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MESSAGE FROM DR ALOK ADHOLEYA, DTD-RNA COORDINATOR, DIRECTOR, TDNBC, PROGRAM DIRECTOR, TERI

The role of nanotechnology in building next generation technologies with wide applicability is well known. It is generally understood that unique and vastly different properties of the material emerges at nanoscales compared to their bulk counterpart. These interesting and useful properties can help address several challenges. A large portion of the global scientific efforts is to explore such unique properties of the materials at the nano-scales. A clear transition from curiosity-driven research to the market-oriented research can be clearly seen from commercialization of nano products to nano-based biotechnologies in recent years. Further advancements and creation of nano-based next generation technologies is expected to be possible by consolidating the efforts from expertise emerging from wide range of disciplines of science and engineering. However, there have been reservations world-wide from the risk assessment point of view, which are also required to be critically examined for the safety of humans, animals and environment. In absence of policy regulations, even the safe, green, low-cost efficacious nano-products are experiencing difficulties in reaching the market. India, among top 3 countries in nanotechnology, is ready to forge ahead at global level by having first 'Guidelines for Evaluation of Nano based Agri-input & food products in India' intended not only to ensure quality, safety and efficacy of these products but also to ease product development in nano agri and food sectors. This is the timely initiative by Government of India to prepare and support for next generation innovation to ensure highest crop productivity and food safety while minimising ecosystem impacts and will keep India in forefronts at the global arena By providing evidence based safety assurance through use of scientific framework in regulatory approval process, the safe nano based agri & food products with clear benefits will likely drive the acceptability and its place in market among the common masses. In this context, DTD-RNA network has organized nanosafety webinar during February 2021 and connected with researchers and networks working in this direction.

ANF AND ANF'S PARTNERSHIP WITH DTD-RNA NETWORK

Asia Nano Forum (ANF) is a network organization, founded in May 2004 and now a registered society in Singapore, known as Asia Nano Forum Society, since October 2007. ANF has currently 15 organization members from 11 countries including Australia, Austria, India, Iran, Japan, Korea, Malaysia, Philippines, Taiwan, Thailand, and Vietnam. The mission of the ANF is to promote responsible development of nanotechnology that will benefit each member on education, economy, and environment by fostering international network collaboration.

ANF Executive Committee meeting during nano tech 2020 in Japan

By forming Working Groups, ANF coordinates activities and aligns resources to better work toward common objectives in various areas. The four active working groups are (1) Standardization – to coordinate the cross-sector activities of ANF members for the purpose of facilitating the development of standards in the area of nanotechnology, (2) User-Facility Network – to advance exchange and partnership activities of professional engineers/researchers in academia and industry, (3) Nano Safety and Risk Management – to coordinate nanosafety activities including harmonization of nano safety training, safety-by-design approach to nanotechnology development and translation of nano research to the marketplace, and (4) Commercialization – to realize economic value of Nanotechnology Research & Development through commercializing demand driven and technology push initiatives in partnership with the industry for sustainable development of ANF member economies.

Take Standardization as an example. As the liaison member of ISO/TC 229 and IEC/TC 113 WG3, ANF has led three projects including IEC TS 62607-4-4:2016 (published), IEC TS 62844:2016 (published), and ISO PWI 4971 (working project). Also, there are the Inter-Lab Comparison among Malaysia, Indonesia, Philippines, Iran, and Thailand, and a new scheme for mutual recognition of nano-enabled products certification between Taiwan's nanoMark and Malaysia's NANOVerify. In addition to nanoMark and NANOVerify, Iran's NanoScale and Thailand's NanoQ are the other two nano marks in ANF society. Another example is the plan for mutual exchange for 2~4 weeks between professional engineers between NIMS (Japan) and Nanotech (Thailand) under User-Facility Network.

ANF also aims at broadening cooperation with regional partners. At the online 4th EU-Asia Dialogue on Nanosafety, a concurrent event during the virtual 17th ANF Summit last October, experts from EU and Asia joined the dialogue with theme "From discussions to implementation". As a follow-up of the EU-Asia Dialogue, a kick-off meeting of an international network-initiative was held online later in December 2020 to expand the common knowledge base for (nano)materials of regulatory significance and to support the needs of various stakeholders including regulatory bodies and industry.

At the 4th EU-Asia Dialogue on Nanosafety last October, Dr. Alok Adholeya from TERI-Deakin Nanobiotechnology Centre (TDNBC) of India also gave a keynote lecture on "Guidelines for Evaluation of Nano-based Agri-input and Food Products in India". These guidelines released in July 2020 encourage Indian innovators and industries to develop and commercialize new nano-based agri-input and food products and can be beneficial for ANF members to help make policy decisions for nano-based products in agriculture and food, too. Actually, an agricultural cooperation between TERI and NCHU from Taiwan has been initiated afterwards. Furthermore, the "DBT-TDNBC-DEAKIN – Research Network Across continents for learning and innovation" (DTD-RNA) covering DBT (Department of Biotechnology, Ministry of Science and Technology), TDNBC, and DEAKIN of Australia has been created to expand globally to foster nanoscience and innovation. With the same vision of promoting research and development of nanotechnology, a networking at its best results in the synergy between ANF and DTD-RNA could be expected.

BNN AND TERI STARTED THEIR COLLABORATION IN THE AREAS OF NANOSAFETY

BioNanoNet Forschungsgesellschaft mbH (BNN) is a non-profit research organization owned by the BioNanoNet Association, which currently counts with 66 member organizations that are active in the fields of Health & Safety, Data & Sustainability and Enabling Technologies. In these fields, BNN furthermore coordinates the national technology platforms NanoMedicine-Austria, SusChem-AT and the Austrian Microfluidics Initiative.

BNNs' mission is to support and guide its members and customers towards a sustainable development of connected technologies with the vision to shape the European high-tech ecosystem to secure a sustainable and prosperous society. By integrating safety, quality and sustainability aspects already in the design phase of a new technology, we support innovative breakthroughs in all sectors. The design process enables us to reach out to the ideal option and find the best solution for each specific use case.

BNN offers its services in four different areas:

- Design for Technology Development: BNN helps you create safe and sustainable processes and products of highest quality. Integrating safety, quality and sustainability aspects already in the design phase of a new technology, supports innovative breakthroughs in all sectors. The design process enables to reach out to the ideal option and find the best solution for your specific use case. BNN guides you through the Safety-by-Design, Quality-by-Design and Sustainability-by-Design processes.
- Innovation Support: Innovation is the key to everything the future can be. Therefore, by sharing BNN's knowledge within the technological and business field, innovation practices and strategic guidance, BNN will help you on visualizing and getting the fastest way for your idea to become reality and make sure that your innovative effort creates long-term and sustainable value.
- Alliances & Clustering: BNN connects organizations with strategic partners to share and join new initiatives and to national and international strategic stakeholders. BNN establishes and coordinates thematic platforms together and leads initiatives that maximize your impact globally. Through a strategic management of topics of common interests, BNN jointly shapes the R&D&I landscape in Europe.
- Complementary Business Support: BNN helps you to maximize your focus on scientific research, sharing our knowledge and experience as a participant in funded projects on international level! Within the last 15 years, BNN has helped to build and manage small to large scale consortia, and to promote and coordinate dissemination and exploitation activities of research projects at all Technology Readiness Levels. BNN supports in the Project Initiation and Grant application, Project Management and Communication & Dissemination.

The success of BNN stems from its "network" and the coordination among leading key players from its platform, which is the engine that drives interdisciplinary and innovative processes in these research areas.

International networking – shaping the collaboration globally – our cooperation with TERI

BNN and TERI (The Energy and Resources Institute) officially started their collaboration in the areas of nanosafety and on their way towards a global roadmap for nanotechnology. First activities to strengthen the interaction started mid 2020 with the invitation of Dr. Alok Adholeya as a speaker to the 4th EU-Asia Dialogue on NanoSafety, that was organized by BNN as a task in the NanoSyn project. After the start of the international network initiative on nanosafety (an outcome of the EU-Asia Dialogue) end of 2020, it became clear now that this collaboration between TERI and BNN will boost the global interaction in the field and that both networks will benefit a lot from each other. Furthermore, besides the networking actions, the knowledge exchange and scientific discussions started already with a highlight, the "Webinar on nanosafety/econanotoxicity and regulatory aspects of nanoproducts" on February 19th, in which Andreas Falk was invited as panelist.

BNN is looking forward to the next activities in our great collaboration!

For more information about BNN take a look on our website www.bnn.at.

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EVENTS ORGANIZED BY DTD-RNA DURING JAN-MARCH 2021

E-winter school workshop on "High- End Characterization of Microalgae: Overcoming the Technological Barriers" on 3rd-4th of March, 2021

Report by Dr Amritpreet Kaur Minhas and Dr Ruchi Agrawal

This e-workshop was organized by TERI-Deakin Nanobiotechnology Centre (TD-NBC) along with International Iberian Nanotechnology Laboratory (INL), Braga, Portugal.

The workshops aimed to contribute to improve the economic viability of algae value chains via research focusing on extracting multiple products from algae. Leading academic researchers, and technocrats from industries participated in our workshop, who shared their knowledge and experiences on various aspects related to micro-algae cultivation and the down streaming which was supported by Lectures and Demonstration based video-clips.

The purpose of the workshop was to bring together students, budding or middle-level scientists/ faculties, engaged in the field of micro-algal research from various regions of the world and gather inputs from the lead experts in the field of microalgae. This workshop provided a platform for the knowledge advancement and to communicate/ collaborate with other experts working in this area. Overall, it was a dedicated forum to discuss the challenges, concerns and prospective solutions for the microalgae downstream processing and to address the questions- 'How microalgae can be a great advantage for industrial applications?' and 'How can they be promoted and exploited in a better manner?'

The workshop included two different sessions:

Session I: New developments in metabolites processing: Algal Biofuels and other commodities

Experts in the field of algal biology shared their recent successes with event participants mainly students who would like to do microalgal research from beginning with huge possibilities of understanding the microalgae.

This session of the workshop summary report provided highlights of each speaker's presentation with a focus on the challenges in achieving viable bio refinery approach in following approach:

- Biomass, Biofuels and By products and microalgae characterisation in OMICS perspectives
- Production enhancement of cyanobacteria as major producer of naturally occurring colorants
- Resources needed in order to address challenges to achieve economical biorefinery approach
- Bioethanol fermentation and biorefinery concept (fuel and high value products); extraction of exopolysaccharides.

On first day of workshop there were three demo session on laboratory protocol as follows:

1. DEMO session on High –Performance Liquid chromatography (HPLC) for carotenoids profiling in algae by Dr Pavan Jutur, Group leader, ICGEB
2. DEMO session on Laboratory scale protocol for production, Extraction, &Purification for phycobiliproteins pigments from Cyanobacteria by Dr. Sunil Pabbi, Professor, Division of Microbiology and Principal Scientist, Indian Agricultural Research Institute (IARI), PUSA
3. DEMO session on the specific characterisation techniques used to obtain information on how light is scattered and used by some microalgae in particular diatom microalgae and other example of photoautotrophic

organism by Dr. Martin Lopez-Garcia, Principal Investigator, International Iberian Nanotechnology Laboratory (INL), Braga, Portugal

Session II: Downstream Technologies: Function, conversion and formulation of co- products

On second day of workshop four speakers delivered the lectures along with three laboratory scale demo session.

This session was to discuss current challenges and addressing the possible solutions to work on the challenges and knowledge Gaps in the downstream processing of microalgae. The topics were broken into four focus questions covering methodologies for handling algal cultures, Sustainable microalgae farming for biofuel and other commodities, Industrial application of microalgae and Characterization of single cell oils through microalgae.

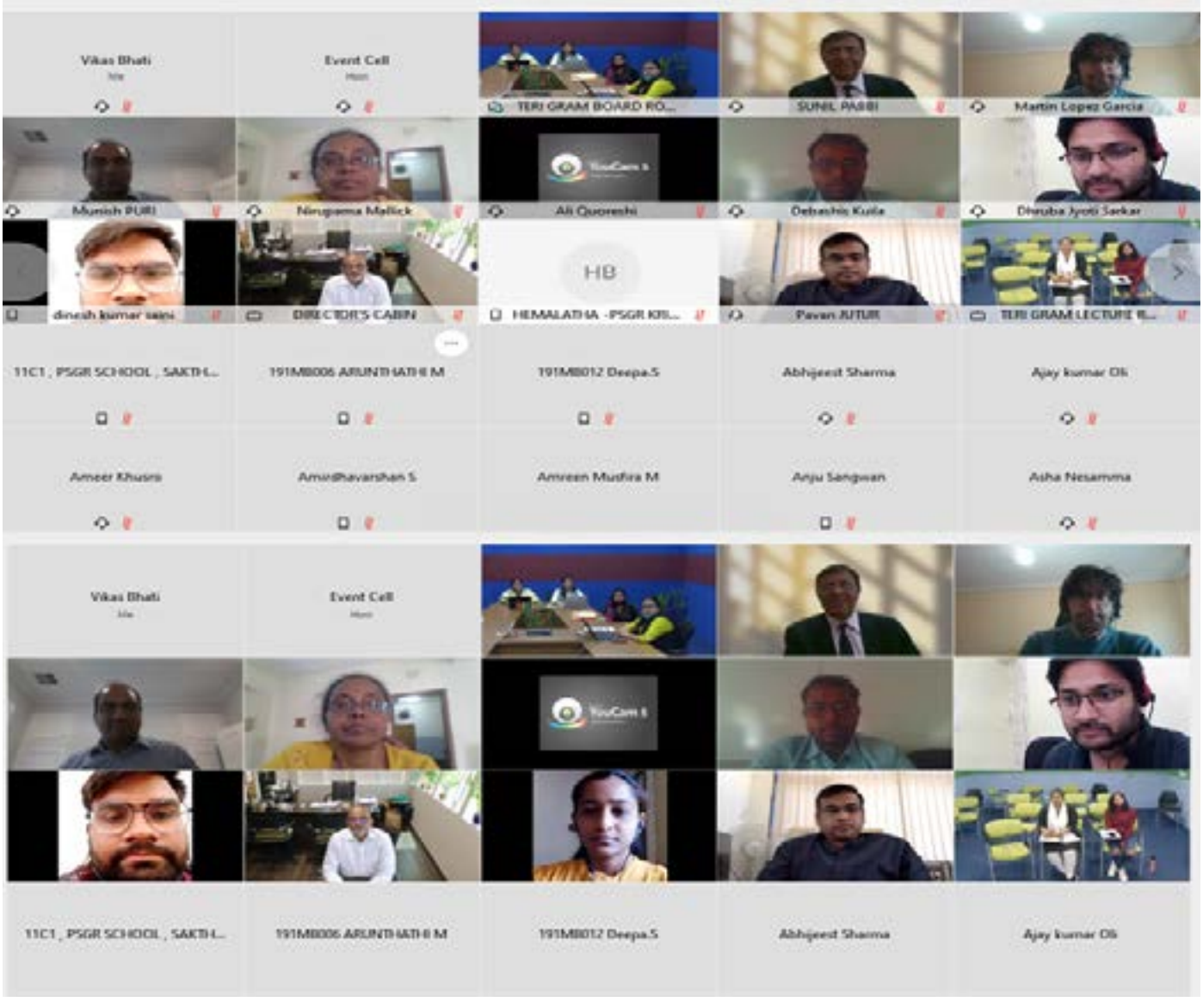
There were three demo session on laboratory protocol as follows:

1. DEMO session on demonstrating a process for lab scale protocol for isolation and multiplication of LG from small scale to large scale cultivation by Dr. Amritpreet Kaur, Associate Fellow, TERI-Deakin Nanobiotechnology Center (TDNBC), Gurugram, India
2. DEMO session on High Throughput screening of growth promoting bacteria for algae by Dr. Shovon Mondol, Ramalingaswami Fellow, TERI-Deakin Nanobiotechnology Center (TDNBC), Gurugram, India
3. DEMO session on Processing Lipids from microalgae by Prof. Munish Puri, Deputy Director, Centre for Marine Bio-products Development, Flinders University, Australia

Key takeaways include:

Attendees and panellist were asked to provide inputs regarding the following question:

- Identifying challenges and strategies in algal biofuel commercialization that poses significant hurdles over the next 5 years?
- Translating bench-scale research to outdoor cultivation practices is a challenge:
  - Focus on cultivation aspects and attaining high biomass without contamination
  - Develop milking process for extraction of high value products such as omega 3 fatty acids from microalgae by not destroying the cell. This process is regarded as a very good cost effective way for oozing out metabolites
  - High value product can be sequester by the fractionation and separation of high quality products and then prioritize the responses separation by producing high quality single products or multiple products.
  - Develop a seasonal rotational concept where a couple of strains can be grown through the year as a rotation because we have a lot of



sunlight So, in Indian context these options need to be addressed in a much better way.

- For high valuables products strains producing triglycerides can be selected in a bio refinery approach
- Algal Technologies are scalable only with products of high value
- Astaxanthin produced from Non GM strains besides Haematococcus pluvialis for human feed and aquaculture can be a game changer. The leftover biomass can be used for animal feed in India as there is a huge million dollar market.
- Heterotrophic microorganisms with high lipid values need to be considered for cultivation and scale up

The major hurdle for microalgae utilization for various applications is the low efficiency along the value chain from harvesting, dewatering, extraction and purification, apart from the development of effective and economically interesting microalgae cultivation systems. This results in low economic feasibilities for the processes based on this interesting biomass resource. A deeper understanding of the aspects related to microalgae cultivation is hence needed so that they can be promoted and exploited in a better manner.

There was an overwhelming response from the budding and middle-level scientists, faculties and students from the various regions of the world, and approximately 300 participants attended actively in the event and have gained valuable learnings that, would help them in achieving their research goals.

Webinar on "Nanosafety/Econanotoxicity and Regulatory Aspects of Nanoproducts" (19th February, 2021)

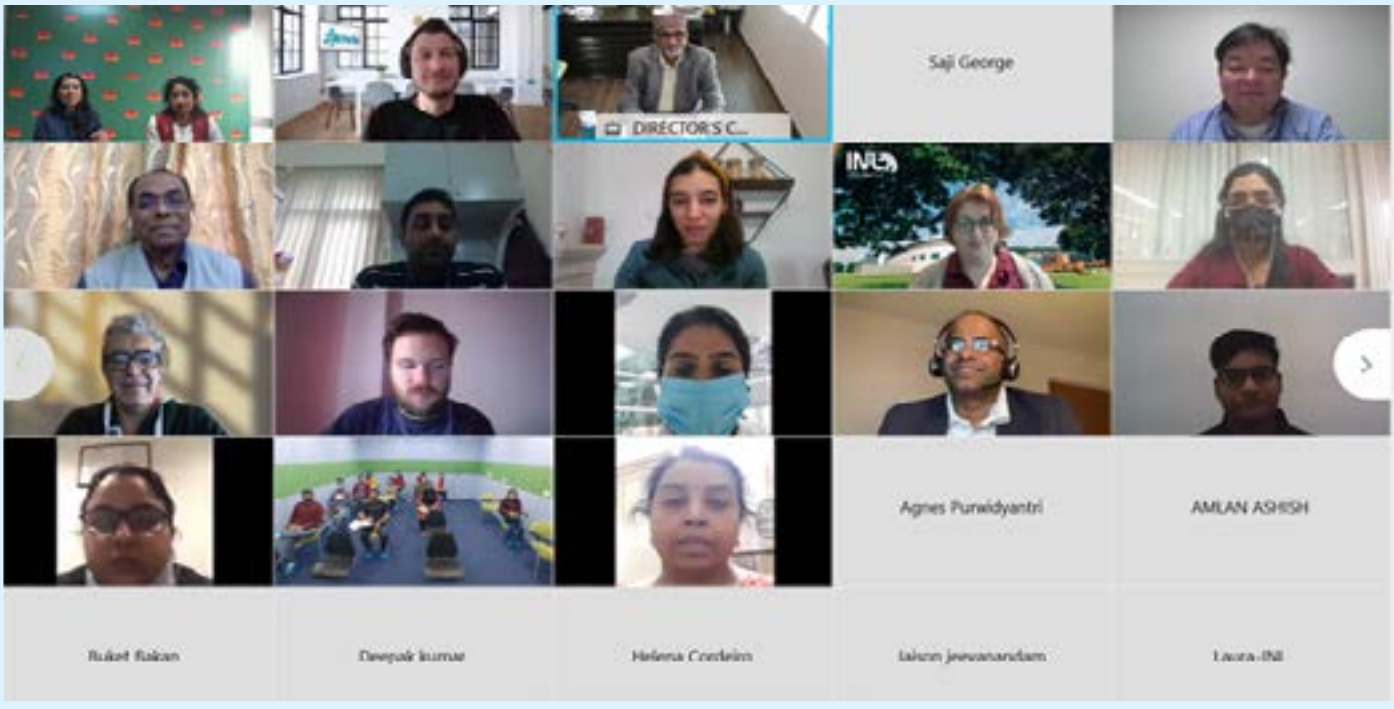
Report Prepared by Dr Pushplata Singh and Dr Sarat Kumar

A webinar was organized by TERI Deakin Nanobiotechnology Centre along with International Iberian Nanotechnology Laboratory (INL), Portugal on February 19, 2021 to discuss the safety and regulatory aspects of nanomaterials. Interdisciplinary collaboration in science is transforming human life with emerging technologies like nanotechnology that are leading to incremental as well as disruptive innovations. Novel products with nanotechnology intervention are projected to revolutionize the health care practice, agriculture and food sectors in future. The emphasis is to create technologies that have high commercial and societal impact. However, the scientific understanding related to evaluation of nanoproducts for efficacy and risk to human health and environment is a critical gap concerning their successful commercialization. The novel multifunctional nanomaterials based products require cautious selection of the available tests as well as additional new tests for quality, safety and efficacy assessment in future. In regard to this, this webinar was organized.The webinar brought together leading academic researchers, medical doctors, technocrats and industries along with representatives from regulatory bodies to exchange and share their experiences on nanosafety/ eco-nanotoxicity and regulatory aspects of nano-agri products and nano-pharmaceutical products.

The webinar involved two sessions each having presentations by senior speakers from academia followed by third interactive session. In the first session, the speakers from INL discussed the methods for developing safe by design nanomaterials. An interactive discussion happened around the suitability of available methods for evaluation of nanomaterials. In the second session the status of available national and international regulatory guidelines was elaborately discussed by speakers from TERI and AIIMS. The third session

involved Interactive Q&A Session with representatives from academia, industries and regulatory bodies.

The webinar covered several topics related to research and development for safe nanoproducts and suitable guidelines for assessment of nano-agro and nano-pharmaceutical products for regulatory clearance. A comprehensive discussion took place with contributions from senior discussants from academia, who directed the attention towards some important topics potential rules and regulations depending on nanoproducts types and age at environmental exposure to provide awareness and practices for minimizing potential health and environmental impacts. This webinar was attended by over 100 participants across India, Portugal, Canada, Brazil, Spain, Ecuador, Colombia, Germany, Austria, Turkey, Sweden, Korea and UK.



DTD-RNA PARTNERS THAT HAVE JOINED DURING DECEMBER 2020-MARCH 2021

Network Partners

BioNanonet (BNN), Austria

Institute Partners

International Fertilizer Development Centre (IFDC), USA

Industry Partners

- KLR Green Biologicals Pvt. Ltd (KLRGB), Nagarjuna Fertilizers & Chemicals Ltd., India
- DCM ShriRam Ltd, India
- Coromandel International Ltd, India
- Adventz Group (Zuari Agro Chemicals Ltd.), India
- Croda India Company Private Limited, India
- Nuziveedu Seeds Ltd and Global Agrigenetics, India
- Smart Farming Technologies, Netherlands

Upcoming events of DTD-RNA network during April–June 2021

Website: https://www.teriin.org/projects/dtd-rna/events.php

- E-Workshop on Quality Control of Arbuscular Mycorrhizal Biofertilizers
- Webinar on Innovations in Industrial Overburdens Management