

Sustainable Agriculture Programme



Sustainable Agriculture (SA) Programme dedicates itself towards creating innovative solutions and developing new opportunities for profitable farming and livelihoods while conserving natural resources. Our research focuses on sustainable agriculture, environment, and bioenergy by developing plant- and microbe-derived products to substantially improve crop yields, thereby reducing carbon footprint in agriculture. We extensively work on key areas aimed towards improving plant and soil health that include plant- and nano-biotechnology to develop green products like nano- and biofertilizers, superfoods, algal-based bioenergy, bioremediation, and resilient crop plants to biotic and abiotic constraints, besides enhancing their nutritional profile.

Our Focus Areas

- Development of regenerative agriculture technologies to improve soil health
- Agriculturally beneficial microbe-based formulations to reduce carbon footprints and increase yield
- Nano-agri inputs for enhancing nutrient-use efficiency and reducing GHG emission from agriculture
- Bioremediation of industrial wastelands
- Green technology-based functional materials from natural/ waste resources
- Superfoods and algal-based bioenergy from advanced bioresources
- Climate resilience of plants through cutting-edge technologies such as trait engineering and gene editing
- Micropropagation for disease-free, high-yielding quality planting material of economically significant crops to improve farmers' income.

Solutions for Sustainable Development

 Next-generation formulations of mycorrhizal biofertilizer: By harnessing the mycorrhizal microbiome and synergistic, agriculturally relevant bacteria, new formulations are being developed. This led to a functionally advanced mycorrhiza biofertilizer product powered by TERI's in vitro P.E.G Technology of Performance Enhancing Green Biologicals 'Uttam Superrhiza', presently being commercialized by agro-industries.





- Nano-nutrients and nano-fertilizers: As an alternative to conventional chemical fertilizers, TERI has successfully developed biologically-synthesized nano-agriproducts including macronutrients, weedicides, and pesticides.
- **TERI's** nanofertilizers are different from others products in the market as they are synthesized using green chemistry using biogenic approach for nanosynthesis which is absolutely safe to the environment.
- **Microalgal farming:** We have developed ecology-inspired solutions by growing algal consortia for increased algal productivity, and a tool to track nutrient stress in real-time algal cultivation system for cultivation of marine microalgae.
- **Microbial products:** Microbial pigments as natural and sustainable sources of colourants for food, cosmetics and textiles are being developed and tested.



TERI and CFCL launch Uttam Pranaam Bio Nano Phosphorus Product

• **Reclamation of wastelands:** Industrial waste sites including fly ash overburdens, alkali-chlor laden sites, distillery effluent discharge sites, phosphor-gypsum ponds, coal mines, red mud, saline, and arid sites are being reclaimed using selected plant species and mycorrhizal formulations.



Reclamation of wasteland

- **Plant biotechnology:** Application of molecular markers genetic assessment and improvement of ergonomically important traits. Bioengineered rice with enhanced photosynthesis for higher yield under elevated carbon dioxide and rice capable of synthesizing its own nitrogen are being developed to suitably address climate change scenarios.
- Micropropagation technology: Micropropagation Technology Park with an annual capacity to produce over three million plants produces disease-free planting material for government projects, nurseries, and commercial growers as livelihood options.

Thematic Domains

Implementation of cutting-edge, transdisciplinary biotechnology, and nature-inspired solutions that harness



Centre for Mycorrhizal Research





Centre for Nano Research



Micropropagation Technology Park

Agriculture Biotechnology

the power of plants, microorganisms, and microbiomes for achieving agricultural and environmental sustainability through four thrust areas involving research, development, production, marketing, and livelihoods.

TERI is driving the future of sustainable agriculture from harnessing Mycorrhiza-based biofertilizers for ecofriendly farming and wasteland revival, to pioneering biogenic nanomaterials for carbon-neutral agriculture. Our Micropropagation Technology Park delivers disease-free, high-quality planting material to boost crop productivity, while our Agricultural Biotechnology program transforms nature's potential for developing natural pigments for textiles, and extracting valuable bioactives from medicinal plants and bio-waste.

Accomplishments

Patented in vitro Mycorrhiza Technology allows for the bulk synthesis of high-quality, pathogen-free, live, healthy, and genetically pure fungal material. The first-of-its-kind manufacturing technology of TERI that is based on in vitro root organ cultivation and the products created at the Mycorrhiza Mass Production plant is FCO compatible with the Fertilizer Control Order, 1985 and is being commercialized through co-marketing partnerships with top pesticide and fertilizer companies. Current developments include novel products such as mycorrhizal formulations tailored to specific crops and soil microbiome components that are compatible with the farming practices for sustainable agriculture.

TERI has also developed nano urea, nano DAP, and nano phosphorus using a green, biogenic approach, ensuring products are safe by design for both human health and environment. These nano-fertilizers are highly efficient and environmentally friendly, and commercialized. They



Microbes and microbe-derived products such as mycorrhiza, microbial polymers and pigments, and plant-microbe interactions



Impact of microbial biofertilizer formulation in controlled irrigation conditions on wheat (3-7% yield improvement observed).



Nanofertlizers synthesized using biogenic approach

represent a sustainable alternative to conventional inputs, with applications in smart agriculture and beyond.



Our research-based innovation has increased corn yield by 8% while reducing reliance on fertilizers by 25%



Drone-based application of nano DAP in a field of corn in Andhra Pradesh showed yield enhancement by 22%

Foliar spray with TERI Nano Urea







Evalution of TERI Nano Urea product under drone application in Chilli



The TERI-Deakin Nanobiotechnology Centre

Capacity building and skill development

- TDNBC is established by TERI's Sustainable Agriculture
 Division in collaboration with Deakin University, Australia in
 2017. The Centre brings together the complimentary expertise
 of TERI in agriculture, biotechnology, green energy, and
 nanotechnology and Deakin University's expertise in material,
 chemical and physical sciences. It aims to take global space
 through the nanobiotechnology interventions in sustainable
 agriculture, environment, and energy. More details can be
 accessed via https://tdnbc.teriin.org/index.php
- Research Network Across continents for learning and innovation (DTD-RNA): In association with the Department of Biotechnology Gol India, TERI and Deakin University have created DBT-TDNBC-DEAKIN – Research Network across continents for learning and innovation in 2018. Workshops via both online and hands-on modes on 'nanoscience research and development' carried out under the programme have helped in capacity development of students and researchers at different levels in India and several Asian, African and European countries. More details can be accessed via https://teriin.org/projects/dtd-rna/





TERI-Deakin Nano-Biotechnology Centre (TDNBC)





DBT Centre of Excellence in Agrinanotechnology (CoEA)

This is created in 2018 through the grant-in-aid for CoE by DBT, India. The centre is continuously catering towards end-to-end nano-products development for sustainable agriculture. The state-of the art facility supports development of effective nanotechnology based solutions as well as lifecycle analysis and safety assessment of nanomaterials as per the Organization for Economic Cooperation and Development (OECD) and the National Institutes of Health, USA (NIH) guidelines. More information on CoEA can be accessed through our web portal: <u>https://www.teriin.org/ projects/coe-ncearan/</u>.

TERI-Shell collaboration for Reducing GHG emission from agriculture

The strategic collaboration between TERI, a renowned think-tank for climate action and Shell, a responsible Oil and Gas company, is established in 2022. The project focuses on development of package of practices for reducing GHG emission from agriculture through use of alternative agriinputs including nanofertilizers and biofertilizers.

Centre of Excellence (CoE) CFCL-TERI

The CFCL-TERI Centre of Excellence for Advanced and Sustainable Agriculture Solutions is a joint initiative between Chambal Fertilisers and Chemicals Limited (CFCL) and TERI beginning from 2024. The centre focuses on addressing challenges in the Indian agriculture sector, including productivity, soil health, nutrient use efficiency, and the impact of synthetic inputs. It aims to develop innovative biogenic solutions like nano biotechnologybased alternatives, bio-fertilizers, and biopesticides. Additionally, 'New Crop Protection Facility' established under this collaboration is dedicated to the development of highly efficacious bio-control products and biogenic formulations in a controlled environment. This initiative underscores TERI's and CFCL's commitment to sustainable agriculture and reinforces India's ability to spearhead science-driven solutions, ecofriendly for a sustainable agriculture.

Agents of Positive Change in the Agriculture Sector

Successful agricultural transformations are accompanied by multiple benefits by creating jobs, increase farmer incomes, provide food and nutritional security. This considers climate-smart strategies for enhanced resource use efficiency, integrating soil biodiversity, women's economic empowerment, prioritizing agricultural value chains in both food and export commodities in a limited number of crop and livestock value chains, better quality seeds and more effective fertilizers/biofertilizers, and farmers' livelihood. Alignment of our R&D activities with initiatives like the PM PRANAM further accelerate this shift by encouraging the adoption of alternative fertilizers such bio and nano fertilizers and reducing dependence on chemical fertilizers.

Awards and Recognitions

- Mycorrhizal technology has been recognized as one of the top 13 Innovators helping India meet its reforestation goals in 2021 by 1t.org through the Trillion Trees Initiative of The Forum of Young Global Leaders and the Global Shapers Community.
- Hindustan Zinc Limited received CII National Award for Environmental Best Practices 2021 for successfully carrying out two projects in collaboration with TERI, including plantation of 50,000 plants in Biodiversity Park at Rajpura Dariba Mine and developing green area on the wasteland recognized as innovative environmental projects by the industry.

TERI and Tata Chemicals Limited (TCL) were recognized with the Marico Innovation Award in the 2010.

Key Patents

- 1. A novel Mycorrhiza-based biofertilizers consortium and Root Organ Culture (ROC)-mediated production of the same.
- Novel Mycorrhiza-based biofertilizers compositions and method for mass production and formulations of the same.
- 3. A novel vanillin-linked noble metal nanocomposite (nanoformulation) for enhancing antibiotic sensitivity against clinical isolates of Pseudomonas sp.
- 4. A novel bioreactor for mass production of arbuscular Mycorrhizal fungi (AMF).

Way Forward

The Sustainable Agriculture Programme aims to proactively contribute to the economic development of the agriculturedependent community by providing products and services, environmental stewardship, and social responsibility. Hence, we continue to create cutting-edge products and technologies for new innovations while preserving and optimizing the use of natural resources



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