, India
01:15 PM – 02:15 PM	**Lunch**

2:15 PM – 3:25 PM	**Session VI – Bio derived nano-Agri input products**
Chair : Prof Colin Barrow, Deakin University, Australia Rapporteur: Dr Amritpreet Minhas, TDNBC, TERI, Gurugram, Haryana, India	
2:15 PM – 2:30 PM	**Increase Agricultural Productivity Without Chemical Fertilizers / Pesticides, by Boosting Photosynthesis Using a Package of Foliar Nano Nutrients** Dr T. Rangarajan, Technical Director, Nualgi Nanobiotech, Bengaluru, India
2:30 PM – 2:45 PM	**Bio derived materials for sustainable agriculture, food safety and Human Health** Dr Shruti Shukla, Senior Scientist, TDNBC, **TERI,** Gurugram, Haryana, India
2.45 PM – 3.00 PM	**Bio Derived Nano-Agri Inputs Products** Mr Dhirendra Kumar, Director of Research and Development, Natural Plant Protection Limited, Bangalore,
3:15 PM – 3:25 PM Panel Discussion	**Bio Derived Nano-Agri Inputs Products** Panellists: Dr Gunjan Mukherjee, Additional Director, Institute of Biotechnology, Chandigarh University and Speakers from the Session Moderator: Dr Mukul Kumar Dubey, Associate Fellow, TDNBC, TERI, Gurugram, Haryana, India
03:30 PM – 04:30 PM	**Poster Pitch Presentations By Young Researchers With Award (3 + 2mins; 13 selected posters)**
Each Presenter will get 3 mins to present followed by a 2 mins discussion	• Development of Dairy based Iron-vitamin C Fortified Food Ink- **Ms Shweta Rathee, NIFTEM, Haryana, India** • Microbial metabolites as emerging photosensitizers for solar cell application-**Ms Arshi Gupta, TDNBC, TERI, Gurugram, Haryana, India** • Biodegradation of Fluoroquinolone antibiotics in wastewater by enzymatic treatment with fungal laccase immobilized on magnetic nanoparticles- **Ms Purvi Mathur, TDNBC, TERI, Gurugram, Haryana, India** • Nano priming of seeds for biotic and abiotic stress management in wheat: Review- **Dr Umesh R. Kamble, ICAR, Haryana, India** • Endophytic Aspergillus terreus mediated gold nanoparticle: its antimicrobial activity against phytopathogens Fusarium oxysporum and

	Rhizoctonia solani- **Mr Rahul Chandra Mishra, TDNBC, TERI, Gurugram, Haryana, India** Fractionation and characterization of rice straw for conversion to agro-based products- **Ms Prabhpreet Kaur, TDNBC, TERI, Gurugram, Haryana, India** • Behavior of Agriculturally Relevant Iron-Based Nanomaterials in Marine Ecosystem-**Ms Natasha Yadav, TDNBC, TERI, Gurugram, Haryana, India** • Inhibitory effect of sulfur nanoparticles against fungal disease (Early Blight)-**Ms Anamika Pal, TDNBC, TERI, Gurugram, Haryana, India** • Production of Biodegradable plastic/polymer by bacteria- **Ms Aksha Dhawan, TDNBC, TERI, Gurugram, Haryana, India** • Biologically derived nano boron-**Ms Drishti, TDNBC, TERI, Gurugram, Haryana, India** • Lifecycle analysis of Phosphorus based nanomaterials in marine environment- **Mr Anurag Nath, TDNBC, TERI, Gurugram, Haryana, India** • Pretreatment Methodologies for the efficient extraction of cellulose from rice straw- **Ms Neha Sharma, TDNBC, TERI, Gurugram, Haryana, India** • Molybdenum disulphide nanosheets for enhancing photosynthesis in agricultural crops- **Ms Chanchal Mony, TDNBC, TERI, Gurugram, Haryana, India**
04:30 PM – 05:00 PM	Culmination of NanoforAgri Prof H B Bohidar, Senior Scientist,TDNBC, TERI, Gurugram Haryana, India Prof Amit Dinda, AIIMS, Delhi, India Dr Pushplata Singh, Director, TDNBC, TERI, Gurugram Haryana, India
05:00 PM – 05:15 PM	**VALEDICTORY SESSION**
	Presentation of Awards for Best Oral and Poster presentation Prof H. B. Bohidar, Prof Amit Dinda, Dr Pushplata Singh, Dr Pallavolu Maheswara Reddy
	Vote of Thanks -Dr Palash K. Manna, Senior Scientist, TDNBC, **TERI,** Gurugram, Haryana, India
05:15 PM - 05:30 PM	**High Tea**

DAY-1, 8th December, 2021

PART-A

SESSION I

Advances in Nano-fertilizers and Nano-pesticides

Session I: Chair

Prof. David Cahill

Deakin University, Australia

Contact email address: david.cahill@deakin.edu.au

Professor Cahill holds a Personal Chair in the School of Life and Environmental sciences, Deakin University, Australia and from 2013 – 2018 was the Associate Dean (Research) for the Faculty of Science, Engineering and Built Environment. David is a member of the Australian Research Council College of Experts and was previously a member of the ARC-Excellence in Research Australia Research Evaluation Committee. He is based at the Deakin University Geelong Waurn Ponds campus. David earned his PhD at The University of Melbourne and following post-doctoral positions in Australia and overseas joined Deakin University. His research focuses on the impacts of biotic and abiotic stress on plants and the use of bio- and nanotechnology to solve problems in agriculture. David is a member of several Australian and American Societies of Plant Scientists and is Associate Editor of the CSIRO journal, Functional Plant Biology. He has been chief investigator on a range of ARC grants and has been strongly supported by State and Federal government funding. David currently supervises 15 Master and PhD students, twenty-seven PhDs have completed under his supervision. He teaches into Master level and undergraduate biology and forensic science courses. David has held a number of senior positions at Deakin University that include being Associate Head of School (Research), Chair of the Faculty Academic Progress Committee, Chair of the Faculty Professoriate and Chair of the University Laboratory and Biosafety Committee.

Keynote Speaker

Dr. J. C. Tarafdar

Former UGC-Emeritus Professor and ICAR Emeritus Scientist

Contact email address: jctarafdar@yahoo.in

Dr. J. C. Tarafdar did his M. Sc. and Ph. D. in Soil Science and Agricultural Chemistry from Indian Agricultural Research Institute, New Delhi and Post Doctorate from Institute of Agricultural Chemistry, Goettingen, Germany. He has made original and well recognized contribution on mobilization of native phosphorus and developed an *in-vivo* filter paper technique for phosphatase estimation. **He is the first in the world successfully developed biosynthesized nano nutrients and nano induced polysaccharide powder for agricultural use.** Dr. Tarafdar has developed many new techniques for Soil Biology. The most notable are: Visual demonstration technique of germinating AM spore, Soil solarization technique for mass scale production of AM fungi, Freeze-drying technique to understand nutrient movement and Electro focusing technique to demonstrate the origin of enzymes. He has published **365** research articles including 38 book chapters and five books. **He has four patents and 73 new organisms in his credit.** Dr. Tarafdar received many awards most notable are Sukumar Basu Memorial Award, IMPHOS-FAI Award, Prof. S.K. Mukherjee Memorial Award, Prof R.S. Murthy Memorial Award, Prof. R. V. Tamhane Memorial Award, Dr. Kartik Oaron Memorial Award, Dr. N. S. Randhawa Memorial Award, ISSS Platinum Jubilee Commemoration Award, Prof. N. P. Datta Memorial Award. Dr. Tarafdar is a Fellow of the most prestigious Alexander von Humboldt (AvH) Germany and DAAD, Germany. He is also a fellow of National Academy of Agricultural Sciences, Indian Society of Soil Science and Indian Society of Salinity Research Scientists. **He is among the best 2% scientist in the world.**

Title: Nanonutrients for crop production and plant protection

Authors: J. C. Tarafdar

Affiliations: Former UGC-Emeritus Professor and ICAR-Emeritus Scientist

Central Arid Zone Research Institute, Jodhpur, Rajasthan-342008, India

Contact email address: jctarafdar@yahoo.in

Abstract

Different nanoparticles can be synthesized through physical, chemical, aerosol and biological means to enhance plant productivity, nutrient use efficiency, plant stress management, soil health management and environmental protection. Nanonutrients application in agriculture may serve as an opportunity to achieve sustainability towards global food production. Important benefits of nanonutrients over conventional chemical fertilizers rely on nutrient delivery system. For example, nutrient can be released over 40-50 days in a slow-release fashion rather than 4-10 days by the conventional fertilizers. The nutrient use efficiency also improved by 2-20 times, therefore, nutrient requirements is less as well as reduces the need for transportation and application costs. Nanonutrients also can be used as nano-bioformulations that can be helpful to solve some limitations of biofertilizers such as ease to handling, enhanced stability, protection against oxidation, retention of volatile ingredients, taste making, consecutive delivery of multiple active ingredients etc. In general, nanonutrients mobilizes 30% more native nutrient than conventional fertilizer application. The average improvement of yield, irrespective of crops and soil types, varies between 24-32% as compared to 12-18% under chemical fertilizers. Nanomaterial influences key life events of the plants that include seed germination, seedling vigor, root initiation, stress management, growth and photosynthesis to flowering. Additionally, nanomaterial has been implicated in the protection of plants against oxidative stress as they mimic the role of antioxidative enzymes such as superoxide dismutase, catalase and peroxidase. With recommended doses of application, it become major economic driving force and benefit consumer and farmers with no detrimental effect on the ecosystem.

Dr. Pushplata Singh

Fellow and Area Convenor

Centre of Excellence in Nano-Agriculture
TERI-Deakin Nanobiotechnology Centre, The Energy and Resources Institute (TERI), Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi 110003
Acting Director, TERI-Deakin Nanobiotechnology Centre (TDNBC)
Adj. Associate Professor, Deakin University, Australia

Contact email address: Pushplata.singh@teri.res.in

Dr Singh is a senior scientist with Sustainable Agriculture Division, TERI. She is at present the Director of the TERI-Deakin Nanobiotechnology Centre. Her expertise is in nanomaterials development, nano-bio interactions, nano- toxicity, life cycle assessment of nanomaterials for agriculture and regulatory affairs. With a PhD in Human Genetics and Genomics and Post- Doctoral experiences in Genomics of human diseases, plants and beneficial microbes; and industrial experience in development of advanced nanomaterials, she collaborates with disparate partners to drive alignment on business objectives and deliverables to achieve closure in a set time frame. She has been significantly contributing towards major research and network project “Centre of Excellence for Advanced Research in Agricultural Nanotechnology (CEARAN) and “DBT-TDNBC-DEAKIN Research Network Across continents for learning and innovation" (DTD-RNA) funded by DBT, India. As a member of TERI team, her role in defining guidelines for the Government of India for safety assessment of NanoAgriProducts has been appreciated. She has independently established two facilities in TERI: Facility for Genomics and big data Analysis; and National facility for safety assessment of nano agro- products. She is an active member of “Bio Nano forum” and “Austria Nano forum”.

Title: Agri-nanomaterials for sustainable agriculture: advantages and limitations

Authors: Pushplata Singh

Affiliations: The Energy and Resources Institute

Contact email address: pushplata.singh@teri.res.in

Abstract

Nanoscale formulations are now suggested as alternatives to bulk agrochemicals to enhance productivity and meet the United Nation's Sustainable Development Goal of "Zero-hunger". This application to the agricultural field is due to the smaller size of nanomaterials (NMs) and their higher uptake efficacy to plants as compared to the bulk counterparts. For reducing the overall synthesis associated carbon footprint and unmonitored release of chemicals in reaction, biosynthesis methods to obtain NMs are proposed. We have successfully developed nanofertilisers, nano-pesticides and smart delivery carriers using biosynthesis approach. These nano-formulations have been tested for their efficacy at lab scale and some are at present under field trials. Although, the novel biogenic nano-agri-inputs have shown promising results to increase productivity, yet their interactions withing the terrestrial and aquatic ecosystems are important to be understood. After application to the agricultural fields, these are released in the environment. They can be taken up by humans and different species either in pristine or transformed forms. Using the standardized methods as provided by the Organisation for Economic Co-operation and Development, International Organization for Standardization, National Institutes of Health, Food and Drug Administration and Environmental Protection Agency, we at TERI-Deakin Nanobiotechnology Centre (TDNBC) have established that our biogenic P, Fe, Zn and B nano-formulations do not have any associated eco- and human toxicity. Results from such assessments can be a guiding scale for risk assessment banding and commercialisation of nano agri-inputs.

Dr. Maan Singh Sidhu

Science, Technology and Higher Education

Royal Norwegian Embassy Commercial Section,

Chanakyapuri, New Delhi, India

Contact email address:
maan.singh.sidhu@innovationnorway.no

Dr. Maan Singh Sidhu is a Counsellor for Science, Technology & Higher Education at the Royal Norwegian Embassy, New Delhi, India. He has also headed two offices of Innovation Norway in India (Delhi and Mumbai) for a short period of time as an acting Country director. Currently, he is representing the Research Council of Norway (RCN), Innovation Norway and the Norwegian Agency for International Cooperation and Quality Enhancement in Higher Education (Diku) in India. Previously, he has worked for the RCN, sin ce 2010 as Special advisor. He has extensive work experiences (over 25 years); from research, innovation, public administration as well as from international industries. He has worked as a National Contact Points (NCP) for business to strengthen Norway's p articipation in the Horizon 2020. He has led several science & technology projects, author of many scientific publications and book chapters, and have significant contributions to the international scientific world.

Title: Indo-Norway Scientific Collaboration: Activities and Opportunities

Author: Maan Singh Sidhu

Affiliations: Counsellor for Science, Technology and Higher Education
Royal Norwegian Embassy, Commercial Section, 50-C, Shantipath,
Chanakyapuri, New Delhi 110021, India.

Contact email address: Maan.Singh.Sidhu@innovationnorway.no

Abstract

India is an increasingly influential global player. Developments in India will have a significant impact on how successful the world is in achieving the Sustainable Development Goals and global climate targets. It is the world's largest democracy and a rapidly growing emerging economy. For all these reasons, and many more, India is an increasingly important strategic partner for Norway. The Norwegian Government has two strategies that emphasize the need to strengthen Indo-Norwegian collaboration. The first one is the Norwegian Government's strategy for cooperation with India, entitled **Norway – India 2030**. One of the priority areas in this strategy is cooperation on research and higher education, being important, but also as a tool to support the other priority areas. There will be an emphasis on political contact and government-level cooperation, business cooperation, and research cooperation, including higher education. Some of the priority areas identified in the strategy are: Ocean, Energy, Climate, environment and global health. The **Panorama strategy** is another important government's Strategy for cooperation on higher education and research with 9 prioritized countries, including India. Some of the main targets in the strategy is increased interaction between education, research and innovation and increased student mobility, outgoing and incoming as well as collaboration between **industry and academia**. Several bilateral projects, in different subjects, such as, clean energy, climate change, polar and geohazards, bioeconomy, ICT, nanotechnology and not the least, social sciences were funded. These joint researches have resulted into good cooperation between Norwegian and Indian research institutions and have brought in many scientific publications

Dr. Tarunendu Singh

Head (Agricultural Services)

Indian Farmers Fertiliser Cooperative Ltd.

IFFCO Sadan, C-1, District Centre, Saket, New Delhi, India

Contact email address: tarunendu@iffco.in

Dr. Tarunendu Singh is a qualified agronomist with contemporary knowledge of crop nutrition and product development. He has been associated with ICAR-National Agriculture Technology Project (NATP)-Rainfed Rice Production System (RRPS) and Diversified Agriculture Support Programme (UPDASP – UPCAR) Uttar Pradesh during the period from 2000-2005. He joined Farmers Fertiliser Cooperative Major - IFFCO in the Year 2006. Since, then he has actively contributed in various capacities in area of crop nutrition management and diversifed product portfolio of IFFCO viz. 100 % WSF's grades, Biostimulants, Biopesticides, Organo-mineral fertilisers, Nanofertilisers etc. He has active interest in fertigation scheduling of crops, water resource and community development projects and designing crop advisory programmes for the welfare of farmers. He has wide exposure and contributed in his own humble way in terms of articles and publications, technical booklets and designing of training modules. He is has been a recipient of several awards and accolades and represented IFFCO at national and international forums.

He is serving on board of IFFCO's subsidiaries & JVs like Gramin healthcare, AquaGT and Aquagri PLC and ushering IFFCO's vision of 'Reaching the Unreached' through efficient products and services.

Title: Efficacy-Biosafety-Toxicity of Nanofertilizers – IFFCO's Experience

Authors: Tarunendu Singh

Affiliations: Head (Agricultural Services), Indian Farmers Fertiliser Cooperative Ltd.

IFFCO Sadan, C-1, District Centre, Saket, New Delhi, India

Contact email address: tarunendu@iffco.in

Abstract

Nanotechnology has been breaking new barriers in many fields such as medicine, aerospace, defence, pollution control, electronics, sensor-based technologies, paints, etc. but its application in agriculture has been limited. Enhancing nutrient use efficiency (NUE) with minimal threat to environment has become critical today for our agriculture food production systems (FPS) to sustain the burgeoning population. Nano fertilisers hold potential to fulfil plant nutrition requirements, ensure farmers profitability and impart sustainability to crop production systems without compromising on crops yield. In addition to numerous other benefits, large surface area to volume ratio offers opportunity for better and effective interaction of nanoparticles to target sites. Indian Farmers Fertiliser Cooperative Limited (IFFCO) - the farmers' own fertilizer cooperative has been in the forefront for promotion of agro-technologies and novel agri-inputs to mitigate problems faced by the farmers. It has indigenously innovated at its Nano Biotechnology Research Centre (NBRC) at Kalol, Gujarat and succeeded in R& D and manufacturing of proprietary liquid nano-fertilizers viz. nano urea, nano zinc, and nano copper. These nano-fertilizers utilize the dynamics of shape, size, surface area and bio-assimilation. There efficacy was evaluated on the basis of multi-location multi-crop trials under varying crop seasons, both by the research institutes and also on the progressive farmers' fields across 11,000 locations on 94 crops across India. Independently, nano nitrogen, nano zinc, and nano copper have also been tested for bio-efficacy- biosafety-toxicity and environment suitability. IFFCO nano-fertilizers meet current national and international guidelines related to nanotechnology or nanoscale agri-inputs. They are in sync with OECD testing guidelines (TGs) and "Guidelines for Testing of NAIPs and Food Products" released by the Department of Biotechnology, Government of India. Harvested produce of crops applied with IFFCO nano-Urea, nano-zinc, and nano-copper have been found fit for consumption with no adverse effect. Nano-fertilizers can lead to economy in application of nutrient fertilizers, better crop harvests with minimal environment footprint. For this, extensive field trials and lab testings have been conducted to ascertain efficacy-biosafety- bio toxicity of nano-fertilizer. Concentrated efforts by IFFCO since 2017-18 have resulted into introduction of world's 1st nano-fertilizer - Nano Urea (liquid) for the farmers. It had also been notified under Fertiliser Control Order (FCO) of Government of India.

Sh. Sagar Kaushik

Global Head, Corporate Affairs UPL Limited, India

Contact email address: sagar.kaushik@upl-ltd.com

Sh. Sagar Kaushik is currently in the role of Global Head – Corporate Affairs. He has joined UPL in 2011, as the COO - UPL Crop Protection business. He successfully led the business teams to develop new products, technologies and expand the UPL footprint. He previously worked for more than 10 years as the president in Global Corporate & Indu stry Affairs. Mr. Sagar Kaushik is also involved in identifying the problems of insects and pests in farms along with farmers.

Title: Industry perspective on Nano-pesticides and Nano-crop nutrients

Authors: Sagar Kaushik

Affiliations: Global Head, Corporate Affairs UPL Limited, India

Contact email address: sagar.kaushik@upl-ltd.com

Abstract

Sustainable farming and potential consumer aspirations for safe food is becoming target for future research. There will be compelling tools like Traceability to enable linkages from Farm-to-Fork. Nano-technology can broaden the scope of bio-efficacy of crop protection products with significant dosage reduction.

Further, industry looks forward to more efficient solutions for customized seed treatment, micro-nutrient applications, postharvest and soil health solutions. Nano-technology, once we have the proven performance and with required de-regulation, would lead to Re-imagining Sustainability in agriculture.

SESSION II

Smart Delivery, Sensing and Precision Engineering

Session II: Chair

Prof. H. B. Bohidar

Senior Scientist (Centre of Excellence in Nano- Agriculture)
TERI-Deakin Nanobiotechnology Centre, The Energy and Resources Institute (TERI), Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi 110003

Former Professor of Physics & Nanoscience
School of Physical Sciences and Special Center for Nanoscience
Jawaharlal Nehru University, New Delhi-110067

Contact email address: bohidarjnu@gmail.com

Professor H. B. Bohidar received his degree of Doctor of Philosophy (in Physics) from the Indian Institute of Technology, Delhi in 1981. He had a distinguished post-doctoral research career, during which he worked at University of Grenoble (1983-1984) in the area of polymer composites and at Institute of Physics, University of Oslo, Norway (1984-1988), following which he joined Jawaharlal Nehru University, New Delhi as an Associate Professor of Physics in the year 1989. He was a visiting Professor at Indiana-Purdue University (1999-2000), and at University of New South Wales, Sydney, Australia (2006). His general area of specialization includes Nanoscience and Nanotechnology, Molecular Biophysics and nano and biocomposites. He has published close to 225 research papers in peer reviewed international journals, has filed 9 patents in the domain of nanoscience, and has published two books: (i) Polymer Science and Biophysics, Cambridge University Press, UK (2015), and (ii) Design of Nanostructures, Wiley-VCH, Germany (2017). Currently, affiliated with TERI-DEAKIN Center for Nanobiotechnology, Gurugram, NCR.

Title: Nanomaterials for enhanced photosynthesis, drought tolerance and plant protection

Authors: David Cahill, Chi Tran, Jim Rookes, Pavani Nadiminti, Hashmath Hussain, Xinhua Lu, Dequan Sun, Lingxue Kong

Affiliations: Deakin University, Geelong Waurn Ponds campus, Australia

Contact email address: david.cahill@deakin.edu.au

Abstract

The application of nanotechnology to plants is still a relatively new concept, yet the use of nanoparticles holds great potential for the manipulation of fundamental processes that lead to enhanced yield in crops faced with biotic and abiotic stresses such as disease and drought. Nanotechnology is providing exciting advances across many fields and is beginning to have impacts in agriculture. Nanomaterials have the potential to deliver bioactive molecules into plants and we have carried out research to characterise and optimise both particle retention and their structure in order to improve outcomes for the delivery of agrochemicals. We have used several nanoparticle platforms to load agrochemicals including nanostructured liquid crystalline particles, and through understanding their adhesion to plant surfaces we have successfully designed materials that greatly improve the efficiency of, for example, herbicide delivery. We also show that uptake by plants of specially designed nanoparticles carrying regulatory molecules can modify plant responses to their environment. For example, we have used model plants to demonstrate that silica-based porous nanoparticles are readily taken up and mobilised and that this can be exploited for targeted delivery of plant hormones. Our studies show how these nanoparticles interact with plants, where they go and how they can be used to release molecular cargo. These new approaches have led to an understanding of nanoparticle interaction and uptake pathways in plants and how the particles may be manipulated. Nanoparticle delivery of bioactives thus provides an innovative way to control biotic and abiotic stress in plants.

Dr. Dhruba Jyoti Sarkar

Scientist (Senior Scale)

ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata, India

Contact email address: dhruba1813@gmail.com, dhruba.sarkar@icar.gov.in

Dr. Dhruba Jyoti Sarkar received his Ph.D. in Agricultural Chemicals from the ICAR-Indian Agricultural Research Institute (ICAR-IARI), New Delhi. For his doctoral thesis on the development of pesticidal nanoformulations he received the institute Gold Medal and also secured ICAR Jawaharlal Nehru Award for P.G. Outstanding Doctoral Thesis Research in Agricultural and Allied Sciences. He joined ICAR-IARI, New Delhi as faculty in 2012 and worked on the development of various superabsorbent nanocomposite products for their application in agriculture for better water and nutrient use efficiency. For his work on the superabsorbent technology he received National Award for Technology Innovation in various Field of Petrochemicals and Downstream Plastic Processing Industry, Ministry of Chemicals and Fertilizers, Govt. of India in 2015. He has three Indian patents and one US patent granted on various nanomaterials for agricultural application. Recently, he is researching on the development of various nanomaterials suitable for fisheries application under the aegis of ICAR-Central Inland Fisheries Research Institute, Kolkata.

Title: Nanopolymers for agri-input delivery: advances and future outlook

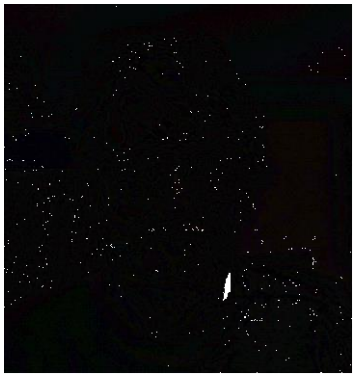
Authors: Dhruba Jyoti Sarkar

Affiliations: ICAR-Central Inland Fisheries Research Institute, Barrackpore, Kolkata-700120, India

Contact email address: dhruba1813@gmail.com, dhruba.sarkar@icar.gov.in

Abstract

Recently, nanopolymers are widely recognized due to their extensive application potential in bioactive molecule delivery. However, their use in agriculture is still limited with some scattered research studies, especially on the delivery of pesticides and fertilizers. For example, use of poly(ethylene glycol) (PEG) based amphiphilic copolymers (ACPs) for developing nanoformulations of pesticides. On spontaneous emulsification, these ACPs develop nanomicelles (~10-300 nm) containing hydrophobic pesticide at the core, which easily penetrates the target systems due to small size and stealth nature of the polymeric shell. Likewise several biopolymers like chitosans, cellulose, etc. are being used to develop nanodelivery systems of agri-inputs. Even fertilizers are being encapsulated using nanopolymers for superior activity. Recently nanofibers of oligosaccharide produced from hydrolysis of carbohydrate polymer is used to develop “Nano Urea” which stimulates biological processes in plants and trigger better growth and development as compared to bulk urea. However, despite these stated advantages, nanopolymers of synthetic and biological origin are yet to reach full potential, which might be due to several key researchable gaps like low loading capacity, lack of biosafety data, environmental fate details, etc. The use of nanopolymers is gaining pace in formulating several agri-inputs and they are being proven as a smart material for targeted delivery to attain sustainable agriculture.



Prof. Norberto Masciocchi

Department of Science and High Technology and To.Sca.Lab, University of Insubria, via Valleggio 11, 22100 Como (Italy)

Contact email address: norberto.masciocchi@uninsubria.it

Prof. Norberto is visiting Scientist (IBM Almaden, San Jose, CA); 1987: DAAD Grant at KFA Jülich, Germany. Author of more than 300 original papers published on leading scientific journals (among which Science and Nature), of more than 100 presentations at Confer ences and in several Italian and Foreign Universities and Research Centers. H -index: 53; No. citations > 11000. Editor of the "Powder Diffraction of Molecular Functional Materials, IUCr, 2004" pamphlet, of the thematic issues of the Journal of Physics and Chemistry of Solids (2004) and of the Journal of Organometallic Chemistry (2005), and of two books: "Diffraction at the Nanoscale: Nanocrystals, Defective and Amorphous Materials", and "Crystallography for Health and Biosciences", published by IUP. Editor of the Powder Diffraction Journal; Member of the Commission for Powder Diffraction of the IUCr; Member of the International Center for Diffraction Data; Invited speaker in several National and International Conferences and Schools. Awardee of the Nasini Pr ize (1999, Italian Chemical Society). Organizer of several International Conferences: EMRS -DCM4, Strasbourg, 2003; III Euchem on Nitrogen Ligands, Camerino, 2004; IV Euchem on Nitrogen Ligands, Garmisch, 2008; ECDM5, Gravedona, 2008; XXII IUCr Madrid, 2011, MISSCA Como, 2013. Organizer of several National and International Schools on Powder Diffraction and related techniques, 1995-2021.

Title: Development of Doped Calcium Phosphate Nanofertilizers: from the Chemical Bench to Field Tests

Author: Norberto Masciocchi

Affiliations: Department of Science and High Technology & To.Sca.Lab, University of Insubria, via Valleggio 11, 22100 Como (Italy)

Contact email address: norberto.masciocchi@uninsubria.it

Abstract

The need of quali- and quantitatively enhanced food production, necessary for feeding a progressively increasing World population, requires the adoption of new and sustainable agricultural protocols. Among them, limiting the waste of fertilizers in the environment has become a global target. Nanotechnology can offer the possibility of designing and preparing novel materials, alternative to conventional fertilizers, which are more readily absorbed by plant roots and, therefore, enhance the nutrient use efficiency. In this context, nanosized urea-doped amorphous calcium phosphate, prepared by simple, eco-friendly, and cost-optimized chemical methods, was tested in a number of crops: durum wheat, cv. Tempranillo and cv. Pinot Gris grapevines and cucumbers, using soil, foliar, fertigation and hydroponic supply. In all cases, despite of the reduction of the absolute amount of nitrogen delivered to the plants, as compared to conventional fertilization protocols, similar, or even better performances, were achieved. These were assessed by physico-chemical methods, estimating, in the different cases, the yield of absorbable nitrogen, the amino acid or gas volatile compounds profiles, berry/root/shoot weights, acidity and total soluble solids, among others.

This work was partially funded by Fondazione Cariplo, Project N. 2016-0648, “HYPATIA: Romancing the Stone: Size-controlled **Hy**droxy-A**pati**tes for Sustainable **A**griculture”.

Dr. Erwann GUENIN

Laboratoire TIMR EA4297 (UTC/ESCOM)

Université de Technologie de Compiègne

Alliance Sorbonne Université

Contact email address: erwann.guenin@utc.fr

E. Guénin was appointed professor in the TIMR laboratory in 2019 (Université de technologie de Compiègne, Alliance Sorbonne Université France) where he previously holds the chair “Green Chemistry and Processes” during 3 years. He initially studied organic chemistry in the "Université de Bretagne Occidentale" (France) where he got his Ph.D. in 1999. Then he worked consecutively as a post-doctoral researcher at University College London (UK) for two years and at Université de Strasbourg (France) for one year. He was appointed as assistant professor at Université Sorbonne Paris Nord in 2002. Since then he has been developing work on synthesis and modification of hybrid nanomaterials for biomedical, sensor or catalysis applications. He is now working at the frontier between green chemistry and chemical engineering for biomass valorization with a special interest in biobased nanomaterials and nanocomposites.

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Title: Production and utilization of nanocellulose and nanochitosan for edible coating

Authors: Mekro Permana PINEM, Endarto Yudo WARDHNO, Danièle CLAUSSE, Khashaya SALEH, Erwann GUENIN

Affiliations : Université de Technologie de Compiègne, UTC-ESCOM, Unité de recherche TIMR, Compiègne, France
University of Sultan Ageng Tirtayasa, Cilegon 42435, Banten, Indonesia

Contact email address: erwann.guenin@utc.fr

Abstract

“Bionanocomposites" prepared from natural polymers (proteins, polysaccharides) are materials that are of growing interest in many applications. They combine both the properties of biopolymers (biodegradability, biocompatibility and mechanical properties in some cases) and the additional properties brought by the use of some of these polymers at the nanometric scale.

We will present here the use of biopolymer nanoparticles for the preparation of bioplastic films from biomass derivatives. The bionanocomposites were prepared from both bacterial cellulose obtained from coconut milk and chitin obtained from crustacean shells. More eco-friendly processes were developed for the preparation of nanocellulose from bacterial cellulose as well as for the deacetylation of chitin to chitosan. The synthesis of the nanoparticle from the biopolymers has been developed and the preparation of plastic films from these products was evaluated. The influence of the use of cellulose and chitosan in nanoparticulate form (or not) was evaluated both on the structure of the films and on their properties. Finally, the addition of beeswax to the formulation allowed obtaining films with an increased water resistance.

Prof Lingxue Kong

Institute for Frontier Materials

Deakin University, Australia

Contact email address: lingxue.kong@deakin.edu.au

Prof Kong has a broad research interest in micro and nanofabrications and systems. His key interests include micro and nanostructured porous materials biomedical and environmental applications; microfluidics and nanofluidics; and micro and nano characterization. He has attracted more than $15 million funds from National Competitive Grants schemes and industry. In colla boration with Prof David Cahill at LES, Deakin University he pioneered the design, characterisation, and controlled delivery of agrichemicals via mesoporous nanoparticles in crops. He has published more than 300 scientific papers with a citation of more than 9,750.

Title: Nanomaterials and nanotechnology – enabling technology for a sustainable agriculture future

Authors: Lingxue Kong, David Cahill, Zhifeng Yi, Dequan Sun and Xinghua Lu

Affiliations: Deakin University

Contact email address: lingxue.kong@deakin.edu.au

Abstract

The controlled and targeted release of agrichemicals into crops for different purposes requires the tailored design of a system that can be delivered into plants through membrane walls of nanopores. A novel decanethiol gatekeeper system grafted onto mesoporous silica nanoparticles (MSNs) was developed in which decanethiol was conjugated only to the external surfaces of the MSNs through glutathione (GSH)-cleavable disulfide linkages and the introduction of a process to assemble gatekeepers only on the outer surface so that the mesopore area can be maintained for high cargo loading. *in vitro* release of SA from decanethiol gated MSNs indicated that the release rate of SA in an environment with a certain amount of GSH was significantly higher than that without GSH. The MSNs can enhance seedling growth and photosynthesis without exerting any oxidative stress or cell membrane damage. It has been demonstrated that the nanoencapsulation of agrichemicals into MSNs can reduce the disease, showing the potential of applying MSNs for plant growth and disease control.

Prof Neena Mitter
Director, Centre for Horticultural Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland
Director, ARC Research Hub for Sustainable Crop Protection, The University of Queensland

Contact email address: n.mitter@uq.edu.au

Prof Neena Mitter is the Director of the Centre for Horticultural Science, Queensland Alliance of Agriculture and Food Innovation, the University of Queensland and the Director of the Australian Research Council Industrial Transformation Research Hub for Sustainable Crop protection. Her career and passion for delivering real world outcomes has received recognitions such as Fellow of the Australian Academy of Technology and Engineering, Women in Technology Outstanding Life Sciences Award, and Gates Grand Challenges Explorations Award. She has >120 publications and has supervised >20 PhD students. She is globally renowned for her leadership of innovative platforms namely 'Environmentally sustainable BioClay platform for crop protection' and 'Clonal propagation of avocado using plant stem cells'. These are ground-breaking platform technologies influencing agricultural production, environmental sustainability, and socio-economic dynamics of farming community. Prof Mitter is also championing a UQ wide initiative on 'Protected Cropping for Tropics and Subtropics'. With increased scrutiny on use of chemicals as crop and animal disease control agents, Prof Mitter is focussed is on developing clean technologies for the agriculture of tomorrow.
Prof Mitter actively contributes into diversity and inclusion as Chair of Cultural Inclusion Council at UQ and the Deputy Council member of the Leadership Council of Cultural Diversity led by Australian Human Rights Commission.

Title: Agricultural nanotechnology: Changing the future of crop protection

Authors: Neena Mitter

Affiliations: Director, Centre for Horticultural Science, Queensland Alliance for Agriculture and Food Innovation (QAAFI), The University of Queensland. Director, ARC Research Hub for Sustainable Crop Protection, The University of Queensland.

Contact email address: n.mitter@uq.edu.au

Abstract

The aim to deliver transformative clean green technologies is the key driver for agricultural nanotechnology innovations for crop protection. Nanoparticle based delivery of pesticides have the potential to provide site-specific and slow-release activity on pests and diseases of plants, with benefits in reduced input and less risk to the environment. Ag-nano innovations for sustainable crop protection needs amalgamation of science and market driven solutions with support from academia, philanthropy, industry and governments and community.

BioClay is one such non-toxic, non-GM, biodegradable crop protection platform that delivers pest targeting RNA interference (RNAi) as a topical application using anionic clay particles. At present the use of RNAi for disease resistance is limited to engineering genetically modified disease resistance plants. Topical application dsRNAs as the key trigger molecule of RNAi, as direct control agents, as resistance factor repressors, or as developmental disruptors, is gaining momentum. 'RNAi in a drum' as a spray-on technology is being actively pursued by many large, well established agrochemical companies as a replacement or alternative to chemicals with potential 'green' credentials. Series of papers have shown that exogenous application of dsRNA can induce RNAi-mediated defence in viruses, fungi and insect pests. The major limitation however is the instability of topically applied naked dsRNA on the leaf surface leading to a very short period of protection. BioClay opens the window of opportunity to deliver the same as a sustainable spray application with extended period of protection. Real world application of exogenous dsRNA for RNAi-mediated resistance will be governed by factors such as cost-effective production, design of regulation and public licensing.

Dr. Arun Banerjee

Team Lead, Reliance Industries Ltd., India

Contact email address - arun.banerjee@ril.com

Dr. Arun Banerjee is the Team Lead for the Precision Agriculture and Photosynthesis project at Reliance Industries Ltd. Arun received his Ph.D. in Biochemistry and Molecular Biology from the Indian Institute of Science in 2011, a master's degree in Biotechnology, and a bachelor's degree in Human Physiology& Chemistry. He has been associated with industrial research and product development for a decade in Reliance Industries Ltd. He significantly contributed towards the laboratory-to-outdoor scale-up of marine microalgae biomass productivity and photosynthesis knowledge-driven strain improvement. His keen interest is to understand the rate-limiting steps of photosynthesis and improve productivity utilizing the kinetic modeling approach. His current work aims to develop affordable and scalable technologies in the area of precision and climate-smart agriculture. His group exploits hyperspectral imaging-based spectroscopy, Drone mounted low-cost sensors, and Satellite remote sensing-based input systems for developing AI-ML-based predictive models to deliver actionable intelligence. It can be surmised that Precision and data-driven agriculture would act as an enabling technology for the science-based application of various agriculture inputs such as nanotechnology-driven formulations. Arun authored many peer-reviewed international publications and filed several international patents for key industrial technologies.

Title- Sensing makes Sense - Using AI and Nano-range Sensors for Precision Agriculture

Authors- Arun Banerjee, Rahul Badhwar, Rajesh Nandru, Kenny Paul

Affiliations- Reliance Research & Development Centre, Reliance Industries Ltd.

Contact email address- arun.banerjee@ril.com

Abstract

The ever-increasing global population, climate change catastrophe, soil health deterioration, and unscientific application of agriculture inputs will lead towards food and nutrition insecurity. If not addressed timely, such interconnected challenges would pose grave menace for the present and future generations. Nanotechnology-enabled agriculture practices such as the application of nano-nutrients, nano-pesticides, and nano-fertilizers are promising emerging technologies towards attaining sustainable food production.

Judicious and precise administration of nanotechnology-driven agriculture inputs and acceptance by the farming community will depend on intelligent sensing platforms, which can sense and measure outcomes at scale. At the same time, early diagnosis of crop diseases is a significant step towards the timely field application of nano-Agri inputs to prevent economic losses. Adoption of nano-range sensing methodologies will facilitate quantifying scientific advantages, evaluate practical challenges, and establish the technology readiness of nano-chemicals. Nano-meter range sensing platforms provide an edge in terms of data variety, data resolution, and scalability. Furthermore, artificial intelligence and deep learning mediated analytics would empower precision and data-driven agriculture solutions to the farming community by providing timely actionable intelligence.

Dr. Sarabjot Singh Anand

Tatras Data, Sabudh Foundation and
BML Munjal University

Contact email address: sarabjot@sabudh.org

Dr. Sarabjot Singh Anand has been involved in the field of Machine Learning since the early 1990s having worked on developing algorithms, applying them to real-world problems and training a host of data scientists in the capacity of being an academic and entrepreneur.
He has published over 90 academic papers on machine learning while an Associate Professor at the University of Warwick and previous academic posts in the United Kingdom. He has used these algorithms to develop solutions in areas as diverse as pay-per-click optimization, recommender systems, prognostic models for chronic illnesses; diver monitoring using CAN bus data, cross-selling and up-selling products in financial retail, churn prediction, house price prediction for the Telecoms, Financial, Retail, Automotive, Manufacturing and Public Sector. His first startup in Ireland won the European IST prize amongst other technology accolades.

Dr. Anand moved back to India in 2012 and co-founded Tatras Data. In 2018 he co-founded Sabudh Foundation in Mohali, Panjab to train engineering students in Machine Learning and to work on social problems in education, farming, governance and healthcare. Dr. Anand is currently adjunct faculty at IISER, Mohali and Director CSE at Munjal University

Title: Development of an intelligent geo-spatio temporal decision platform for farmer collectives

Authors: Sarabjot Singh Anand

Affiliations: Co-founder and Chief Data Scientist, TATRAS, Sabudh Foundation, and BML Munjal University, Okhla Industrial Area, Phase 2, New Delhi – 110020, India

Contact email address: sarabjot@sabudh.org

Abstract

In a world full of uncertainties, the thought that we should leave small holding farmers to deal with the uncertainties and yet provide us with food is troubling. Recent advances in Artificial Intelligence, specifically, Machine Learning and Deep Learning, as well as the dropping cost of reliable sensors, makes it possible for data driven decision making in agriculture. Keeping this in mind, we have undertaken the development of a platform that can be used by collectives of farmers to maximise their yield and profitability. In this talk I will describe the strides we have made in this direction.

SESSION III

Perceptions amongst farmers, Industries and Field Trials

Session III- Chair

Dr. Mandira Kochar

Fellow and Area Convenor

TERI-Deakin Nanobiotechnology Centre, The Energy and Resources Institute (TERI), Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi 110003
Adj. Associate Professor, Deakin University, Australia

Contact email address: mandira.kochar@teri.res.in

Dr Mandira Kochar received her PhD Degree in Genetics (Microbial Genetics) from Delhi University in 2007.I have extensive research experience for almost 18 years focused on Molecular Microbiology, Microbial Physiology and Genomics to support thematic areas of Agriculture and Environment Sustainability as well as Multidrug Resistance in bacteria. Work in her research group has concentrated on molecular and functional analysis of plant growth regulators [Nitric oxide (NO) and indole acetic acid (IAA)] crosstalk in the plant-associated bacterium, *Azospirillum brasilense* and has extended understanding of the role of these molecules in plant-microbe interactions. She is actively looking at novel strains capable of forming biofilms in nature to develop sustainable agriculture solutions. She has been involved in the TERI-Deakin University PhD program since 2011 as a Supervisor guiding and mentoring PhD students on their projects for award of PhD degrees. Her current research interests lie in studying naturally existing microbiomes, microbial biofilms, and developing novel bioformulations for improving agricultural productivity. She also works on regulation of plant-microbe interactions, microbial genomics and nanotechnology based interventions for sustainable agriculture.

Sh. Dhananjay Edakhe

Zydex Industries Pvt Ltd, Vadodara, Gujarat

Contact email address: dhananjay.edakhe@zydexindustries.com

An experienced Agri- inputs sales & marketing professional, People-person currently working in Bio-Ag industry in India. Mastered the art of working on innovative technology in the sphere of agriculture inputs & taking it to the next level. He has Good exposure of working in B-2-B & B-2-C model business ecosystem in agri-business sector in India & SEA countries. Major experience has been in the spectrum of agri-Inputs sales & business development especially in Crop nutrition domain (Bulk Fertilizers, Water Soluble Fertilizers, Speciality Agri products, Bio-fertilizers), Crop protection (Ag Biological's/ Microbes)&partly Seeds (Field & Vegetable crops).

Area of expertise:

Sales, Business development,

Strategic business planning

Alliance business management (Developing and managing), B-2-B, B-2-C

Profit centre operations

Organization development

Commercial talent development, Raising business start-up operations to the next level specialisation: Sales and Marketing of Agri-inputs, Driving Performance

Title: Bio-Agriculture in India-An industry perspective

Authors: Dhananjay Edakhe

Affiliations: Zydex Industries Pvt Ltd, Vadodara, Gujarat

Contact email address: dhananjay.edakhe@zydexindustries.com

Abstract

The green revolution brought remarkable gains in food production but with no concern for sustainability. In India the availability and affordability of fossil fuel based chemical fertilizers at the farm level have been cause of excess use of chemical fertilizer inputs.
Dependence on chemical fertilizers for future agricultural growth would mean further deterioration in soil quality, possibilities of water contamination and unsustainable burden on the fiscal system.
Government's objective is to provide safe food with high nutrient content produced with minimum chemical fertilizers and pesticides to masses at an affordable price. This can happen now with Bio-Farming with next generation of Bio-Fertilizer technology with ability to revive Bio-Fertility of soil with higher organic carbon. New Generation of Bio fertilizer like Zytonic M are addressing soil modification to make them soft, porous, improve moisture holding capacity along with improved water recharge also. It consistently shows 15-20% higher production at 50% reduction in NPK in first use itself (50,000 active users who can confirm these results).
It has been observed that only 25-30 % chemical nutrients are used in Plants based on leaf petiole Tissue analysis. When biology is restored it has been documented in India and abroad that Bio-fertilizer offers various benefits. Besides accessing nutrients, for current intake as well as residual, different bio-fertilizers also provide growth-promoting factors to plants and some have been successfully facilitating composting and effective recycling of solid wastes. By controlling soil borne diseases and improving the soil health and soil properties these organisms help not only in saving, but also in effectively utilizing chemical fertilizers and result in higher yield level.

Dr. Vijayakumar P. Shanmugam,

INST Mohali, India

Contact email address: psvijayakumar@inst.ac.in

Dr. Vijayakumar P. Shanmugam obtained his PhD in 2006 from Tamil Nadu Agricultural University; and Post Doc on nanoscience in National Chemical Lab, Pune; on photothermal and sensor application in Taiwan. He has been a visiting scientist in NIOSH, US. Have couple of patent and few awards such as outstanding reviewer award in Elsevier, finalist in Swiss young researcher.

Currently he is working in Institute of Nanoscience and Technology, Mohali and has introduced the concept of targeted agricultural inputs possible with nanotechnology. Have 1500 citation with over 30 publications in this over half with impact more than 10.

Title: Carbon based agriculture nano-technologies- regulatory limitations and ways to overcome

Authors: P.S.VijayaKumar

Affiliations: Institute of Nano Science and Technology Mohali.

Contact email address: vijayakumarshanmugham@gmail.com

Abstract

In the modern agricultural practice chemicals play an important role in the crop production, protection and preservation. To make this more effective we immobilized these active ingredients in the carbon matric and checked its efficiency. Although it is efficient in the open broadcasting there are further more modification and testing required taking it for the industrial scale. Hence we explored the domain where the broadcasting is not the method for the application, here carbon wrapper and pheromone were developed which is ready to adopt technologies.

Dr. Anand Gole

General Manager-R&D (Fertilizers and Speciality Nutrients Division)

Coromandel Lab @ Monash IITB-Monash Research Academy

Near Victor Menezes Convention Centre IIT Bombay, Powai,

Mumbai 400076

Contact email address: GoleA@Coromandel.Murugappa.com

Dr. Anand Gole joined Coromandel International in 2018 as GM-R&D in Fertilizers & Specialty Nutrients. He is currently heading R&D at Coromandel lab @ Monash, Mumbai. He and his team focus on new product/ technology development using different scientific principles and approaches. Prior to moving into Coromandel, he was a Senior Scientist at Tata Chemicals Innovation Centre, Pune for 9 years. Dr. Anand completed his Ph.D. in Physics in the area of Nanotechnology in 2002 at National Chemical Laboratory, Pune, under the guidance of Dr. Murali Sastry. He spent 6 years out of India in France, US and Singapore. His academic stint focused on spherical and anisotropic nanoparticle synthesis, surface modification, immobilization, protein-lipid and protein-nanoparticle biocomposites, thin films, sensing and imaging. After moving to Tata Chemicals, he pioneered the area of nano-in-Agri which was jointly funded by Tata Chemicals and DBT-BIRAC through which he was able to commercialize the first nanotechnology-based micronutrient formulation in India, currently being sold under the brand name of SURPLUS by Rallis India. Till date, he has 50 publications in international journals and 7 patents, out of which two have been commercialized.

Title: Nano Fertilizers – Lab to Market

Authors: Dr. Anand Gole

Affiliations: General Manger (Research & Development)

Contact email address: GoleA@Coromandel.Murugappa.com

Abstract

Nanotechnology is an enabling technology. It is at the interface of basic sciences and Engineering. The interest in nanotechnology stems from the highly unusual optoelectronic and physico-chemical properties of nanomaterials that are significantly different from their bulk counterparts. While high-tech areas such as electronics and biomedical applications are the first to receive attention, it is equally important to conduct research and contribute to nanotechnology in the areas that have a direct impact on food, water and nutrition. This is especially important for the area of agriculture which faces phenomenal stress due to reducing arable land, increasing population that requires increased food production, soil quality degradation, increased and imbalanced use of Agri inputs, environmental concerns and other such pressing problems.

There is an increase in interest in nanofertilizers due to perceived benefit of increased yields and reduced basal fertilizer application. Important open-ended questions include: Can nano-fertilizers really benefit famers with regards to cost vs benefit, without impacting environment and ensure farmer safety? Is this sustainable? Only time will be able to answer these questions.

My talk will focus on the journey of nanofertilizers from lab to market. I will briefly touch upon the following points: a) New product development in industry; b) Currently available nanofertilizers in the market; c) Synthesis methods for nanofertilizers; d) Typical field trials and the importance of benefit: cost analysis; e) Appropriate controls and careful conclusions to be drawn during trials; f) Farmer need, influencers, perceptions and support.

Dr. Naresh Prasad

Deputy General Manager Chambal Fertilizers & Chedhrumicals Limited, Ghaziabad, India

Contact email address: naresh.prasad@chambal.in

Post graduate from Narendra Deva University of Agriculture Technology, Faizabad, UP and recipient of Vice Chancellor Gold Medal. Ph.D. from Indian Agriculture Research Institute, New Delhi in Soil Science and Agriculture Chemistry. Worked on the project leading to increased nitrogen use efficiency. Served FAI for 10 years as Senior Agronomist. Author and Co-author of various publications on agriculture promotion in general and fertiliser in particular. Published more than 50 numbers of articles / papers in agricultural Magazines and Journals. Currently working with Chambal Fertilisers and Chemicals Limited as Deputy General Manager and looking after the Market support and development activities of the company. Engaged in new product testing / evaluation, sourcing, branding and commercialisation. Earlier developed the speciality product segment in the company starting from import/ indigenous arrangements, branding, packaging, logistics, sales, etc. Looking after Agricultural Development laboratories for last mile delivery of balanced use of plant nutrients and addressing soil health issues. Recipient of various FAI awards like ‘Best Article’ published in ‘Fertiliser News’ and ‘Khad Patrika’, Technology Transfer and Best Video Film. Providing technical knowledge support and training to all concerned at various levels in the company.

Title: Nanofertilizers

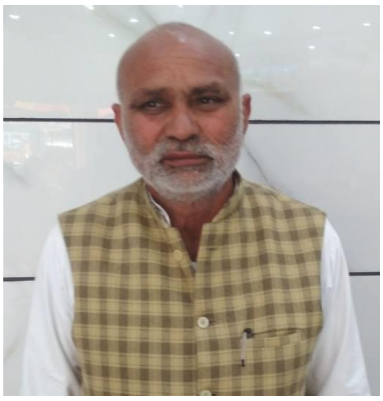
Authors: Naresh Prasad

Affiliations: Deputy General Manager, Chambal Fertilizers and Chedhrumicals Limited, Ghaziabad, India

Contact email address: naresh.prasad@chambal.in

Abstract

Fertilizers replace the nutrients that crops remove from the soil. Without addition of fertilizers, crop yields and agricultural productivity would be significantly reduced. That's why mineral fertilizers are used to supplement the soil's nutrient stocks that can be quickly taken up by the crops. The role of fertilisers in making India food self-sufficient is very well recognised and documented. However, the low efficiency of applied fertiliser nutrients particularly that of nitrogen (40%) is a major concern. It, therefore, becomes all the more essential to increase the nutrient use efficiency by all possible means. It is in this context the prospects of Nano-technology to address the low efficiency issues being faced not only in India but all across the world is being explored. Off late there has been some success in this segment and some of the products are commercialised are being used /tested on farmers' field. We need to experience some more seasons to really comprehend the benefit accrued to the farming community as compared to the use of conventional fertilisers. One thing which is scientifically not yet answered that how the gain in nutrient use efficiency through Nano fertilisers can be more than 100%.There are serious question being raised on mass balance through Nano as compared to conventional fertiliser use. The nutrient requirement of the crop has to be met to get the desired yield and is irrespective of the product and technologies. The Nano-technology is un-doughtily quite promising but there is need to evaluate it properly in all respects before commercialisation and going for recommendation to farmers.



पूरा नाम: श्री कंवल सिंह चौहान
किसान उद्यमी, वकील और पद्मश्री पुरस्कार विजेता, हरियाणा, भारत
संपर्क ई - मेल पता: kanwalsingh62@gmail.com

हरियाणा के सोनीपत जिले के ग्राम अटेरना निवासी श्री कंवल सिंह चौहान प्रगतिशील किसान हैं। उनके आसपास के क्षेत्र में वे एक क्रांतिकारी किसान के रूप में जाने जाते हैं, वहीं सरकार ने उन्हें **फादर ऑफ बेबी कॉर्न** का नाम दिया है। उन्होंने किसानों को इस क्षेत्र में स्वीट कॉर्न, बेबी कॉर्न और मशरूम की खेती शुरू करने और इसकी खेती करने के लिए प्रोत्साहित किया।

- 2010 में उन्हें भारतीय कृषि अनुसंधान परिषद (आईसीएआर), कृषि और किसान कल्याण मंत्रालय, भारत सरकार द्वारा कृषि में विविधीकरण के लिए एनजी रंगा किसान पुरस्कार से सम्मानित किया गया था।
- उन्हें महिंद्रा ट्रैक्टर्स द्वारा महिंद्रा कृषि सम्राट पुरस्कार - 2015 प्राप्त हुआ।
- उन्हें अखिल भारतीय किसान गठबंधन (एआईएफए) द्वारा एआईएफए प्रगतिशील किसान पुरस्कार 2017 से सम्मानित किया गया।
- हाल ही में (Oct 2021)उन्हें भारत के माननीय केंद्रीय कृषि मंत्री से कृषि नेतृत्व के लिए पुरस्कार भी मिला है

शीर्षक: कृषि-नैनो प्रौद्योगिकी का एकीकृत दृष्टिकोण: चुनौतियां और भविष्य के रुझान

लेखक: श्री कंवल सिंह चौहान

संबद्धता: किसान उद्यमी, वकील और पद्मश्री पुरस्कार विजेता, हरियाणा, भारत

संपर्क ई - मेल पता: kanwalsingh62@gmail.com

सार

नैनो टेक्नोलॉजी को खाद्य और कृषि में समस्याओं के संभावित समाधानों में से एक माना जाता है। बढ़ती जनसंख्या को भोजन प्रदान करने की आवश्यकता तथा बदलती जरूरतों को पूरा करने के लिए कृषि उत्पादकता में सुधार और बेहतर फसल संरक्षण हेतु आधुनिक नैनो-जैव प्रौद्योगिकी में कृषि प्रणालियों को बेहतर बनाने की क्षमता है। फसलों में भारी मात्रा में रासायनिक उर्वरक की तुलना में, नैनो-पोषक तत्वों के उपयोग से जमीन और सतह के पानी में पोषक तत्वों की कमी को दूर किया जा सकता है और इस तरह पर्यावरण प्रदूषण को भी कम किया जा सकता है। निस्संदेह, नैनो तकनीक उस युग में सटीक खेती (यानी, न्यूनतम इनपुट के साथ कृषि उत्पादन में वृद्धि) की संभावना प्रदान करती है, जहां स्थिरता की बढ़ती मांग लागत को कम करने और कृषि और प्राकृतिक संसाधनों के अत्यधिक उपयोग को मजबूर करती है। हालांकि, कृषि में अभूतपूर्व नैनो तकनीक की भागीदारी से अब तक प्राप्त रोमांचक परिणामों के बावजूद, उनकी प्रासंगिकता अभी तक किसानों तक नहीं पहुंच पाई है। इस विरोधाभास के लिए कई कारण जिम्मेदार हैं। जिनमें से प्रमुख है नैनो कृषि के लाभों के बारे में किसानों के बीच कम जागरूकता इसलिए, किसानों को शिक्षित करना और प्रौद्योगिकी हस्तक्षेप के साथ कृषि क्षेत्र में सुधार करना किसानों के आर्थिक विकास के साथ-साथ स्थिरता को मौलिक रूप से बढ़ाने का एकमात्र तरीका है। एक और मुद्दा है, अगर हम कृषि उत्पादकता में वृद्धि के बारे में बात करते हैं, तो कृषि उत्पादन बढ़ाने के दो स्रोत हैं। क्षेत्र और उत्पादकता। गैर-कृषि उपयोगों के लिए भूमि की बढ़ती मांग और देश के कुल भौगोलिक क्षेत्र में कृषि योग्य भूमि के पहले से ही कम होने के कारण, खेती के तहत क्षेत्र में और विस्तार संभव नहीं है। अत: प्रति इकाई भूमि की उत्पादकता में सुधार के माध्यम से कृषि उत्पादन को बढ़ाना होगा और कृषि-नैनो प्रौद्योगिकी के एकीकृत दृष्टिकोण का उपयोग करके इस उत्पादकता में सुधार किया जा सकता है।

Oral Pitch

Preparation and characterization of nanolignins: towards supports for nanocatalysts

Zhao Zhang, Vincent Terrasson, Erwann Guénin*

Université de Technologie de Compiègne, ESCOM, TIMR (Integrated Transformations of Renewable Matter), Centre de Recherche Royallieu-CS 60 319-60 203 Compiègne Cedex, France;

*Corresponding author e-mail: erwann.guenin@utc.fr

Abstract

With our continued in-depth understanding of the environmental pollution and resource crisis, the renewable and degradable properties of biomass materials are being increasingly valued. As the second most abundant natural polymer material after cellulose, lignin has received extensive attention in recent years. The development of bio-based products from lignin is an important part of any comprehensive biorefinery concept because of their biocompatibility and biodegradability. They not only diversify the combination of products and markets, but also benefit waste recycling and economic sustainability. Currently, the exploitation of nanolignin is the subject of a tremendous amount of research. Lignin nanoparticles have potential applications in antioxidants, thermal/light stabilizers, reinforced materials and nanomicrocarriers owing to their advantages of non-toxicity, environmental resistance, excellent thermal stability and biocompatibility. In addition, the utilization of economical and environmentally friendly nanolignin as feedstock for the evolution of chemical industry conforms to green chemistry principles and sustainable development concepts. Therefore, the formation of lignin-based nanomaterials will open up a different perspective for expanding the high-value applications of lignin. In our study, a facile and environmentally friendly approach to the preparation of homogeneous and stable lignin nanospheres is presented. The spherical nanoparticles around 85-125 nm were prepared through the π-π interactions between molecules in the self-assembly process. Furthermore, the thermal stability of LNPs was significantly enhanced compared to that of lignin. In vitro cell viability evaluation experiments indicated that the prepared nanoparticles had no cytotoxicity and excellent biocompatibility with mouse fibroblast. The high-quality and renewable LNPs will provide a novel perspective for multifunctional and diverse applications of bio-based nanomaterials.

Investigation for eco-safety and transformation of potential Phosphorus based nanofertilisers by using Caenorhabditis elegans as a terrestrial model

Ayushi Priyam[1, 2*], Luis O.B. Afonso[2], Aaron G. Schultz[2], and Pushplata Prasad Singh[1, 2]

[1]*National Centre of Excellence for Advanced Research in Agricultural Nanotechnology, TERI - Deakin Nanobiotechnology Centre, Sustainable Agriculture Division, The Energy and Resources Institute (TERI), DS Block, India Habitat Centre, Lodhi Road, New Delhi, 110003, India*

[2]*School of Life and Environmental Sciences, Deakin University, Geelong, Victoria, 3217, Australia*

*Corresponding author email: ayushi.priyam@teri.res.in

Abstract

Evaluation of the behaviour of nanomaterial (NM) *in vivo* constitutes an important preliminary step in eco-safety assessment of nanoagriinputs. Nanoscale phosphorus-based formulations are now being explored as an alternative for P fertilisers, but their effects on different environmental organisms still remain to be determined. In this study, the effects of multiple types of P based NMs on *Caenorhabditis elegans* were examined. The study involved four variants of nanohydroxyapatites (nHAPs) synthesized either via a biogenic or a chemical route and another NM, nano-Phosphorus (nP), biosynthesized from bulk rock phosphate (RP). These NMs differed in their physicochemical properties, most prominently in shape and size. The effects on exposure of NMs were assayed in *C. elegans* by using survival, hatching and reproductive cycle as the key endpoints in comparison to bulk calcium phosphate and RP. Trophic transfer from the feed *Escherichia coli* OP50 to *C. elegans* and transformation of nHAPs and nP was also investigated using FITC tagged NMs. Contrary to the bulk RP, none of the variants of nHAP and nP were found to affect survival significantly up to 500 $\mu g \cdot mL^{-1}$. Reproductive cycle assay reveals that nHAPs and nP do not affect the parental generation (F0) and there is no detrimental effect on F1 brood size. The NMs retained their hydrodynamic properties after undergoing trophic transfer and transformation. The study provides scope for future application of biogenic nP and nHAP as safe nanofertilizers. This study also suggests that *C. elegans* being a terrestrial species and having ease of manipulation may be explored further to study trophic transfer of agriculturally relevant NMs and associated eco-safety.

Zinc Nano- fertilization enhances wheat grain yield and zinc concentration

Achchhelal Yadav, Monika Kundu and P. Krishnan

ICAR-Indian Agricultural Research Institute, New Delhi-110012, India

*Corresponding author email: achchheyadav@yahoo.com

Abstract

Among the micronutrients, zinc (Zn) is having a very important role in wheat growth and yield. It is recommended to apply adequate amount of zinc on crops during their developing stage so that the crop growth, yield and zinc content in the edible part of plants could be improved. Nonetheless, surplus use of conventional Zn fertilizers is deleterious to soil as well as plant health. Therefore, it's an urgent need to have formulations of Zn with enhanced use efficiency that could improve crop performance with minimum input. In this context we carried out a pot experiment during 2019-20 and 2020-21, applying zinc oxide nanoparticles (ZnO-NPs) vis-à-vis zinc sulfate ($ZnSO_4$) as conventional fertilizer, at the research form of ICAR-Indian Agricultural Research Institute, New Delhi. The rate of application of ZnO-NPs in the pot soil were 0, (Control), 20, 25 and 30 mg kg^{-1}. We also apply equal amount (equal to Zinc in ZnO-NPs) of ZnSO4 in the pot soil separately. We compared and assessed ZnO-NPs and $ZnSO_4$ use efficiencies on wheat growth, yield and Zn uptake in grains. Results revealed that photosynthetic rate and stomatal conductance were significantly ($p<0.05$) more under 25 mg kg^{-1} soil ZnO-NPs treatment over its counterpart of $ZnSO_4$. Among the crop yield parameters such as tillers ($plant^{-1}$), number of grains ($spike^{-1}$), grain weight ($plant^{-1}$), biomass ($plant^{-1}$) and yield were significantly ($p<0.05$) more under ZnO-NPs at 25 mg kg^{-1} treated soil as compared to any other treatment. Zinc (Zn) concentration in grains increased with dose of ZnO-NPs and it significantly more than $ZnSO_4$ treated soil at each treatment level. The increased crop growth, yield and higher concentration of zinc might be due to increased surface to mass ratio of ZnO-NPs and increased durability of absorption via roots as compared to the conventional $ZnSO_4$ fertilizer. The present study aimed at to assess and compare the potential impacts of Zn nanoparticles over the $ZnSO_4$ conventional fertilizer on growth, yield and zinc concentration in grains.

Effect of galvanotaxic graphene oxide on chloroplast activity: Interaction quantified with Biolayer-Interferometry coupled confocal microscopy

Sahu B.K., and Shanmugam V. *

Institute of Nano Science and Technology, Sector-81,Knowledge City Mohali, Punjab, 140306, India

*Corresponding author email: vijayakumarshanmugham@gmail.com

Abstract

The knowledge on the effect of graphene oxide (GO) on plants are limited to germination, growth, and toxicity. Since, chloroplast generates sugar by the reduction of CO2 with the optical stimulation through a series of electron transport chain and GOES being the 2D material with electron transport property, it is reasonable to check their interaction. Here, the effect of GO without and with amine conjugation (AGO) having opposite charges were allowed to interact with chloroplast. The uptake is documented by using biolayer interferometry coupled with confocal imaging. The ex vivo chloroplast activity with GO and AGO has been tested and found that the GO treatment shows 1.3 times more activity than control. In contrast, AGO function as efficient electron conductor and cause imbalance in the redox beyond the capacity of the antioxidant rich chloroplast solute. Finally, in vivo toxicity has been evaluated in the spinach plants, which highlights the chance of AGO application as herbicide to remove any unwanted plants.

Synthesis of Nano-zeolites as delivery vehicles for nutrients

A. Anand*[1], S. Singh[1], N. Dwivedi[1], D. M Cahill[2], S. Mateti[2], J.Mondon[2], P. K. Manna*[1]

[1] *TERI Deakin Nanobiotechnology Centre, TERI Gram, Gwal Pahari, Gurugram, India*

[2] *Deakin University, Faculty of Science Engineering and Built Environment, Australia*

*Corresponding author email: ashita.anand@teri.res.in, palash.manna@teri.res.in

Abstract

There is a critical requirement to develop smart materials that can release nutrients systematically at the particular sites of the plants which would be valuable in limiting nutrition deficiency in crops and substitute conventional fertilizers. We have addressed the possibility of utilizing nano-zeolites as carriers for nutrients on the basis of slow release kinetics. Zeolites are known to possess extensive surface area and capable of regulating the adsorption and desorption of nutrients that can eventually increase crop yields. Non-toxic, cost effective and environmental friendly nano-zeolites were synthesized through facile methods and were characterized by various techniques including XRD, TEM, FT-IR, DLS and BET. The synthesized particles are porous having a pore diameter of 31 Å. The synthesis protocols were optimized to select the best performing nano-zeolite variant from loading perspective. Our results suggest 38% loading efficiency of NH4 + that can act as a source for nitrogen as compared to 14% loading efficiency obtained with commercial zeolite. A slow and controlled release pattern was observed in water over a period of 288 hours and it was established that maximum nutrient release occurs between 24 to 72 hours. In summary, our zeolite is a promising candidate to be a next generation slow release fertilizer.

Nanomaze Lure: Pheromone Sandwich in Graphene Oxide

Interlayers for Sustainable Targeted Pest Control

Chandel M.*, Kaur K., Muthusamy E., Subaharan K., and Shanmugam V.

Institute of Nano Science and Technology, Sector 81, Knowledge City, Sahibzada Ajit Singh Nagar, Punjab, 140306, India

*Corresponding author email: vijayakumarshanmugham@gmail.com

Abstract

The indiscriminate use of pesticides leads to irreparable damage to the ecosystem, which motivates for sustainable alternatives like pheromone-assisted pest management. The tomato pinworm *Tuta absoluta* is a major threat to tomato cultivation. Moreover, its green management technology uses a pheromone trap that has a short field life. To overcome this problem, a pheromone composite with graphene oxide (GO) and amine-modified graphene oxide (AGO) that can extend the diffusion path has been developed. The composite stimulates an effective electrophysiological response in the antenna, which results in trapping of a significantly higher number of insects as compared to the commercial septa, thus qualifying it for field evaluation. Compared to AGO, the GO composite has pheromones assembled into a multilayer, which increases the pheromone diffusion path. This in turn resulted in the extension of the pheromone life that proportionally increased the pest trapped. This technique will be beneficial to farmers as they have longer field efficacy to keep the pest damage low in an environmentally friendly manner.

Influence of essential oils on xanthan gum-based nano-formulated edible film

Nishant Kumar[1]*, Shruti Shukla[2,*], Ashutosh Upadhyay[1,*]

[1]*National Institute of Food Technology Entrepreneurship & Management (NIFTEM), Sonipat, Haryana, 131028, India*

[2]*TERI-Deakin Nanobiotechnology Centre, Sustainable Agricultural Division, The Energy and Resources Institute, TERI Gram, Gwal Pahadi, Gurugram, Haryana 122001, India*

*Corresponding author email: shruti.shukla@teri.res.in (SS); ashutosh@niftem.ac.in (AU); nishantniftem@gail.com (NK)

Abstract

Essential oils (EOs) are natural products from plant sources, and used in food and pharmaceutical sectors as preservatives as well as flavoring and stabilizer agents. EOs possess antimicrobial, antioxidant, antifungal activities due to the presence of secondary metabolites and volatile compounds such as phenolic and flavonoids etc. The volatile and phenolic compounds of EOs are responsible for inhibiting of fungal and bacterial growth, thus enhancing antioxidant activity, which leads to extended shelf-life of food products. In recent decades, EOs among the natural products have been extensively used as stabilizers, antimicrobial and antioxidant agents to be incorporated into food products and packaging materials. In the present study, different EOs (rosemary, clove-leaf, clove-bud, peppermint, tea tree, lemongrass, and oregano) were used to prepare nano-formulated edible films along with 1% xanthan gum as a polymeric base. The influence of EOs was investigated on the physical, mechanical, thermal and other properties of the developed nano-formulated edible films. The results showed that the incorporation of EOs influenced the antimicrobial activity against yeasts and molds with a significant reduction in the viable counts of the tested pathogens, including the properties of xanthan gum-based edible films. The findings of this study reinforce the suggestion of using EOs as natural fungicide alternatives to commercial fungicidal agents for developing novel types of natural nano-formulations for preservation of fruits and vegetables as well as other types of food products using EO-based edible packaging.

Self- readable Metal Organic Framework based Immuno-probe for detection of Aflatoxin B1

Rashi Bhardwaj*, Tinku Basu

Amity Centre for Nanomedicine, Amity University Uttar Pradesh

*Corresponding author email: rbhardwaj@amity.edu

Abstract

Aflatoxin B1 is an IARC group 1 carcinogen and genotoxic material, produced by a fungus called aspergillus Flavus, which proliferates in grains like rice and peanuts when they are stored in hot and humid conditions. Now-a day's electrochemical immuno-sensors are being preferred over conventional sensing techniques like LC-MS, GC as they are swift, low cost, and easy to use in any kind of solution. They aid in electron transfer which further helps us to determine the concentration of the analyte.

The present work relates to the construction of a self-readable immuno-sensor based on MOF 5 as sensing scaffold. Herein we have used Toluene Blue as redox dye which has been encapsulated in MOF 5. This dye encapsulated in MOF 5 is further conjugated with aAFB1 antibody using carbodiimide chemistry. Further, a bovine serum albumin protein is employed to avoid non-specific bindings. Herein this redox dye conjugated antibody will act as a novel analytical agent which doesn't require any external electrochemical mediator like ferro ferri in case of electrochemical sensing. This immuno-probe taken only 22 mins including the incubation of AFB1 over this electrode, finally washing and sensing.

The fabricated immuno-electrode could detect AFB1 over a varied range with three different concentrations of AFB1 antibody. They are labelled as Ab20, Ab40 and Ab60 and are able to detect from 2-140ng/ml. The immuno-electrodes exhibit high sensitivity with negligible interference from AFB2 and AFM1.Further, the commercialization potential of the developed probe can be predicted by high stability, minimum interference and wide linear range.

DAY-2, 9th December, 2021

PART-B

SESSION IV

Regulatory Aspects of Nanotechnology

Session IV: Chair

Dr. Pushplata Singh

Fellow and Area Convenor

Centre of Excellence in Nano-Agriculture
TERI-Deakin Nanobiotechnology Centre, The Energy and Resources Institute (TERI), Darbari Seth Block, India Habitat Centre, Lodhi Road, New Delhi 110003
Acting Director, TERI-Deakin Nanobiotechnology Centre (TDNBC)
Adj. Associate Professor, Deakin University, Australia

Contact email address: Pushplata.singh@teri.res.in

Dr Singh is a senior scientist with Sustainable Agriculture Division, TERI. She is at present the Director of the TERI-Deakin Nanobiotechnology Centre. Her expertise is in nanomaterials development, nano-bio interactions, nano- toxicity, life cycle assessment of nanomaterials for agriculture and regulatory affairs. With a PhD in Human Genetics and Genomics and Post- Doctoral experiences in Genomics of human diseases, plants and beneficial microbes; and industrial experience in development of advanced nanomaterials, she collaborates with disparate partners to drive alignment on business objectives and deliverables to achieve closure in a set time frame. She has been significantly contributing towards major research and network project “Centre of Excellence for Advanced Research in Agricultural Nanotechnology (CEARAN) and “DBT-TDNBC-DEAKIN Research Network Across continents for learning and innovation" (DTD-RNA) funded by DBT, India. As a member of TERI team, her role in defining guidelines for the Government of India for safety assessment of NanoAgriProducts has been appreciated. She has independently established two facilities in TERI: Facility for Genomics and big data Analysis; and National facility for safety assessment of nano agro- products. She is an active member of “Bio Nano forum” and “Austria Nano forum”.

Dr. Waluree Thongkam

National Nanotechnology Center NANOTEC), Thailand

Contact email address: Waluree.tho@nanotec.or.th

Dr. Waluree received her Ph.D. in Nanotoxicology from Faculty of Mathematics and Natural Science department of Pharmacy, Herinrich Heine Universität Duesseldorf (HHU), Duesseldorf, Germany in 2017. She was a guest scientist in Particles, inflammation and g enome integrity group at Leibniz research institute for environmental medicine (IUF), Duesseldorf, Germany. Dr. Waluree recent work is related to Nanosafety. She supports Thailand National Nanosafety and Ethics Strategic Plan, which includes 3 strategies. Push for policy development, Knowledge management and Industry - public Engagement on nanosafety issues.

- Recently working as senior technical officer, Nano -Safety Alliance Section at National Nanotechnology Center (NANOTEC)
- Develop Nanotechnology standard with Thai industrial standards institute (TISI)
- Scientific expertise on Nanotechnology field especially on Engineer nanoparticles toxicity and safety.
- Experiences on food safety and regulation.
- Experience at international level cooperation in Europe and Asia
- Experience on cooperate with government (University, Regulatory body etc.) and private sector (Company), -Experience on media (TV and radio) and group communication (As lecturer, speaker and moderator)

Title: Overview of recent Nanosafety activities for industry in Thailand

Authors: Waluree Thongkam

Affiliations: National Nanotechnology Center (NANOTEC), Thailand

Contact email address: Waluree.tho@nanotec.or.th

Abstract

The first Thailand National Nanosafety and Ethics Strategic Plan was established and approved in 2012 by the Office of National Higher Education Science Research and Innovation Policy Council (NXPO). The Second plan was approved in 2017 to 2021 and got extension from the NXPO until 2024. To ensure and permanently improve the guidelines of these National Strategic Plan, the National Nanotechnology Center (NANOTEC) coordinates together with the help of other organizations to implement the Nanosafety plans through various activities. The Nanosafety Program at NANOTEC focus on 4 important points: Policy, Research, Knowledge management and Public awareness. Since December 2020 the memorandum of understanding was signed by 9 organizations on the topic of development of Nanosafety network for industry. The development of Nanosafety network for industry consist of 3 groups: The technical support group (NANOTEC, Thailand National Institute of Metrological), The regulator group (Thailand Industrial Standards Institute, Thailand Food and Drug Administration, Department of Industrial Works, Office of the Consumer Protection Board) and The user group. (The Federation of Thai Industries, Nanotechnology Association of Thailand, Council of Scientific and Technological Association of Thailand) The talk will focus on the recent activities that the Nanosafety network for industry is working together for Nanosafety and Standardization in Thailand.

Dr. C. Anandharamakrishnan

Director, National Institute of Food Technology, Entrepreneurship and Management (NIFTEM), Thanjavur, India

Contact email address: anandharamakrishnan@iifpt.edu.in

Dr. Anandharamakrishnan is presently the Director of National Institute of Food Technology, Entrepreneurship and Management (NIFTEM) . Before being appointed as the Director of NIFTEM he was Principal Scientist and Coordinator for the Academy of Scientific & Innovative Research (AcSIR) at CSIR-CFTRI. He is having more than two decades of experience in research and administration. His areas of research include design of engineered nano and micro scale delivery systems for the controlled and targeted release of food bioactive compounds, 3D food printing, engineered human dynamic gastrointestinal system and glycemic index studies, spray drying and spray-freeze-drying of food products and computational modeling of food processing operations. His research endeavors are well documented in the form of 116 impact factor-publications with an average impact factor of 4.01, two International patents and seven Indian patents.

Dr. Anandharamakrishnan awarded with prestigious 'ICAR - Rafi Ahmed Kidwai Award for Outstanding Research in Agricultural Sciences - 2019'. He was awarded with Tata Innovation Fellowship 2019-20 by DBT, Government of India. He was also awarded with National Design Award 2019 for outstanding contribution by The Institution of Engineers, National Design and Research Forum. He is also the recipient of the prestigious NASI -Reliance Industries Platinum Jubilee Award 2018 and the AIFPA Special Platinum Jubilee Award for Development of Food Processing Technology & Innovation 2018.

Title: Functional Foods and Advances in Nano Delivery Systems

Authors: C. Anandharamakrishnan

Affiliations: Director National Institute of Food Technology, Entrepreneurship and Management (NIFTEM) – Thanjavur (An Institute of National Importance; formerly Indian Institute of Food Processing Technology - IIFPT)

Ministry of Food Processing Industries, Government of India
Thanjavur, Tamil Nadu - 613005, India

Contact email address: director@iifpt.edu.in, anandharamakrishnan@iifpt.edu.in

Abstract

Nanotechnology, with an emerging thrust in nutraceuticals, has expanded into many scientific domains. Currently, micro/nano encapsulated biomolecules are valued at 1 billion US$ and are expected to reach 20 billion US$ in the next 10 years. This treatise covers aspects of nanocarriers, including liposomes and solid lipid nanoparticles, in addition to those underexplored in the food sector. Importantly, strategies for co-encapsulation of micronutrients, modified spray drying processes, and the integration of food 3D printing concepts will be presented. Spray-freeze drying (SFD) is another notable recent technique in the micro and nanoencapsulation of thermolabile and unstable nutraceutical ingredients. Some interesting works include the production of DHA and vanillin microcapsules, probiotic cells with high viability and enhanced volatile retention. Electrospraying is another emerging technique for the encapsulation of nutrients in the nanoscale. ß-carotene was nano encapsulated using zein proteins through electrospraying technique, providing a 1.7-fold increased permeability as evaluated using *ex vivo* gut sac technique. Likewise, solid lipid nanoparticle bearing ß-carotene core molecules developed through an electrospraying approach was found to be better stable during storage and gastric conditions. In a recent electrospray-based resveratrol encapsulation study, zein coated nanoparticles with increased permeability of 1.15-fold were produced. Overall, this treatise is focused on the deep scientific profundity of nanotechnology in the encapsulation of nutraceuticals and discuss the recent scientific pursuit in nutrient delivery systems.

Prof. Rai S. Kookana

Chief Research Scientist: CSIRO Australia

The University of Adelaide

Contact email address: rai.kookana@csiro.au

Dr. Rai Kookana received his doctorate degree (PhD) from the University of Western Australia in 1989. He has been carrying out Research and Development on the fate and effects of Organic Contaminant in the Environment over > 35 years. Dr Kookana's current research interests include characterising and managing ecological risks, in the aquatic and terrestrial e nvironments, of contaminants of emerging concern (e.g., Per - and Poly -fluoro Alkyl Substances commonly known as PFASs, hydraulic fracking chemicals, pharmaceuticals and personal care products, and nanomaterials including nanopesticides). Dr Kookana has published >250 j ournal papers, with an H-Index of 51 and total citations exceeding 11,000.

Dr Kookana was elected Fellow of the Soil Science Society of America in 2012. In 2016, he was awarded the prestigious Prescott Medal by Soil Science Australia. Dr Kookana served as the Science Fellow of the Australian Pesticides and Veterinary Medicines Authority (APVMA) from 2010 -2020. He currently represents the International Union of Pure and Applied Chemistry (IUPAC) at the Scientific Committee on Antarctic Research (SCAR). Dr Kookana was elected as the President of IUPAC Division of Chemistry and The Environment for the biennium (2018 -2020) and is currently a Titular Member of the IUPAC.

Title: Nanopesticides: Regulatory Evaluation of Environmental Risks

Authors: Rai S. Kookana and Melanie Kah

Affiliations: CSIRO Land & Water, Locked Bag 2, Glen Osmond, SA 5064, Australia.
The University of Auckland, School of Environment, Auckland 1010, New Zealand.

Contact email address: Rai.Kookana@csiro.au

Abstract

The potential of nanopesticides to improve the environmental footprint of farming is significant - both in reducing the amount of chemical in the environment, and bolstering yields by minimising losses. For example, a nanopesticide allows the targeted delivery of insecticide or nematicide in the rootzone of plants, where insects or nematodes are active, without releasing it on the surface of soil, thus not only making it more effective in pest control but also reducing its runoff into waterways. However, sound scientific approaches are needed to evaluate their safety from human and environmental health perspective (Kookana et al. 2014; Kah and Kookana, 2020).

Recently, key contributions have been made to the literature on the potential of nano-innovation in agrochemicals sector, considering the global food and environmental needs (Kah et al., 2018; Kah and Kookana, 2020). Based on a series of projects dedicated to regulatory aspects of nano-enabled pesticides, we developed risk assessment frameworks for both ecosystem and human health (Kookana et al. 2014; Kah et al. 2021). These frameworks take not only the active ingredient (AI) into consideration but also the nanocarrier (NC) and excipients associated with the product. We show that at least three entities need to be tracked during the assessment: the NC-AI complex, the empty NC remaining after the complete release of the AI, and the released AI. Overall, our frameworks suggest a tiered approach for risk assessment, which is applicable for a range of nanopesticide products to support regulators and industry in making informed decisions.

Prof. Amit Kumar Dinda

Department of Renal and Transplant Pathology, All India Institute of Medical

Adjunct faculty, TERI-deakin Nanobiotechnology centre

Sciences, New Delhi -110029

Contact email address: dindaaiims@gmail.com

Prof. Amit Kumar Dinda is officer in -charge of Division of Renal and he has keen interest in experimental pathology with interdisciplinary research in immunopathology, tissue engineering, cancer biology and Nanomedicine. He is actively working in the area of application of Nanotechnology in Medicine and Nanotoxicology. His laboratory has developed nanoparticle based oral gene delivery system and nanoadjuvant for developing single shot booster free vaccine, development of novel nanoc arriers for Amphotericin B, technology for delivering 4 anti-tubercular drugs in one nanoparticle, macrophage targeted siRNA delivery system for reversal of Atherosclerosis plaque, combined chemo and photothermal therapy for superficial bladder cancer and study of long term fate and toxicity of gold nanoparticle. Visiting Professor in Albert Einstein Institute of Medical Sciences, New York 2004 -5, Visiting Professor University of New South Wales, Australia 2008. He is Founder Secretary of Indian Society of Nanomedicine (ISNM), Ex -President of Indian Society of Renal & Transplant Pathology, Ex -Vice President of Society for Tissue Engineering and Regenerative Medicine (India) (SABOI), Ex -Vice President, Electron Microscopy Society of India (EMSI), Fellow, and Electron Microscopy Society of India (EMSI). He has published more than 300 papers in peer reviewed journals and holds 8 Indian Patents.

Title: Is there a flip side of Nano? How to limit it?

Authors: Amit Kumar Dinda

Affiliations: Department of Renal and Transplant Pathology, All India Institute of Medical

Adjunct faculty, TERI-Deakin Nanobiotechnology centre Sciences, New Delhi -110029, India

Contact email address: dindaaiims@gmail.com

Abstract

Innovative nano interventions in agriculture and food could result in low-cost, high-efficacy goods and processes, which would be particularly beneficial to developing countries. However, nano-based products (like any new product) must be examined for potential detrimental human and environmental impacts. To support existing agricultural and food rules and regulations, new standards for the evaluation of emerging nano-based products based on current scientific understanding are the need of the moment. The current DBT recommendations, which were developed in collaboration with relevant government agencies and stakeholders, provide a brief review of existing global legislative and regulatory requirements for nano-based agricultural inputs and food products. The existing regulatory provisions of India may further add desired provisions based on these guidelines. These guidelines apply to the following two categories of products: Nano-agri-input product (NAIP), defined as an agricultural input preparation containing intended for applications (through soil, seed, foliar and drip in crops as well as by other means) on crop for the purpose of farming and Nano-agri product (NAP), defined as an agricultural preparation containing nanomaterial intended for consumption or application in food/feed and their supplements as well as nutraceutical delivery. These guidelines are aimed to help researchers, manufacturers, importers and other stakeholders involved in research and development of nano-based agri-input and food products and to encourage commercialization of these products.

Prof. Amitava Mukherjee

Director, Centre for Nanobiotechnology (CNBT), VIT, Vellore

Contact email address: amitav@vit.ac.in, amit.mookerjea@gmail.com

Dr. Amitava Mukherjee is a Senior Professor and Director at Centre for Nanobiotechnology, Vellore Institute of Technology (VIT), Vellore, India. He has 367 publications in peer - reviewed journals (citation index 13774; h -index 58; i 10 - index 235). He has four granted and ten filed patents in the areas relating to Environmental Technology. Prof. Mukherjee has so far received sixteen funded projects as Principal Investigator from several federal agencies in India. He has been admitted as the Fellow of Royal Society of Chemistry and Royal Society of Biology, UK in 2016. He has been recently named among the top 2% of the scientists in the world in Environmental Science in a survey published by Stanford University. He currently serves as Associate Editor of Fron tiers in Nanotechnology, Academic Editor of Plos One, and the Member of Editorial board in the following journals - Environmental Pollution, Science of the Total Environment, Toxicology Reports, and Proceedings of the National Academy of Sciences (Biological Sciences).

Title: Sustainable Nano fertilizers: A "Lab to field" Approach

Authors: Prof. Amitava Mukherjee

Affiliations: Director, Centre for Nanobiotechnology (CNBT), VIT, Vellore

Contact email address: amitav@vit.ac.in, amit.mookerjea@gmail.com

Abstract

Given the heavy reliance of the current agricultural practises on the chemical fertilisers, proper nutrient management of crops and soil fertility will be a critical concern worldwide in the coming decades. Nanotechnology has the ability to optimize fertiliser formulation with the desired chemical composition, enhance nutrient use efficiency, and increase plant productivity while reducing the environmental effect. For designing successful nanofertilizers the inputs from the field should be given due consideration. In this study we have synthesized different Fe3O4-urea nanocomposites with Fe3O4 NPs: urea ratio (1:1, 1:2,1:3) i.e. NC-1, 2, and 3 respectively, and checked their efficacy for growth and yield enhancement. Oryza sativa L. cv. Swarna seedlings were treated with different NCs for 14days in hydroponic conditions and significant up-regulation of photosynthetic efficiency and nitrogen metabolism were observed due to increased availability of nitrogen and iron. From the pot experiments, we found significant enhancement of growth, grain nutrient content, and NUE in NC supplemented sets. 1.45-fold increase in crop yield was achieved when 50% N was supplemented in form of NC-3 and the rest in form of ammonium nitrate. NC supplementation can also play a vital role in minimizing the use of bulk N fertilizers because, when 75% of the recommended N dose was supplied in form of NC-3, 1.18-fold yield enhancement was found. Thus, our results highlight that, slow-release NC-3 can play a major role in increasing the NUE of rice.

Dr Namrata Pathak

Scientist- F & Associate Head (Senior Director), Nano Mission-DST,

Ministry of S & T, GoI

Contact email address: namrata.pathak@gov.in

Dr. Namrata Pathak has more than a decade's experience of Research and development in Natural Resources management (esp. WATER QUALITY sector).She did her Ph.D. in Environment and Biomass from JNU followed by post-doctoral fellowship from university of Siegen, Germany. She coordinated several International conference on Rainwater Harvesting & Catchment Systems, Coordinated Strategic Oriented & planning Process (SOPP) for the organization, Coordinated with AFPRO Field Units in formulation of socially relevant innovative programmes on Water Quality Monitoring and treatment & Facilitated workshops/deliberations on water quality monitoring (WQM) for drinking and irrigation water. She is actively involved in Participatory Planning, Monitoring & Evaluation of Integrated Watershed and Livelihood support projects and Project Appra isal and Evaluation for CAPART. She is also involved in Collaborations & - Orchestrating National Dialogue through Strengthening of Nano -Standards Related Work at National level (CSIR, BIS, and NPL), Development of National Regulatory Framework Roadmap and Formulation of Joint Inter-Agency R&D Programmes in specific areas. She is currently leading the Technology Missions Division (Nano Mission), DST as associate head.

Title: Nano S & T Regulations' - DST Initiatives

Author: Dr. Namrata Pathak

Affiliations: Scientist- F & Associate Head (Senior Director), Nano Mission-DST,

Ministry of S & T, GoI, India

Contact email address: namrata.pathak@gov.in

Abstract

Nanotechnology is an ever emerging field which cuts across all prominent sectors, be it water purification , agriculture, pharmaceuticals ,medicine, food safety, textiles, transport, aerospace, electronics, advance materials, ,infrastructure etc. It cuts across almost all spheres of S & T and has paved way for numerous emerging /futuristic technologies (Nano robots & AI , EHS , precision agriculture, hybrid fertilizers, solar energy conversion etc).The most recent application of Nanotechnology that the world witnessed was during coronavirus pandemic with respect to filters , sensors , masks & vaccine development.

At DST, Nano Mission is an umbrella programme supporting: Basic Research Promotion & Infrastructure Development, Nano Applications & Technology Development Programmes HRD, International Collaborations &- Orchestrating National Dialogue through:

- Strengthening of Nano-Standards Related Work at National level (CSIR, BIS, NPL)
- **Development of National Regulatory Framework Roadmap**
- Formulation of Joint Inter-Agency R&D Programmes in specific areas

WHY REGULATION REQUIRED?

Some of the engineered nanoparticles are harmful owing to their atomic dimensions. They might penetrate into living organisms, causing adverse environmental and health impacts. Therefore, NTs should be subjected to rigorous safety testing and be regulated on toxicity effects

DST- INITIATIVES-

A Task Force was set up for laying down roadmap for a Regulatory Framework for Nano Technology in India, with a multi-agency involvement way back in 2010

a) First ever document entitled," ***'Draft Guidelines and Best Practices for Safe Handling of Nanomaterials in Research Laboratories and Industries"*** came in Year 2013

b) DST was a contributor towards Inter-Ministerial Expert Committee towards development of :

(i) Guidelines ***for Evaluation of Nanopharmaceuticals in India***", Oct 2019

(ii) ***Guidelines for evaluation of nano-based agri-input & food products in India"***, Mar '20

Dr. Paul Wright

School of Health and Biomedical Biomedical Sciences,

RMIT University, Melbourne, Australia

Contact email address: paul.wright@rmit.edu.au

Paul Wright is Australia's foremost expert in nanotoxicology and nanosafety, and the nanosafety advisor to the Australian Nanotechnology Network (ANN). He is the toxicologist and an Associate Professor at RMIT University's School of Health and Biomedical Sciences, at Bundoora in Melbourne, Australia. Over the last three decades, Pa ul has been actively researching, teaching and advising government authorities, committees, industry and public groups in Australia and internationally about toxicology and safety issues associated with the development and use of chemicals and, since 2006, about nanomaterials. He heads RMIT's Nanosafety Research Group and led RMIT's large contribution to the Australian Consortium for the OECD's recent nanosafety testing program. Paul is a Fellow and the President of the Australasian College of Toxicology an d Risk Assessment (ACTRA), and a Fellow of the International Union of Pure and Applied Chemistry (IUPAC). He is also a Councillor of the International Union of Toxicology (IUTOX) and a former director of the IUTOX Executive Committee. Paul is the Co -chair of the Asia Nano Forum (ANF) Working Group on Nanosafety and Risk Management and the nanosafety expert for the EU Horizon 2020 project "GoNano" (http://gonano -project.eu/) via RMIT Europe, which developed co -creation methodologies for nanotechnology applications in food, health and energy.

Title: Effective Co-creation methods for developing nanotechnology applications

Authors: Paul Wright

Affiliations: School of Health and Biomedical Sciences, RMIT University, Melbourne, Australia

Contact email address: paul.wright@rmit.edu.au

Abstract

Smart and sustainable nanotechnology product development includes the safe-by-design approach, and ethical and societal considerations – especially for food-related applications and public concerns over their safety. Previous efforts in public engagement with new technologies that put citizens and other stakeholders together in a session have shown that discussions are often hampered by the diverse levels of technical knowledge of participants. The European Union (EU) Horizon 2020 project "GoNano: Governing Nanotechnologies through Societal Engagement" (Grant Agreement 768622) used responsible research and innovation (RRI) and co-creation principles to help solve this problem for developing nanotechnology applications in food, health and energy. GoNano achieved this by engaging with citizens and other stakeholders (i.e. researchers, producers, policy makers and civil society organisations) in a continuous process of deliberative workshops and online consultations to co-create research aims and concrete product suggestions for future nanotechnology. This process separated citizen and stakeholder activities while still enabling 2-way dialogue between the groups to incorporate outputs from one session as inputs to another. GoNano's co-creation methodologies, guidelines and online toolkits are available at http://gonano-project.eu; and its outcomes used in the GoNano winter school (RMIT Europe, Barcelona, Spain, Feb. 2020) and online microcredentials to train nanotechnologists and people involved in innovation processes. Governance of nanotechnologies requires the involvement of societal engagement, preferably through effective co-creation processes, to address public concerns about how nano-products may affect them, their environment and workplace, and how they are controlled, regulated and labelled.

Mr. Vipin Saini

CEO, Biological Agri Solutions Association of India

Contact email address: ceo@basai.org

Mr. Vipin Saini is a Regulatory Affairs Specialist, Educationalist, Environmentalist, Toxicologist, Data analyst, Writer & Publisher and Humanitarian having about 30 years' experience in the field of biosciences and related regulatory aspects related to National and International norms.

He has been involved in Regulatory Compliance towards achieving agriculture sustainability and maintainin g Food Security, Safety & its Nutrition Value during production and post production scenario while being an active member of:

1. Various Government sub-committees and State Departments
2. Industry bodies e.g. FICCI, ICC-NRetc.
3. Farmer Bodies

In addition to the following:

i. He Manage & lead highly specialized/multi -disciplinary teams, and provide technical leadership in high-level policy analysis & networks,
ii. Advocate strategic partnerships, best practices and effective policy dialogue; develop and negotiate effective working relationships and agreements with all stakeholders,
iii. Lead comprehensive review and analysis of Govt. of India policies, strategies and programs and provide guidance towards achieving key result,
iv. Promote the alignment of various Government policies, programs and initiatives among various stakeholders, Author and Publisher of < 25 books

Title: Interdisciplinary Complexities of implementing Nano Agri-input regulations in Agriculture

Authors: Mr. Vipin Saini

Affiliations: CEO-Biological Agri Solutions Association of India

Contact email address: ceo@basai.org

Abstract

INDIA, is considered as an advanced developing country, having great potential for maintaining a meaningful global presence. Legislations have been enacted in the plenty to practically satisfy all stakeholders in every situation. Unfortunately, as and when a situation demands a new legislation is enacted or framed, with a little understanding of the already existing regulations in enforcement. A chaos is created and a lack of clarity of the exact regulations required create a confusion in manners which are often devastating. The complex network of such legislations being enforced in a bureaucratic and scientific conflict, leaving the stakeholders vulnerable to an outcome which is usually unpredictable and a matter of grave concern. The presentation is an attempt to 1. reflect the complexity of understanding all legislations involved and regulated through various ministries at a political level and relevance of scientific opinion, 2. Lack of an understanding in correlating various legislations in an effort to harmonize a strategic solution to environmental risk assessment and management, and 3. Complexity of regulatory enforcement under various legislations and effective communication of possible environmental impact and hindrances in addressing public awareness.

SESSION V

Advances in seed treatment

Session V: Chair

Dr.Arvind Kapur

Managing Director (Acsen HyVeg Pvt Ltd)

Contact email address: arvindkapur@acsenhyveg.co.in

Dr. Kapur is pres ently the managing director of Acsen HyVeg Pvt Ltd. H e is renowned for developing vegetable seeds which increase s the profitability of farmers and provide better nutrition to the consumer. With his rich experience of 40+ years in agricultural research and 32 years in the private seed sector, he has won laurels on various global platforms. In 2020 , he was identified amongst '10 Best Leaders in Agriculture Industry - 2020' by CEO Insights Magazine. He has also received **BHARTIYA UDYOG RATAN AWARD** in 2006 and in 2015 for individual Achievements and National development from Indian Economic Development and Research Association (IEDRA) and recognition by MARQUIS "Who's Who in the World" in 2013, 2014, 2015. He is a Faculty member of the International Service for National Agricultural Research (ISNAR) located in Hague Netherland and part of the study gro up to do study in India regarding agriculture policies and managing new technolog ies for sustainable agriculture. Since five years he is a Board member of Group for Agricultural Research (GFAR) of FAO representing Private sector from Asia for setting the research priorities for CGIAR institutes.

Dr. Udaya bhaskar K.
Sr. Scientist (Seed Technology)
ICAR-Indian Institute of Seed Science, Regional Station, Bengaluru

Contact email address: udaya9252@gmail.com

Dr. Udaya bhaskar K. pursued his PhD (Seed Science & Technology) from IARI; New Delhi during 2009 thereafter joined ARS in June, 2009 and was being in ICAR service since then. I was initially posted at ICAR -VPKAS, Almora and was there till March, 2012. Thereafter Joined ICAR -IISS, Mau and is serving thereon . Handled the coordination of nation -wide network project on “Seed” i.e. ICAR Seed Project for 9 years. Around 15 Research Papers were being published in peer reviewed journals. International (ISTA) training programmes pertinent to sampling, purity, germin ation & vigour were being attended. More than 20 national and 5 international training programmes were coordinated. I had attended nanotechnology training programmes at TNAU, Coimbatore, ICAR-CIRCOT, Mumbai and MPUAT, Udaipur. Research work pertinent to sy nthesis of nanofibres through electrospinning and infusion of analyte was attempted.

Title: Overview of Engineered Nanomaterials for Seed Quality Enhancement

Authors: Udaya bhaskar K, Radhika C, Sripathy K. V, and Bhojaraja Naik K

Affiliations: ICAR-Indian Institute of Seed Science, Regional Station, Bengaluru, India

ICAR-National Bureau of Soil Survey and Land Use Planning, Nagpur, India

Contact email address: udaya9252@gmail.com

Abstract

On perusal of research endeavours, it is quite obvious that soft materials *viz.* polymer based engineered nanomaterials can be the favourable alternatives to develop third generation seed quality augmentation systems. It is all because of safety, loading efficiency and cargo protection. However, this domain is largely underexplored in plant systems *per se*. Research attempts in this domain by keeping scalability and cost effectiveness as important tenets shall tread into nanomaterials enabled green and sustainable seed quality enhancement strategies. In reference to experiment attempted by us at the backdrop of nanofibre synthesis through electrospinning, cellulose acetate and ethyl cellulose polymer systems are maneuvered for synthesis of nanofibres and microcapsules. Infusion of analyte (GA_3 @ 100 ppm) in ethyl cellulose polymer system and coating of resultant microcapsules on maize seeds was achieved. With respect to germination potential, hastening of speed of germination (first count) over control indicates seed performance has been improved without any negative physiological effects of polymer system. Referred technology can unravel a whole realm of possibilities towards precision agriculture i.e. precise application of analyte, less chemical foot print and prolonged release of analyte.

Dr. Sandeep Kumar Lal

Principal Scientist
Division of Seed Science and Technology
ICAR-Indian Agricultural Research Institute, New Delhi – 110 012, India

Contact email address: skl_nsp@yahoo.com, sandeeplal@iari.res.in

Dr. Sandeep Kumar Lal, Principal Scientist (Seed Technology) at Division of Seed Science and Technology, IARI, New Delhi has a research experience of more than 22 years. He graduated from GBPUAT, Pantnagar and obtained his M.Sc. and Ph.D. in Seed Science and Technology from ICAR -IARI, New Delhi. He started his career as ARS Scientist in 1999 and posted at AICRP - NSP (Crops), New Delhi for 4 years. Thereafter, he joined, IARI, New Delhi and was associated in the seed production of agri-horticultural crops (2006 -10). Subsequently, he was tra nsferred to the division and actively involved in research, teaching and extension activities. His areas of interest include hybrid seed production, seed quality evaluation and enhancement. He has been entrusted with the responsibility of Incharge, STL and involved in seed testing of commercial and service samples. Besides, he been has been assigned the responsibility of PI, SPC under AICRP- NSP (Crops) since 2019. He has published 45 research papers in International / National peer -reviewed journals, 48 po pular/ technical articles, 84 symposia abstracts, 2 books, 3 technical bulletins and several book chapters. He has organised 40 international/ national training programmes and seminars, published 30 training manuals and delivered more than 100 training lectures. He is a life member of several scientific societies and Fellow of Indian Society of Seed Technology (ISST). He is serving as Secretary, ISST since 2017.

Title: Nanoparticle mediated seed quality enhancement techniques

Authors: Sandeep Kumar Lal, Chaithanya G., Praveen Kumar, S V Mounika, and Jagadish Gowda

Affiliations: Division of Seed Science and Technology, ICAR-Indian Agricultural research Institute, New Delhi – 110012, India

Contact email address: skl_nsp@yahoo.com

Abstract

Global agriculture is threatened by the triple challenge, which includes feeding the burgeoning population, securing the livelihood of small and marginal farmers and reducing the environmental degradation. Hence, we need to promote such agricultural systems that give equal weightage to environmental, social and economic concerns, as well as ensuring optimum crop yields. Nanotechnology is considered as one of the key technologies in the twenty-first century; nanotechnology-driven precision farming is desirable for maximization of output and minimization of inputs through better monitoring and targeted action. Seed is the basic and most critical input in agricultural production and the response of all other inputs depends on quality of seeds to a large extent. Quality seed is the key for modern agriculture which demands every seed to be readily germinal and produce vigorous seedlings, thus ensuring high crop yields. It is also considered to be a vehicle for delivery of improved technologies through genetic enhancement, improved crop establishment/ performance and incorporation of new traits. The use of nano-enabled products for seed quality enhancement can provide seed protection, biofortification, plant resistance against biotic and abiotic stresses, or even the combination of these effects, which can help to reduce the required quantities of pesticides and fertilizers. Nanoparticles are effective because of their small size and unique physio-chemical properties, which make them an ideal seed treatment agent. We have undertaken few studies on different crops viz. Wheat, chickpea, maize, pigeon pea, onion and cucumber to investigate the effect of nanoparticles on the seed yield and quality parameters. The results have quite encouraging but the underlying mechanisms how nanomaterials could stimulate germination need to be unravelled. Numerous studies have demonstrated the ability of nanoparticles to penetrate seed coats and enhance water uptake over time, which facilitates rapid and uniform germination, seedling growth and flowering. Nonetheless, the mechanism of nanomaterial-induced water uptake inside the seed is still largely unknown. Moreover, further research is urgently needed to unravel the behavior and fate of altered agriculture inputs and their interaction with biomacromolecules present in living systems and environments.

Mrs. Ranita Das

Chief Technical Officer

International Business, Geolife Agritech India Pvt. Ltd.,

Maharashtra, India

Contact email address: exports3@geolifegroup.com

Dr. Das as a speaker have represented the company in several international platforms and conferences to introduce the company's cutting edge technology and innovative products. She completed her masters in Botany with specialization in Molecular Biology & Biotechnology from University of Calcutta. She has an experie nce of working in the agri industry for almost 8 years now. Dr. Das passion for sustainable agriculture makes her look for new innovations that can make a difference and can give a new perspective to the entire Ag industry.

Title: Integrating Nanotechnology in Seed Treatment

Authors: Mrs. Ranita Das

Affiliations: Chief Technical Officer of Geolife Agritech India Pvt. Ltd, India

Contact email address: exports3@geolifegroup.com

Abstract

Nanotechnology has the potential to revolutionize agriculture and play an important role in food and crop production. Plants and microbes serves as a potential pathway for the transportation of nanoparticles (NPs), closely resembling endogenous mineral nutrients. In modern agricultural production system, rapid and uniform seed germination with Nutrient uptake capability is required for successful seedling establishment with enhanced yield achievement. Among the different seed priming methods, **Microbial Nano-priming** is more effective mainly because of its small size and unique physicochemical properties loaded with beneficial microbes. Microbial Nano-priming modulates biochemical pathways and the balance between reactive oxygen species and plant growth hormones providing beneficial microbes for nutrient uptake, resulting in the promotion of stress and diseases resistance. Microbial Nano priming is a technique based on the combination of seed priming with beneficial microbes and nanoparticle treatment. During Nano priming the nano particles are taken up and retained by the seed coat and beneficial microbes start helping macro and micronutrients uptake. After the integration of loaded nano particles the system slowly releases the active compounds into the seed coat and microbes starts protecting, an providing nutrients. Microbial Nano-priming increases seed germination, seedling growth and development, vigour, rate of seedling emergence. Geolife has developed a product loaded with zinc oxide, magnesium oxide, thiamine nanoparticles with beneficial microbes that have a positive impact on seed and seedling vigor, germination, providing nutrients, radical scavenging activity, salinity resistance and production of antioxidant enzymes, protein content, root length and yield.

Dr. Manish Patel

Executive Director – Incotec India Pvt Ltd, Ahmedabad Vice President – Asia Pacific Seed Association (APSA), Bangkok Co-Chairman, Standing Committee on Seed Technology, APSA, Singapore. Founder Director – Gujarat Seed Valley, Gandhinagar, Gujarat, India

Contact email address: manish.patel@incotec.com

Dr. Manish Patel, Executive Director of INCOTEC India Pvt Ltd., Ahmedabad, India is among the well -known young seed entrepreneurs of India. Dr. Patel is 'Plant Breeder' by academy and 'Seed Technologist' by profession. He is Pioneer person in setting up Indian operations of INCOTEC (the global leader into Seed Enhancement Technology based in Netherlands). During the last just over two & half decades, Dr. Patel, through his deep knowledge of the subject and clear understanding of the market & grower requirements has given a totally new definition to 'Quality Seed' in Indian Seed Industry by performance assurance against biotic and abiotic stresses through seed treatments. He is pioneer in introducing all novel advance seed technologies in India and in neighbouring South Asian countries like Seed Coating / Seed Priming / Seed Pelleting / Encrusting/Seed Upgrading/ Hybrid Genetic Purity tes t etc from the very rich reservoir of technologies from INCOTEC group, The Netherlands. He has set up the state – of art 'An Advanced modern Seed Technology facility' as well state – of art ultra -modern 'Seed Analytical Testing laboratory' in Ahmedabad (In dia) where due validation for usefulness and effectiveness under Indian conditions through joint testing programmes with leading agricultural research institutions in the country are being carried out. It is of its first kind to get accreditation under NAB L in seed sector in India from private sector. And its only one facility recognizes by DSIR as R&D unit for Seed Science and Technology research in country among private sector. He has been able to develop an enviable client base of more than 300 major seed companies.

Title: Scope of Nano Technology in Seed Enhancement

Authors: Dr. Manish Patel

Affiliations: Executive Director, Incotec India Pvt Ltd, India

Contact email address: manish@incotecasia.com, www.incotec.com

Abstract

Nano Science and Nano Technology are too late in its entry into Agriculture field as compared to other sectors like health, electronics, environment and energy. It's still at research and development stage within Agriculture and looks very promising & potential for years to come to meet all the need of growing agriculture with sustainability. Seed is real nano inputs among all inputs being used in Agriculture and there is a lot possibility of using Nano technology in Seed sector mainly for seed enhancement. Early diagnosis of crops towards pest and disease using nano sensors and nano based diagnostic kit will help in producing healthy seeds with highest productivity. There are end number of opportunity in integrating nano technology in formulations of various actives and additives and its application on seeds using methods of seed coating like filmcoating, encrusting, pelleting and priming for fortification of seeds. Such active and additive could be nano pesticide, nano nutrients, nano stimulants and encapsulated biologicals to deliver real value on seed with highest efficiency and in most sustainable way without harming environment. Controlled release and target delivery of applied active ingredients using nano encapsulation technique has brighter scope in harnessing unmet need of seed value addition. We should also emphasis use of nano applications in seed quality assurances specially SEM (Scanning Electron Microscope), NIR analysis, Digital imaging like thermal, multispectral etc to bring into practice non-distructive methods with higher accuracy and precision. Nano technology can go with nano inputs (seed) in revolutionary way in most environment friendly way with mega output.

SESSION VI

Bio derived nano-Agri input products

Prof. Colin J Barrow

Deakin University, Australia

Contact email address: cbarrow@deakin.edu.au

Dr Colin Barrow is Alfred Deakin Professor and Chair of Biotechnology at Deakin University. He is Program Leader for the Marine Bioproducts CRC and Deputy Director of the ARC Centre for Green Chemistry. His research is focused on marine biotechnology and green chemistry in manufacturing. Professor Barrow has a Ph.D. in chemistry and an MBA, more than 350 peer -reviewed publications, several patents, and has presented at numerous conferences and workshops. He has served as a member of the Expert Advisory Committee for Canadian Natural Health Product Directorate (NHPD), the TGA Advisory Committee for Complementary Medicines and is a founding member of Int ernational Society for Nutraceuticals and Functional Foods (ISNFF). Professor Barrow has two joint laboratories in China, one at Qingdao University and the other at Yunnan Minzu University, where he is a Guest Professor.

Dr. T. Rangarajan

Director, Technical of Nualgi Nanobiotech, Bengaluru, India

Contact email address: trangarajan1950@yahoo.co.uk

T. Rangarajan, B.Tech. (1971) from IIT, Madras and a Fellow of the prestigious IIM Ahmedabad (1986), started his career as an Entrepreneur. Way back in 1972, he founded a medium scale unit MINIPRO at Bangalore, to manufacture electronic components. Subsequently, he branched to academics, with a doctorate in Management, specializing in Organizational Behaviour, from IIMA
After brief stints with Ahmedabad Management Association, Entrepreneurship Development Institute of India and Centre for Organizational Development, he has been an independent Management Consultant for nearly two decades, conducting training programme s in Creative Problem Solving Skills and Entrepreneurship Development, undertaking management research projects and offering business counselling to small and medium scale industries, besides teaching in quite a few Management Institutes in Bangalore. He w as the founder Principal of a postgraduate (MBA/MCA) College at Kurnool and a Visiting Faculty at the Indian Institute of Management, Kozhikode, where he has taught Marketing Management, Human Resource Management and Research Methods for Managerial Decisio ns. Since 2003, Dr. T. Rangarajan has been Director / Dean of various B Schools in Hubli, Bengaluru, Nagpur and Chennai, initiating several steps in infrastructure and Faculty development. He is currently the Director – Technical of Nualgi Nanobiotech, Bengaluru.

Title: Increase Agricultural Productivity without Chemical Fertilizers / Pesticides by boosting Photosynthesis through the use of a Package of Foliar Nano Nutrients.

Authors: T.Sampath Kumar and Dr.T. Rangarajan

Affiliations: Technical Director, Nualgi Nanobiotech, Bengaluru, India

Contact email address: Sampath@nualgi.com; trangarajan1950@yahoo.co.uk

Abstract

Proof of the pudding is in the eating. Nualgi Nano Biotech has been in the business of increasing Agricultural Productivity, without Chemical Fertilizers / Pesticides, by the use of its products, for the past 17 years, and has sufficient data to show that it can be done and has been done for crops such as cabbage, ginger, roses, banana, mangoes and several others.
This is done by improving the efficiency of photosynthesis and the osmotic processes. This in turn gives better yields, besides increasing the resistance to pests and diseases, thereby avoiding the need for pesticides and fertilizers. Essentially, Nualgi manufactures, plant food, provided in sizes, smaller than the pores of the leaf, so that it is easier to digest, assimilate and use!
Both Indian and American patents have been obtained for this product.
Economic benefits of the usage of this product outweigh its costs and enable even small and marginal farmers to benefit from this technology.
Details of the product, processes, and results will be provided in the presentation.

Dr. Shruti Shukla

Senior Scientist/ Fellow (DBT-Ramalingaswamy Fellow)

Centre of Excellence in Nano-Agriculture

TERI-Deakin Nanobiotechnology Centre, TERIGRAM, Haryana, India

Contact email address: shruti.shukla@teri.res.in

Dr. Shukla is currently working as a Senior Scientist (Fellow) at TERI -Deakin Nanobiotechnology Centre, India. She is also awarded the DBT-Ramalingaswamy Re-Entry fellowship in 2019 which she initiated with the National Institute of Food Technology Entrepreneurship and Management (NIFTEM), India. Dr. Shukla is having more than 10 years abroad experience as Assistant Professor in the field of Food Science, Biomaterials and Biosensing at South Korean Universities. Her research interests are to ex plore rapid immuno -detection techniques, nano -sensors for food pathogens and toxins, oriental fermentation & functional foods, nano-formulations and nano-sensing for food & agricultural safety. She has published more than 100 articles in the worlds' most p restigious SCI-indexed journals. She is also serving the editorial role in various prestigious international journals. Dr. Shukla obtained her master's degree in Microbiology from Jiwaji University and Doctorate in Botany/ Life Sciences from Dr. H.S Gour C entral University, Sagar, India. Her continuous research interests are to explore new techniques with nano -micro structures for fabricating sensing and food-agricultural toxicant adsorbing devices. She has completed a few international research projects in the field of fermented foods and their safety aspects and developed multiplexed portable sensor devices. She has also captured a DBT-NER research grant with North–Eastern research institutions for developing functional nano -coatings for prolonged shelf-life of fruits and vegetables.

Title: Bioderived Materials for Sustainable Agriculture, Food Safety & Human health

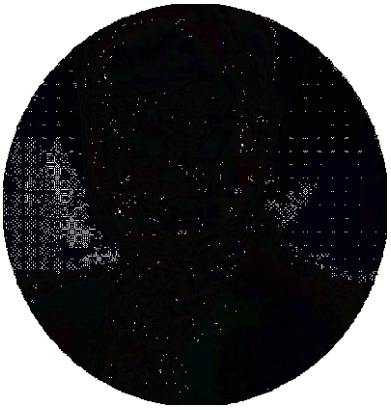
Authors: Shruti Shukla, Rita Choudhary, Amritpreet Kaur Minhas, Ruchi Agrawal, Suneeti Singh, Palash Kumar Manna, Pushplata Singh

Affiliations: TERI-Deakin Nanobiotechnology Research Centre, Teri Gram, Gurugram, Haryana, India

Contact email address: shruti.shukla@teri.res.in

Abstract

In the proposed approach, an innovative concept is presented for utilizing various biogenic agro-waste generated materials including mesoporous silica nanoparticles, cellulose and lignin materials, fluorescent carbon dots and algal metabolites from crude biomass as potential agents for developing sustainable solutions for smart nutrient delivery, seed coating, nutraceuticals development, plant growth enhancement, nano-sensors, anticancer therapeutic agents, and as adsorbents for various food and agricultural hazards via different synthesis approaches. Overall, the bioderived nanomaterials developed have great multifunctional possibilities in agriculture, food and medicine sectors as delivery vehicle, adsorbents, as well as in diagnostics and drug delivery or nano-medicine systems for improving human health.



Dhirendra Kumar

Director of Research & Development

Natural Plant Protection Limited, India (Subsidiary of UPL)

Mr. Dhirendra Kumar holds a M.Sc. In Plant Genetics and Breeding from the Punjab Agricultural University, India. He is also a Double Postgraduate (MBA) from the Punjab Agricultural University, India as well as IIFT, New Delhi. Over the 40 years in the Indu stry, He spearheaded the Research & Development of 'Zero Residue' Agriculture inputs in India and has been advocating the development of Green Technologies in Agriculture. Mr. Dhirendra currently serves as the Director for Research and Devlopment in Natura l Plant Protection Limited, A Wholly owned subsidiary of UPL, Mumbai.

Poster Pitch

Development of Dairy based Iron-vitamin C Fortified Food Ink

Rathee S, Shukla S, Ojha A

Food Science and Technology, NIFTEM, India

Corresponding author email: shwetarth9@gmail.com

Abstract:

The present study aims to make simple, economic and stable sodium alginate-chitosan nanocomposite for loading of vitamin c coated magnetic nanoparticles (MNP). The preparation was done with the use of simple ionic gelation technique. The synthesized nanocomplex were characterized by Fourier transform infrared spectroscopy, dynamic light scattering, thermogravimetric analysis, UV spectroscopy, and XRD. The nanocomplex shows high loading capacity, slow and sustained release. Its responsive to both pH and magnetic field stimuli. Finally, its printability assessment of fortified dairy based nanofood ink was done on foodini printer. 1D and 2D tests were done for preliminary trials. The food ink is definitely a solution not only for alleviating iron deficiency anemia but also the problem of malnutrition prevalent in developing countries in a sustainable way.

Microbial metabolites as emerging photosensitizers for solar cell application

Arshi Gupta [a,b], Sangram K. Lenka [b] , Shyam S. Sharma [b], Fred Pfeffer [a], S.V. Eswaran [b], Xavier Conlan [a] , Wenrong Yang* [a], Mukul Dubey* [b]

[a]School of Life and Environmental Sciences, Deakin University, Waurn Ponds, VIC, Australia
[b]Nanobiotecdhnology Centre, TERI Deakin Nanobiotechnology Centre, Gurugram, Haryana, India

*Corresponding author email: guptaarsh@deakin.edu.au, m.dubey@teri.res.in, wenrong.yang@deakin.edu.au

Abstract

The dye-sensitized solar cells based on synthetic Ruthenium dyes and organic metal-free dyes are widely recognized, however, their toxicity, scarce availability of raw material, high cost, and complex synthesis procedures have been a limitation. This led to the exploration of nature-based dyes. Metabolites from plants such as chlorophyll, carotenoid, flavonoid, and betalains have been tested in dye-sensitized solar cells (DSSC) but their narrow absorption spectrum, absence of functional groups to bind strongly with semiconductor, and non-availability of the electron-withdrawing group to achieve efficient intramolecular charge transfer (ICT) resulted in low-efficiency of solar cells, also these metabolites have drawbacks such as low photo and thermal stability. On the other hand, microbial metabolites have additional advantages over plant-based metabolites such as broad sunlight absorption, good photostability, non-toxic properties, and the ability to be produced in bulk through bioreactor approach. There are more than 22000 microbially generated bioactive metabolites reported to date which can be potentially explored for their application in solar cells. However, only a few reports are available on the use of microbial pigments in dye-sensitized solar cells with the highest power conversion efficiency (PCE) of 2.3 % for monascus yellow which is very encouraging. Though this research is in its infancy it shows the promise of these sensitizers for solar cell applications. In our research, purified bacterial cultures were isolated from roots of eggplant, chili, sweet potato, and okra plant, and the fungal culture of Monascus p. was revived for the pigments extraction. The structural, optical, and electrochemical properties of the extract was characterised and the initial data showed broad absorption in the range of 350 – 600 nm, presence of functional groups required for binding with the semiconductor, and HOMO-LUMO levels required for favourable charge transport in solar cells. The data clearly indicated the promise of microbial pigment as suitable photosensitizer for solar cell application.

Removal of Fluoroquinolone antibiotics in wastewater by enzymatic treatment with fungal laccase

Purvi Mathur[1,2], Mandira Kochar[*1] , Damien L. Callahan *[2], Mukul Dubey, Xavier A. Conlan[3], Frederick M. Pfeffer[3]

[1]TERI-Deakin NanoBiotechnology Centre, Sustainable Agriculture Division, The Energy and Resources Institute, New Delhi 110003, India

[2]Deakin University, School of Life and Environmental Sciences (Burwood Campus). 221 Burwood Highway, Burwood, VIC 3125, Australia.

[3]Deakin University, School of Life and Environmental Sciences, (Waurn Ponds Campus). 75 Pigdons Road. Locked Bag 20000, Geelong, VIC 3220, Australia

*Corresponding author email: mandira.kochar@teri.res.in, damien.callahan@deakin.edu.au

Abstract

The presence of antibiotics in the environment is a global concern because of the emergence of antibiotic resistance bacteria and potential hazard to humans and the ecosystem. Fluoroquinolone antibiotics (FQs) are an emerging class of contaminants that are used extensively in human and veterinary medicine. They are recalcitrant in nature and hence present in effluents, wastewater and water bodies. This work aims to study the removal of fluoroquinolone antibiotics from aqueous solutions by enzyme mediated oxidation process and optimization of the conditions thereof by response surface methodology (RSM) using Box-Behnken designs (BBD). For this, seven indigenous macrofungal isolates were selected to screen for their laccase production capability. Among them, isolates viz., *Pleurotus eryngii, Pleurotus florida* and *Pleurotus sajor caju* were found to exhibit high laccase activity in the preliminary studies and were thus selected for the optimization studies to enhance laccase production. After this, experiments were conducted to optimize the enzymatic oxidation for wastewater treatment by analysing the effect of independent variables namely, pH, temperature, mediator concentration and antibiotic concentration on the degradation percentage of flouoroquinolone antibiotics. Since the degradation obtained using crude and commercial enzymes were comparable, the cost economics using crude laccase was evaluated against commercial laccase and it was evident that the total treatment cost could be reduced by 71.7%, indicating a promising and cost-effective alternative for wastewater treatment. Eventually, we expect to immobilize the enzymes on porous magnetic nanoparticles to overcome any losses during the treatment and for prolonged stability and recyclability.

Nano priming of seeds for biotic and abiotic stress management in wheat: Review

Umesh Kamble*, CN Mishra, AK Sharma, Ravindra Kumar,

Poonam Jasrotia, Gyanendra Singh and GP Singh

*Corresponding author email: Umesh. Kamble@icar.gov.in

Abstract

Wheat is one of the crops in India where elevated productivity is being achieved through genetic gains made out of robust breeding programme. Wheat production in India is all time high *i.e.* 109.58 million tonnes covering the area of 31.6 million ha during 2020-21. However, changing climatic conditions such as drought, erratic rainfall, terminal heat etc., and occurrence of several diseases threaten wheat production. Although wheat breeding programmes are designed to develop climate resilient varietiessuitable to different agro-climatic zones, seed technological interventions are crucial, since seed acts as a conduit for transfer of genetic gains to the farmers. Use of third generation seed quality enhancement strategies *viz*. nanotechnology for external as well as internal designing of seed is the future of the modern day agriculture. Seed nano-priming is a novel technique in which nanoparticles are deployed for seed priming, although nanoparticles uptake occurs in the seed and a portion is retained on the seed surface as a protective coating. This facilitates regulation of seed germination, storage, modulating plant growth and resistance to several abiotic & biotic stresses. Several researchers reported that multi-walled carbon nanotubes (50-630nm) promote cell elongation, xylem and phloem elongation, rapid root growth and higher biomass in wheat. Further, metallic nano particles *viz*., zinc oxide, iron oxide (50-100 nm) and silicon nanoparticles found to be beneficial in reducing the cadmium toxicity in the wheat. Colloidal solution of copper & zinc nanoparticles found to alleviate drought stress by enhancing leaf area and relative water content. Although, metallic nano particles are being utilised for stress management and yield enhancement, bio-safety and regulatory mechanism restricts its use at commercial scale. Therefore, bio-origin nano-materials need to be explored for seed quality enhancement which are effective, eco-friendly and widely accepted by the end users. Chitosan is an organic natural biopolymer utilised as fertiliser, biocide, elicitor and anti-stress agent. Further, clay nano composites owing to unique architecture, biodegradability and tailor-made composition show several advantages over other materials. The use of chitosan based nanoparticles can play vital role in the management of spot blotch disease and stored grain pests of wheat. Designing chitosan/clay based nano particles for biotic and abiotic stress management, controlling germination (pre-harvest sprouting) and safe seed storage holds the potential for future use.

Endophytic *Aspergillus terreus* mediated gold nanoparticle: its antimicrobial activity against phytopathogens *Fusarium oxysporum* and *Rhizoctonia solani*

Rahul Chandra Mishra[1, 3], Rishu Kalra[1, 3], Colin J. Barrow[3] and Mayurika Goel[1]*

[1]TERI-Deakin Nano Biotechnology Centre, The Energy and Resources Institute (TERI), TERI GRAM, Gurgaon, 122001, India
[3]Centre for Chemistry and Biotechnology, School of Life and Environmental Sciences, Deakin University, Waurn Ponds, VIC 3220, Australia

Abstract

Numerous studies have established the usefulness of endophytic fungi mediated gold nanoparticles as biocontrol agents against agricultural and food borne pathogens. The present study was aimed to bio-fabricate gold nanoparticles (GNP) utilizing the methanolic extract of endophytic isolate *Aspergillus terreus*. The biosynthesised gold nanoparticles (GNP023) were characterised using UV-visible spectroscopy (UV-Vis); transmission electron microscopy (TEM), Fourier transforms Infrared spectroscopy (FTIR) and X-ray diffraction (XRD) studies. The antibacterial activity of GNP023 against several food borne pathogens was investigated using *in vitro* antifungal assays against devastating phyto pathogens. Maximum Zone of Inhibition was observed for *S. aureus* and *V. cholera* at 400 μg /ml, which was compared with a positive control. The radial mycelial growth of the two phytopathogenic fungal strains *Fusarium oxysporum* and *Rhizoctonia solani* were both inhibited by the tested gold nanoparticles GNP023 in a concentration dependent manner. Maximum inhibition of 52.5 % and 65.46 % were observed against *Rhizoctonia solani* and *Fusarium oxysporum*, respectively, at the concentration of 200 μg/ml. Also, the gold nanoparticles were found to be nontoxic when tested against Human kidney embryonic 293 (HEK293) cells. Thus, the current work supports the application of myco-synthesised gold nanoparticles as a versatile antimicrobial candidate against food borne pathogens.

Comparison of different pretreatment methods for cellulose extraction from rice straw

Kaur P [a], Bohidar H B [a], Chaudhary R [a], Pfeffer F [b], Williams R [b], Agrawal R [a*]

[a] TERI-Deakin Nanobiotechnology Center, Gwal Pahari, Gurugram, NCR 122001, India
[b]Deakin University, Geelong Waurn Ponds Campus, Victoria 3216, Australia

***** Corresponding author email: ruchi.agrawal@teri.res.in

Abstract

The overexploitation of resources and the emerging need to look for sustainable alternatives has led to an increased research interest in bio based products. Cellulose is the most abundant organic compound with unique surface chemistry, crystallinity, tensile strength and biodegradability. Owing to these properties cellulose has gained wide range of applications in manufacture of biofuels, hydrogel, packaging materials, cosmetics, and others. Amongst the various sources of cellulose, lignocellulosic agricultural residues are attractive substrates due to their low cost, renewability and wide availability. Utilizing the potential conversion of low economic value agricultural residue such as rice straw into high value added cellulose product will not only provide a renewable source of cellulose but also solve the associated problem of waste disposal. The extraction of cellulose from rice straw can be achieved by disruption of the robust lignocellulosic structure. With regard to this, numerous physical, chemical, physicochemical and biological pretreatment methods have been applied for delignification and extraction of cellulose. Each of these methods has its own merits and demerits, and mostly a combination of methods may be applied to make the entire process more efficient. The effective models of pretreatment methods need to be designed on the basis of experimental investigation of physiochemical characteristics of extracted cellulose. The proposed work will give a comprehensive comparison of characteristics of cellulose variants extracted using various pretreatment methods and discuss their effectiveness for achieving technology transfer from lab to industry.

Behavior of Agriculturally Relevant Iron-Based Nanomaterials in Marine Ecosystem

Natasha Yadav[a,b], Luis O.B. Afonso[b] , Aaron G. Schultz[b], Himadri Bihari Bohidar[a],

Pushplata Prasad Singh[a,b]*,

[a] National Centre of Excellence for Advanced Research in Agricultural Nanotechnology, TERI - Deakin Nanobiotechnology Centre, Sustainable Agriculture Division, The Energy and Resources Institute (TERI), DS Block, India Habitat Centre, Lodhi Road, New Delhi, 110003, India

[b]School of Life and Environmental Sciences, Deakin University, Geelong, Victoria, 3217, Australia.

*Corresponding author email: pushplata.singh@teri.res.in

Abstract

Recently, engineered nanomaterials (ENMs) are finding applications in agriculture all over the world to boost crop yield because of their low dose, cost-effectiveness, and improved efficiency. Thus, the increased production and use of these NMs will lead to their exposure to the natural environment. Once ENMs enter the environment, the marine ecosystem becomes their ultimate fate, where their existence is governed by their specific interactions with the complex abiotic and biotic components present in that system. The ENMs after such interactions may form transformed nanomaterials and exert toxic effects on life forms present in a marine ecosystem. In this context, an assessment of the colloidal stability in sea water, and potential toxic effect of agriculturally significant iron-based NPs on marine species has been investigated. This study emphasizes two critical time-dependent attributes of transformative behavior (aggregation and sedimentation) of these nanomaterials exposed to a complex saltwater environment. Several advanced experimental approaches were used to systematically map the changes in morphology and physicochemical features of these materials. Their apparent hydrodynamic diameter systematically increased with time with the concomitant loss of larger aggregates to sedimentation. With respect to potential toxic effects, only chemically synthesized commercial iron nanoparticles (Sigma-Aldrich) exposure had a deleterious effect on the development of *Bacillus subtilis, Planomicrobium soli,* and *Escherichia coli*. These findings revealed that various NMs interact with microbial species in distinct ways, depending on their source, morphology, and aggregation state in the growth medium which in turn influences their bioavailability in the marine ecosystem.

Inhibitory effect of sulfur nanoparticles against fungal disease (Early Blight)

Pal, A*[1,2], Dwivedi, N[2], Bohidar, HB [2] , Kaur, P ,Cahill, D[1], Rookes, J [1],

Yang, W [1], Tikrey, DS[2], Manna, PK [*2]

[1]Deakin University, School of Life and Environmental Sciences, Waurn Ponds Campus, Geelong, Victoria, 3216, Australia

[2]National Centre of Excellence for Advanced Research in Agriculture Nanotechnology, TERI- Deakin Nanobiotechnology Centre (TDNBC), TERI Gram, Gwal Pahari, Gurugram, Haryana- 120003, India

*Corresponding author email: **anamika.pal@teri.res.in; *palash.manna@teri.res.in**

Abstract

The usage of nanomaterial-based fungicides for combating the rising resistance of farm pests has been steadily expanding in recent years because of their advantages over conventional bulk fungicides. However, pathological aspects of non-metal nanoparticles are lacunae in crop protection applications. In this context, sulfur nanoparticles have been synthesized via green, chemical and biological methods. The formation of nanoparticles was confirmed using preliminary and advanced characterization techniques, such as DLS, XRD, SEM, EDAX, and TEM analysis. Furthermore, their efficiency as an antifungal agent against *Alternaria solani* (causing Early Blight in tomatoes) was evaluated. The antifungal effect of the chemically synthesized sulfur nanoparticles (OSNPs) on *Alternaria solani* is documented for the first time in our study that reduces the application dosage by approx.10-16 times of commercial pesticides. Our study reveals that OSNPs have fungicidal capabilities, allowing them to treat fungal disease in tomato without impairing host growth. Overall, the present research work shed light on the fate of the OSNPs in the plant's metabolic cycle in addition to its fungicidal properties and set a benchmark for its commercialization.

Production of Biodegradable plastic/polymer by bacteria

A. Dhawan[*1], H.B. Bohidar[1], P.K. Manna[1], R. Choudhary[1], M. Goel[1], R. Williams[2], F. Pfeffer[2], C. Smith[2], A.K. Dinda[3], P. P. Singh[*1]

[1] TERI Deakin Nanobiotechnology Centre, TERI Gram, Gwal Pahari, Gurugram, India

[2] Deakin University, Faculty of Health, Australia

3 All India Institute of Medical Sciences, New Delhi, India

*Corresponding author e-mail: aksha.dhawan@teri.res.in, pushplata.singh@teri.res.in

Abstract

Traditional plastics engender a considerable threat to the marine and terrestrial ecosystems by degrading into micro-plastics, releasing toxic chemicals, and choking the wildlife. It also poses a significant concern to agriculture as its application ranges from mulching to agriculture nets thereby retarding the growth process of plants. This study deals with the production of alternative biodegradable plastics, polyhydroxybutyrate, having similar properties to the synthetic plastic derived from the microorganisms. PHBs are also referred to as green plastics and are produced intracellularly by bacteria under the nutrient(s) limiting conditions.

This work aimed to screen several in-house bacterial strains for their potential to produce PHB. Various microbial isolates were screened by Nile blue A staining, and the *Alcaligenes* sp that showed maximum PHB production was selected. Fourier transform-infrared analysis of the extracted compounds indicated the characteristic C=O peak of PHB. Gas chromatography-mass spectroscopy confirmed the presence of PHB monomers. UV–Vis spectrophotometric analysis indicated the presence of PHB at 235nm. The isolate was able to accumulate 35-40% PHB.

As *Alcaligenes* sp shows the promising results, it can be used for the production of PHB. Further, for the feasible biopolymer production and to boost its yield, agro-waste can be used as the potential carbon source followed by the substrate optimization. Owing to its excellent properties like biodegradability, biocompatibility, good tensile strength and thermo-plasticity, it presents great potential for applications in biomedical, pharmacological, agricultural, and packaging areas thereby confronting the emergence of an eco-friendly environment in near future.

Biologically derived nano boron

Drishti[a,b], Pfeffer F[b] , Cahill D[b], Conlan X[b], Yang W[b], Bohidar H[a], Singh S[a], Singh P[a,b]*

[a]TERI - Deakin Nanobiotechnology Centre, Sustainable Agriculture Division, The Energy and Resources Institute (TERI), DS Block, India Habitat Centre, Lodhi Road, New Delhi, 110003, India
[b]School of Life and Environmental Sciences, Deakin University, Geelong, Victoria, 3217, Australia

*Corresponding author email: pushplata.singh@teri.res.in

Abstract

The substitution of conventional chemical fertilizers with nano fertilizers has gained increased attention in recent years in order to sustain high yields and protect the environment. Boron is the second most deficient micro-nutrient in world's agricultural zones across the globe. The objective of the research project is to follow a biological, eco-friendly and sustainable route to synthesize agriculturally relevant boron nano fertilizer. The nano fertilizer should not only be highly beneficial and efficient for agricultural crops, but also exhibit low or no toxicity towards environment. To achieve this, we have used cell free extract of bio-derived bacteria and successfully synthesized boron nanomaterial. After thorough characterization of the boron nanomaterial, we aim to investigate its effect and dose dependent toxicity on carefully curated *in vivo* and *in-vitro* model systems. As confirmed by TEM and XRD, biologically synthesized nano boron is 20-50 nm, uniformly spherical shaped, crystalline nanoparticles. The particles lie in the range suitable for agricultural purpose. Surface functionalization by FTIR, Raman spectroscopy elucidates boron oxide as the dominant functional group fraction. The effect of nano boron has been evaluated on plant growth promoting rhizopheric bacteria and it shows a safe effect up to 1000 ppm. First ever, biologically synthesized boron nanomaterial exhibits no adverse impact on soil bacteria and needs to be tested on more model systems before release in the environment. Results from this study further encourage elucidating the effect of nano boron on agricultural crops and other non-target organisms of the environment. The study has scope to fill the research gap of boron deficiency for agricultural land along with determination of safe limit for health and environment.

Lifecycle analysis of Phosphorus based nanomaterials in marine environment

Anurag, Nath[1, 2]*, Luis O.B. Afonso[2], Aaron G. Schultz[2], Himadri Bihari Bohidar[1], Pushplata Prasad Singh[1, 2]

[1]TERI-Deakin Nanobiotechnology Centre, TERI Gram, Gwal Pahari, Gurugram, Haryana

[2]Deakin University, School of Life and Environmental Sciences, Geelong, Victoria, 3217, Australia

*Corresponding author email: anurag.nath@teri.res.in

Abstract

The extensive use of nanomaterials in the form of nano-fertilizers and pesticides has increased in the past decade especially in farming practices. This increased use of nanomaterial has raised concerns regarding their impact on environment and human health. Nanomaterial released directly or incidentally, travel through various modes to eventually reach the aquatic environment. These nanomaterials enter and stays dispersed in the environment and subsequently undergo transformation eventually leading to their accumulation in the flora and fauna inhabiting that environment. Several abiotic and biotic factors influence the behavioral properties of theses nanomaterials leading to their structural transformations which play a crucial role in deciding their fate and bioavailability. In this report, transformative studies of biologically synthesized Phosphorous based nanomaterials - nanohydroxyapatite (nHAP) and nano phosphorous (nanoP) have been extensively studied and compared with chemically synthesized counterparts. The size distribution histograms of these nanoparticles suspended in sea water were mapped over a time period of 28 days and compared with deionized water. This data clearly reflected the behavioral changes in the suspended particles due to the influence of abiotic and biotic factors present in sea water on their lifecycle. The effect on bacterial population was also analyzed to note impact on the growth of biological species. Biologically synthesized nHAP and nanoP were observed to show promising results with lower levels of ecotoxicity.

Pretreatment Methodologies for the efficient extraction of cellulose from rice straw

Neha Sharma[1], Rita Choudhary[1], Mandira Kocher[1], Ben Allardyce[2], Rangam Rajkhowa[2] Ruchi Agrawal[1]

[1]TERI Deakin Nanobiotechnology Centre, TERI Gram, Gwal Pahari, Gurugram, India

[2]Deakin University, Institute for Frontier Materials, Geelong, Australia

*Corresponding author e mail: NehaS@teri.res.in

Abstract

Recently, development of sustainable and environmental friendly biomaterials has gained the attention of researchers as alternatives over petroleum based materials. Biomaterials are promising candidate to mitigate the sustainability issues, posing the renewability, biodegradability and cost effectiveness. Thus, this study is to explore and optimize the methodology for the production of cost-effective biomaterial based delivery system for delivering the agrochemicals to the plants. To achieve this, rice straw (agro-waste) was selected as a raw material for extraction of cellulose. The rice straw was treated with steam, various concentration of alkali (5%, 8% and 12% NaOH) treatment, alkali assisted ultrasonication, alkali-urea assisted ultrasonication and organosolvent method followed by the estimation of recovery (yield %) of the obtained cellulose-rich fraction. The cellulose rich fraction was investigated using Fourier transform infrared (FTIR) spectroscopy, Scanning electron microscopy and Transmission electron microscopy to determine their ability to be used as a carrier for delivering the agrochemicals. FTIR spectra of treated samples showed the efficient removal of hemicellulose, lignin as was evident by the disappearance of peaks (1594 and 1427 cm^{-1}) after alkali treatment. The scanning electron micrographs of the native rice straw (RS) indicated compact and intact structure with a rough surface whereas, smoother surface and loosening of the fibrillar structure was observed in treated samples signified the removal of non-cellulosic components and delignification. The results are promising however to gain the insight of the biomaterials based delivery system capable of improving the crop yield further studies of biomaterials with agrochemicals need to be implemented.

Molybdenum disulphide nanosheets for enhancing photosynthesis in agricultural crops

Mony, C[1,2*], Kaur, P, Yang, W[2], Rookes, J[2], Callahan, D[2], Eswaran, S.V.[1], Manna, P K[1*]

[1]TERI-Deakin Nanobiotechnology Centre, TERI Gram, Gwal Pahari, Gurugram, Haryana

[2]Deakin University, School of Life and Environmental Sciences, Geelong, Victoria, 3217, Australia

*Corresponding author email - chanchal.mony@teri.res.in; palash.manna@teri.res.in

Abstract

Photosynthesis is a dynamic, complex, photo-catalytic process that plays a key role in the growth and development of plants. It converts solar energy to chemical energy by precise organisation of light harvesting molecules in the photosynthetic system. Artificially imitating such systems is difficult due to the complexity of the photosynthetic cascades. Nanoparticle mediated photocatalytic complexes can act as a source for improving photosystem efficiency. Nanomaterials, such as molybdenum disulfide (MoS_2) capture sunlight efficiently and assist in photosynthesis enhancement. Besides, nanosheets offer additional advantage of increased surface area for sunlight harnessing. In this study, MoS_2 nanosheets have been synthesized via chemical route using hydrothermal reactor and biological route using isolates from phyllospheric microflora. To check their effect on plant growth and development, tomato plants were exposed to varied concentration of chemically and biologically synthesized MoS_2 nanosheets. The biologically synthesized MoS_2 nanosheets treated plants were observed to germinate faster than the control plants with prominent roots and shoots. Biologically synthesized nanosheets showed promising results even at the highest concentration of 1000 ppm. This study promises development of plants with enhanced photosystem efficiency leading to improved agricultural productivity even in the regions with less sunlight durations and it can act as a potential solution for small land holding farmers.

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