Role of DBT in promoting biotechnology-based development in North East India

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Since 2009–2010, DBT has been making concerted effort towards development of North Eastern Region (NER) of India. Under its Twinning Programme, >300 collaborative research projects are currently underway, between NER institutions and those from rest of the country. Advanced diagnostic infrastructure established in medical colleges/institutions in NER has enhanced quality of disease diagnosis and patient care. Network projects on organic farming, Jhum cultivation, and value addition on cash crops and animal products have benefited the farmers of NER. Centres/Units of Excellence and Biotech Hubs, established across NER, are promoting quality research, education and training in biosciences.DBT awards National and Overseas Associateships to NER scientists for advanced training at leading institutions in India or abroad. DBT's Visiting Research Professorship programme allows eminent scientists to mentor young faculty in NER institutions. In a unique initiative to motivate young students, DBT provides support for setting up basic biotechnology labs in senior secondary schools in NER. All in all, DBT's NER programme has been relentlessly fostering quality research in biosciences, creating a large pool of skilled manpower, and establishing high-end infrastructure facilities in various areas under biotechnology. Green shoots of biotechnology-led development in NER are now strikingly visible.

Keywords: Biotechnology, Centres of Excellence, research and development, network programmes.

Introduction

THE North Eastern Region (NER) of India includes eight states, viz. the so-called 'Seven Sisters' – Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura, and Sikkim. With its 2000 km of international border with Nepal, Myanmar, China, Bhutan and Bangladesh, NER is truly the frontier region of India. Serving as a meeting point for various communities, faiths and cultures since antiquity, NER has become one of the most diverse regions of the world in terms of tribal ethnicity, language and cultural traditions. It is home to nearly 250 tribes, each with its own unique language, cultural tradition and perhaps genotype. With its geo-climatic conditions varying from subtropical, tropical and temperate to alpine zones, and with more than 60% of its geographical area under forest cover, NER also represents a region of mega-biodiversity. More than half of the 15,000 flowering species occurring in India are found in NER; of the 1300 species of orchids reported from India, about 700 species of ornamental and rare orchids are found in NER alone. Identified as one of the two biodiversity 'hotspots' of India (the other being the Western Ghats), with its rich bioresources spread across diverse ecosystems and nurtured by indigenous communities, NER offers ample potential for growth and development. However, NER has remained arguably the most backward region of the country, prompting the Government of India (GoI) to make unprecedented commitment to allocate 10% of its total budget for the development of the region. Accordingly, the Department of Biotechnology (DBT) has earmarked 10% of its total annual budget towards biotechnology-based development activities in NER. In 2001, DBT established a permanent institution in NER, namely the Institute of Bioresources and Sustainable Development (IBSD) at Imphal, Manipur, with a mandate for bioresources development and their sustainable use through biotechnological interventions for the socio-economic growth of the region. More importantly, DBT has adopted the approach of proactively engaging with the scientific communities of NER and facilitate their interaction with leading institutions in the rest of the country. This approach has helped evolve and implement collaborative or network biotech programmes that are aimed at harnessing rich bio-resources of the region for its development. Recognizing the importance of this mission, DBT created a special cell in 2009–10, the North Eastern Region-Biotechnology Programme Management Cell (NER-BPMC), functioning through Biotech Consortium India Limited (BCIL), for conceptualizing and implementing need-based and region-specific biotechnology programmes in NE. NER-BPMC works in close cooperation with various Ministries/Departments/Agencies at the

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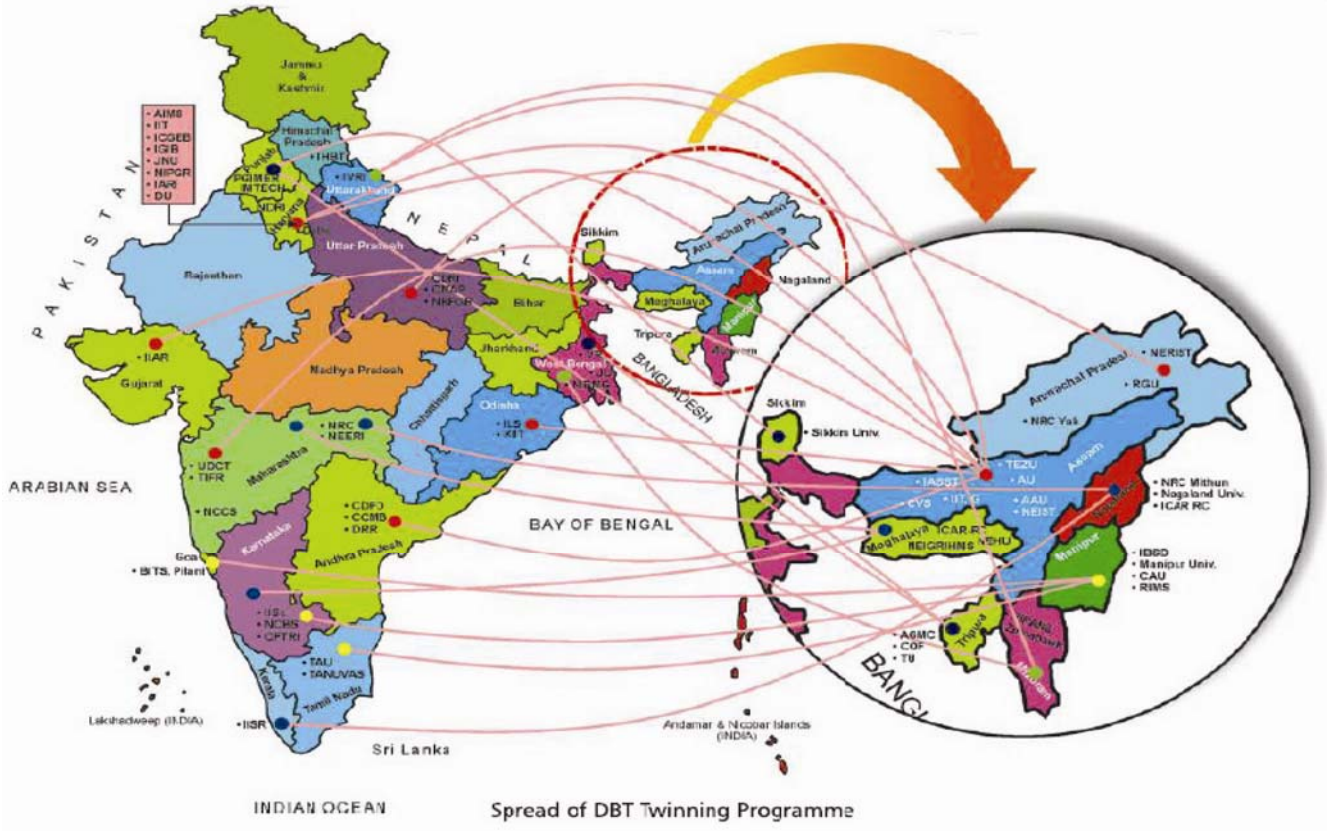

Figure 1. The Twinning Programme: institutes from the North Eastern Region (NER) collaborating with those in other regions of the country.

Central and State level along with universities, and research and development (R&D) institutions towards the common goal of developing and executing quality R&D and extension biotech programmes, including human resource development (HRD), research capacity building, training and entrepreneurship.

Twinning Programme: enhancing competence in R&D

The Twinning Programme has been one of the very first programmes launched by NER-BPMC in 2010–11. It has since emerged as the flagship programme of NER-BPMC, addressing R&D issues across the entire gamut of healthcare (medical biotechnology), agriculture (agri-biotechnology), livestock and fisheries (animal and aquaculture biotechnology), and in the areas of environment, medicinal and aromatic plants (MAP) with specific relevance to the developmental needs of the region. As shown in Figure 1, the Twinning Programme has made a huge impact by catalysing vibrant collaborations between institutions from NER and those from the rest of India, evolving NER-specific projects and their implementation across all eight states of the region.

As illustrated in Figure 2, scientists from NER institutions such as Assam University, Silchar (AUS); Gauhati (Guwahati) University (GU); Tezpur University (TU); Indian Institute of Technology-Guwahati (IIT-G); Assam Medical College and Hospital (AMCH), Dibrugarh; CSIR-North East Institute of Science and Technology (NEIST), Jorhat; Assam Agriculture University-Jorhat, (all in Assam); North-Eastern Hill University (NEHU), Shillong (Meghalaya); Regional Institute of Medical Sciences (RIMS), Imphal; Manipur University, Imphal (both in Manipur); Mizoram University, Aizawl (Mizoram); Nagaland University, Lumami; ICAR-NRC on Mithun, Medziphema (Nagaland); Tripura University, Agartala; Agartala Government Medical College (AGMC) (all in Tripura); Rajiv Gandhi University, Itanagar; North Eastern Regional Institute of Science and Technology (NERIST), Nirjuli (all in Arunachal Pradesh); Sikkim University, Gangtok (Sikkim), etc. are actively collaborating with those from institutes in the rest of India like IIT-Kharagpur; NIBMG, Kalyani (both in West Bengal); ICGEB, AIIMS, IGIB, JNU (all in New Delhi); ICMR-NIIH, Mumbai; ICMR-NIRRH, Mumbai; NCCS, Pune (all in Maharashtra); CSIR-CDRI-Lucknow (Uttar Pradesh); M.S. Swaminathan Foundation, Chennai; Cancer Institute, Chennai (both in Tamil Nadu); Punjab University; CSIR-IMTECH; PGIMER (all in Chandigarh), etc.

Starting with less than 75 proposals funded in the first year (Figure 3), the Programme has blossomed into

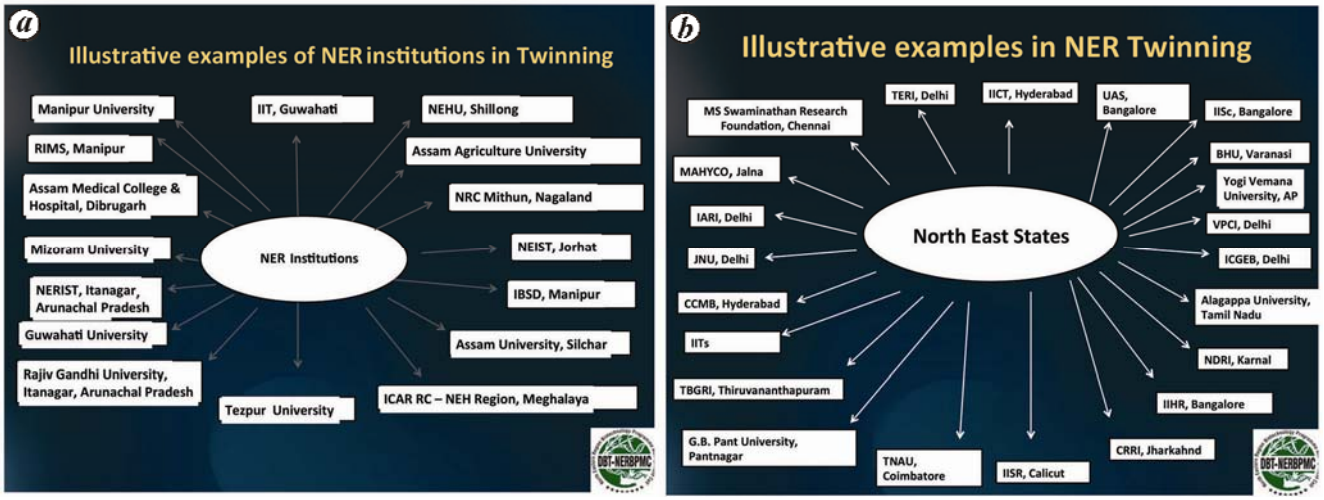

Figure 2. Examples of (***a***) NER institutes and (***b***) other institutes participating in the Twinning Programme.

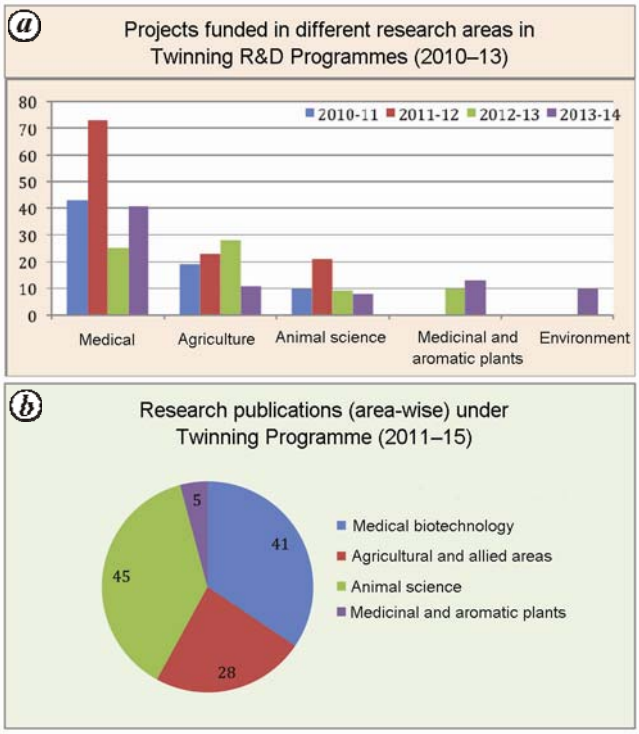

Figure 3. ***a***, Year-wise distribution of the Twinning projects funded in different branches of biotechnology. ***b***, Area-wise publications resulting from the Programme.

receiving more than 525 proposals in the current Twinning cycle (2015). This reflects the continued popularity of the programme which has generated palpable enthusiasm and optimism in the NER scientific fraternity. Table 1 provides the relevant data.

All proposals received under the Programme go through the process of peer-review and stringent evaluatiuon by the subject-specific Expert Committee comprising reputed experts drawn from across the country. As shown in Table 1, so far, more than 300 Twinning projects have been implemented, resulting in more than 100 research papers published in peer-reviewed journals (Figure 3) and more than 400 young scientists of NER trained in advanced biotechnology. Research papers include those published in high-ranking peer-reviewed journals like *PLOS One*, *Plos Neglected Diseases*, *Veterinary Microbiology*, *Transboundary and Emerging Diseases*, *Chemical Communications*, *Planta*, etc.

Table 1. Twinning Programme: year-wise number of proposals received and funded

Year	Total number of proposals under the twinning Programme	
	Received	Recommended
2010	197	72
2011	234	117
2012	310	72
2013	261	83

As apparent from the illustrative list of publications presented in Table 2, the subject matter of projects ranges from molecular characterization of microbial pathogens such as *Entamoeba histolytica*, PPRV, etc. to evaluation of synthetic constructs for protection against Alzheimer or Parkinson diseases, to transcription of drought resistance genes in cowpea. It may be pertinent to mention here that although the list of publications submitted under the Twinning Programme is much longer, for the purpose of this article only those publications have been considered which clearly acknowledged DBT support received under this Programme. Secondly, since many Twinning projects are now at an advanced stage of completion, it is fair to expect a significant increase in quality publications/patents/products from this programme in the coming years.

Theme-based network programmes in agriculture, healthcare and animal biotechnology

In addition to the Twinning Programme, DBT has reached out to initiate theme-based network programmes in all the three major areas of biotechnology, namely agriculture, healthcare and animal biotechnology.

Biotechnology-led organic farming

For example, a multi-centric network programme on 'Biotechnology-led organic farming' has been implemented for promoting eco-friendly agricultural practices in 14 districts across all the eight NE states (Figure 4), with emphasis upon the application of bio-inputs (biopesticides, bio-fertilizers) for organic farming of key high-value crops (HVCs) of NER, mass multiplication of required bio-inputs and evaluation of their efficacy.

Table 2. Ten Selected publications from the Twinning Programme

1. Paul, A., Nadimpally, K. C., Mondal, T., Thalluria, K. and Mandal, B., Inhibition of Alzheimer's amyloid-β peptide aggregation and its disruption by a conformationally restricted α/β hybrid peptide. *Chem. Commun.*, 2015, **51**, 2245–2248 (IF: 6.83).
2. Nath, J., Ghosh, S. K., Singha, B. and Paul, J., Molecular epidemiology of amoebiasis: a cross-sectional study among North East Indian population. *PLoS Negl. Trop. Dis*., 2015, **9**, e0004225 (IF: 4.44).
3. Roy, S. *et al.*, Experimental observation and theoretical investigation on a novel Cd(II) complex with π-hole interaction involving nitro groups. *Cryst. Eng. Commun.*, 2015, **17**, 3912–3916 (IF: 4.03).
4. Sarkar, T., Banerjee, S. and Hussain, A., Significant photocytotoxic effect of an iron(III) complex of a Schiff base ligand derived from vitamin B_6 and thiosemicarbazide in visible light. *RSC Adv*., 2015, **5**, 29276–29284 (IF: 3.84).
5. Passari, A. K., Mishra, V. K., Saikia, R., Gupta, V. K. and Singh, B. P., Isolation, abundance and phylogenetic affiliation of endophytic actinomycetes associated with medicinal plants and screening for their *in vitro* antimicrobial biosynthetic potential. *Front. Microbiol*., 2015, **6**, 273; doi: 10.3389/fmicb.2015.00273 (IF: 3.9).
6. Gogoi, P., Ganar, K. and Kumar, S., Avian paramyxovirus: a brief review. *Transbound. Emerg. Dis.*, 2015; doi: 10.1111/tbed.12355 (IF: 3.11).
7. Phom, L., Achumi, B., Alone, D. P., Muralidhara and Yenisetti, S. C., Curcumin's neuroprotective efficacy in *Drosophila* model of idiopathic Parkinson's disease is phase specific: implication of its therapeutic effectiveness. *Rejuv. Res*., 2014, **17**, 481–489 (IF: 4).
8. Muthuchelvan, D. *et al.*, Molecular characterization of pestes-despetitis ruminants virus (PPRV) isolated from an outbreak in the Indo-Bangladesh border of Tripura state of Northeast India. *Vet. Micobiol*., 2014, **174**, 591–595 (IF: 2.51).
9. Kumar, C. S. and Kumar, S., Species based codon usage in fusion protein gene of Newcastle disease virus. *PLoS One*, 2014, **9**, e114754 (IF: 3.53).
10. Sadhukhan, A. *et al.*, VuDREB2A, a novel DREB2-type transcription factor in the drought-tolerant legume cowpea, mediates DRE-dependent expression of stress-responsive genes and confers enhanced drought resistance in transgenic Arabidopsis. *Planta*, 2014, **240**, 645–664 (IF: 3.26).

The programme was aimed at refining organic farming technologies, developing organic farming standards acceptable to NTOP for linking small-marginal farmers of NB India with high-value markets, capacity building of farmers for integration of agro-biotech knowledge in farming practice and pilot-scale production of selected bio-control agents locally for wider use and acceptability. Work carried out by 14 Krishi Vigyan Kendras (KVKs) on 12 crops covering 98.9 ha of land has demonstrated the feasibility and beneficial outcome of replacing the chemical use by bio-inputs such as biopesticides, biofertilizers, botanicals under different agro-ecological settings in NER, thus fulfiling the major objective of the project. Various bio-inputs used in the study include farmland manure (FYM), vermicompost, neem cake, *Trichoderma harzianum*, *Azospirillum* spp. and phosphate solubilizing bacteria (PSB). As a result of bio-inputs, the increase in percentage yield of ginger ranged from 4.5 to 29.2, turmeric from 6.5 to 32.5, king chilli from 9.0 to 36.6, and French beans from 5.3 to 70.0 (Figure 5), while it was 28 for pineapple and 8.3 for mandarin orange.

Various bioinputs and their application dose have been developed for four crops with export potential, viz. turmeric, ginger, pineapple and mandarin orange. An organic certifying agency has audited, guided and helped in obtaining group certification for organic produce of the farms involved in the project, thus helping farmers sell their products as 'organic certified'. Each of the 14 KVKs is now fully equipped with requisite infrastructure for large-scale multiplication of *Trichoderma* spp. and other bioinoculants. They have also conducted training of 2400 farmers for integration of agro-biotech knowledge in production practices, and production of selected biocontrol agents locally for wider use and easy acceptability (Figure 6).

Most importantly, this programme, implemented by IBSD; ICAR's Research Complex for Northeastern Himalayan Region, Umiam, Meghalaya and Zonal Directorate, Zone III (KVK), ICAR-RC, Umiam, Meghalaya, has shown the feasibility of a collaboration between DBT and ICAR for enhancing integrated extension support for promotion of knowledge-based agriculture in NER. The programme has produced 31 technical bulletins/booklets/information folders/leaflets in English as well as local languages (Mizo, Assamese, etc.) for the benefit of farmers. Three publications and one conference presentation further document the work carried out under this project. Further work may be continued by individual investigators as fresh projects.

Impact assessment of jhumming on native plants and soil microbiota

Another network project was on 'Impact assessment of jhumming on native plants and soil microbiota and

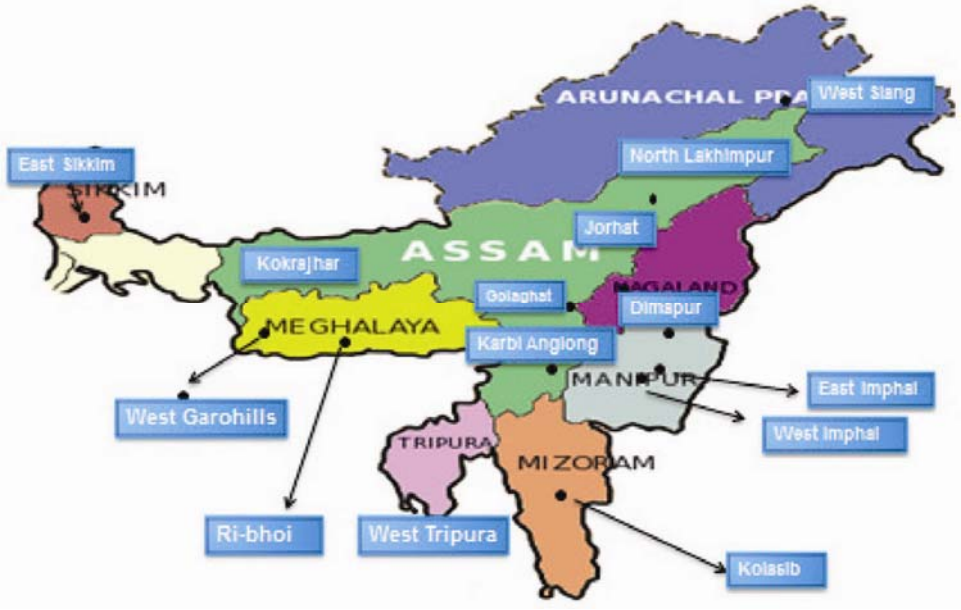

Figure 4. Distribution of 14 Krishi Vigyan Kendras (KVKs) in eight states of NER.

Figure 5. French beans and king chilli produced under organic farming.

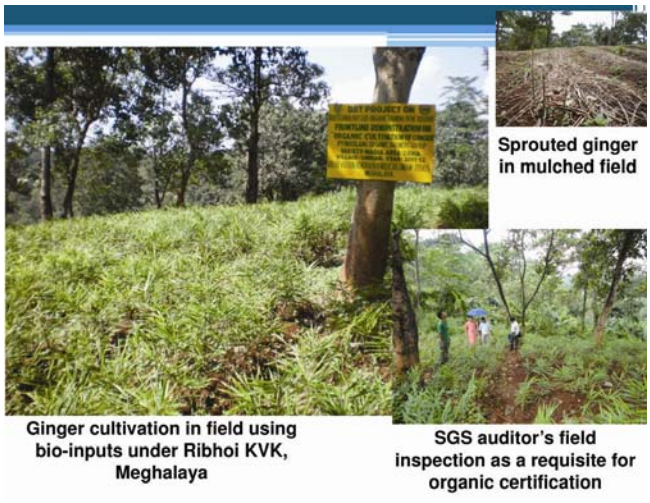

Figure 6. Organic farming of ginger at KVK in Meghalaya.

restoration of sustainable jhum agro-ecosystem in North East India', implemented by eight institutes at independent sites in three places, viz. Diphu, Assam; Changki, Nagaland and Muallungthu, Mizoram, representing 2–3, 4–5 and 8–10 years of jhum fallow periods respectively. This programme was aimed at amelioration and eco-restoration of jhum lands in NE India. Its specific objectives include estimating the genetic and biochemical diversity of untapped microbial pool, screening for heat and acidity-tolerant microbes, bio-prospecting studies for stress-tolerant genes and allele mining, defining roles of hardy native plant species resilient to slash and burn practices in jhum system, developing rapid multiplication technique for eco-restoration during fallow periods, and exploring the possibility of establishing symbiotic relationship between native plant species and potential microbes.

Value addition in jackfruit and citrus

A multi-centric programme on 'Value addition in jackfruit and commercialization of its processed products' aims at identification of superior genotypes of jackfruit and their molecular characterization on the one hand, and validation and commercialization of technologies for value-added products from jackfruit on the other. Being implemented by the University of Agricultural Sciences (UAS), GKVK, Bengaluru; College of Home Science, Central Agricultural University (CAU), Tura, Meghalaya; Department of Horticulture, AAU, Jorhat; NGOs GRAMA, Bharanganam, Kottayam, Kerala; Parivarthan (Women SHG), Karnataka; Kadamba Marketing Society, Karnataka; KVK, Tripura (under ICAR-RC, Tripura Centre); KVK, Kamrup, Assam (under AAU, Jorhat), the programme has identified more than 40 elite jackfruit genotypes from Karnataka, Assam and Tripura for culinary or table purposes, organized training workshops for farmers regarding the existing jackfruit technologies, and produced value-added products (Figure 7). Marketing and supply chain is being developed through involvement of farmers and entrepreneurs.

A similar programme on 'Value chain development in citrus' aims at using modern technologies for mass production of citrus plants and value-added citrus products. This collaborative DBT programme is being implemented by ICAR-RC, Nagaland; ICAR-RC for NEH Region, Shillong, Meghalaya; NRC for Citrus (ICAR), Nagpur; and IIT Kharagpur. So far, more than 2000 seedlings of rough lemon have been raised, Khasi mandarin and sweet orange have been successful grafted, and processing of citrus juice standardized. A poly-house for multiplication of citrus rootstocks has also been constructed.

Medicinal and aromatic plants

A network programme on biotech-facilitated utilization and conservation of selected MAP has focused on molecular taxonomic characterization of some important species and isolation and pharmacological evaluation of their bioactive extracts/ingredients for specific medicinal value. The programme also promotes Good Agricultural Practices (GAP), and large-scale production of planting material and post-harvesting technologies. It is being implemented by Assam Agricultural University (AAU), Jorhat; College of Veterinary Sciences, AAU, Guwahati and NEIST, Jorhat. Under this programme, four plant species (*Homalomena aromatica*, *Clerodendrum indicum*, *Acorus calamus* and *Piper longum*) have been selected for in-depth taxonomical studies, development of GAP, mass multiplication and post-harvest management. The contents of alkaloid, tannin, flavonoid and riboflavin amongst the germplasm of *H. aromatica* have been determined. Distinct RAPD DNA sequences for 22 genotypes of the targetted plant species from different areas of NE India have been assigned distinct accession numbers by the GenBank.

Chemical ecology of NER

Recently, a collaborative research programme on 'Chemical ecology of North Eastern region' has been launched, with scientists from institutions in Bengaluru (National Centre for Biological Sciences (NCBS); Indian Institute of Science (IISc), University of Agricultural Sciences) and those from NER institutions (IBSD; Regional Centre of IBSD, Gangtok, Sikkim; NEHU, Shillong, Meghalaya; Nagaland S&T Council, Kohima, Nagaland and Rajiv

Figure 7. Some items developed under the programme on value addition to jackfruit.

Gandhi University, Itanagar, Arunachal Pradesh), being partners. The programme will focus on identification of the origin and composition of plant, insect and vertebrate pheromones and semio-chemicals; analysis and (re)-engineering of chemical communication mechanisms; molecular and structural mechanisms; behavioural and neural mechanisms and biochemical, genetic and physiological mechanisms governing interactions between flora and fauna of the NER. Chemicals, volatile and non-volatile, mediate interactions within and across species, on being sensed by cell surface receptors by the organisms. Chemicals also form the basis of more direct interactions and exchanges that do not involve signalling. For instance, toxins and venoms are used to capture and subdue prey; exchange of metabolites sustains mutualistic relations, and some parasites chemically alter host behaviour to suit their own ends. Chemical ecology encompasses the study of all such interactions that are mediated via chemicals (rather than visual or auditory cues) and which impact the ecology, evolution and behaviour of the interacting organisms. The field also intersects with the areas of ethnobotany and biologically informed bioprospecting, investigating the ecological and biochemical basis of NER plant and insect species used in traditional medicine. Such studies may: (a) identify useful plant and insect substances and their biosynthetic origins, and (b) provide fundamental biological information asking, for instance, whether 'medicinal insects' accumulate and store plant-derived alkaloids that underlie their medical use in ancient societies.

Network programme on nasopharyngeal carcinoma

In the healthcare sector, NER offers unique challenges and opportunities. Displaying extraordinary ethnic diversity with various tribes maintaining their unique genetic make-up, NER has its fair share of healthcare or medical challenges to deal with. For example, nasopharyngeal carcinoma (NPC), the so-called 'Naga cancer', common in people of Chinese descent, is relatively rare in most parts of the country; however, it records the highest age-adjusted incidence (~20/100,000) in Kohima district, Nagaland and is also prevalent in Manipur and Mizoram[1,2]. DBT has put together a network programme for mapping the incidence of NPC and discovering specific mutations in chromosomal and mitochondrial DNA, possibly associated with NPC pathogenesis. The programme will also determine the role of Epstein Bar Virus (EBV) and human papillomavirus (HPV) co-infections in etiopathogenesis of NPC, develop serological and molecular biomarkers for diagnosis/prognosis of the disease, and determine HLA alleles associated with susceptibility and/or severity of disease in NER. This multicentric collaborative programme is being implemented by five principal institutes, viz. Dr B. Borooah Cancer Institute, Guwahati; Assam University, Silchar; Cachar Cancer Hospital and Research Centre, Silchar (all in Assam); Institute of Life Sciences, Bhubaneswar (Odisha); All India Institute of Medical Sciences, New Delhi, and five collaborating centres from NER, viz. Arunachal State Hospital, Tawang (Arunachal Pradesh); Civil Hospital, Aizawl (Mizoram); Civil Hospital, Dimapur (Nagaland); RIMS, Imphal (Manipur), and Gauhati Medical College, Guwahati (Assam).

A virtual Centre for Animal Disease Diagnosis and Management

In the area of animal biotechnology, DBT has recently launched an ambitious programme on Animal Diagnostics and Services in Animal Health and Disease (ADSAHD) for surveillance and control of trans-boundary, exotic and zoonotic pathogens.

The name of the programme has since been changed to 'Advanced Animal Disease Diagnosis and Management Consortium (ADMaC)'. It is essentially a virtual centre comprising 14 different institutions from NER and other parts of the country, as explained below. NER, owing to its unique geographical location sharing five international borders, bears constant threat of exotic trans-boundary diseases of our valuable livestock[3,4]. ADMaC is aimed at strengthening regional infrastructure and capabilities for developing latest diagnostics and organizing rigorous surveillance for the highly contagious and ravaging diseases, so that forecasting model on disease outbreaks in the region can be developed. This will help in setting up formidable defence to guard the territories against possible onslaught by exotic virulent pathogens. The programme has been conceptualized in a unique tripartite model involving three core laboratories in NER, three national institutes, and departments of Veterinary and Animal Husbandry of all the eight NE states. The three core laboratories will be located at College of Veterinary Science, AAU, Guwahati; ICAR Research Centre for NEH Region, Barapani, Meghalaya, and Central Agricultural University, Seleish, Mizoram. The three national institutes participating in this project are National Institute of High Security Animal Diseases (NIHSAD), Bhopal; National Research Centre on Equines, Hisar, and National Institute of Veterinary Epidemiology and Disease Informatics (NIVEDI), Bengaluru. This project is expected to develop a suitable model in the field of diagnosis and monitoring of endemic, ubiquitous and trans-boundary animal diseases, including diseases of zoonotic importance, development of the much-needed affordable user-friendly diagnostic kits and protocols, next-generation improved vaccines, disease data bank, and a library of microbial cultures from the most important biodiverse region of the country. Successful implementation of this project will enable the scientific community in the field of veterinary science to develop an animal health management package, including early warning and disease

forecasting mechanisms. The control strategy of livestock diseases based on early warning system will in turn increase overall productivity of the livestock of these states leading to overall economic growth of the region in particular and the country as a whole.

Centres of excellence

DBT–AAU Centre for Agriculture Biotechnology in NER

In the agri-biotechnology sector, a Centre of Excellence (COE), i.e. 'DBT–AAU Centre for Agriculture Biotechnology in NER' has been established at AAU, Jorhat. This Centre focuses on research in the areas of gene technology, allele mining, molecular breeding and microbial gene prospecting. It is engaged in developing skilled/trained human resource, generating bio-inputs to assist eco-farming in NER, and documentation and genetic cataloguing of bioresources for management of IP-related issues.

All this will lead to establishment of an accredited laboratory for quality analysis of farm inputs and products. The Centre has successfully carried out *in vitro* regeneration and transformation experiments in both chickpea and black gram. DNA from 611 rice germplasms has been extracted; bacterial isolates from soil samples have been characterized for acid-tolerance; three new strains of bio-inoculates (biofertilizers) have been isolated and identified, and techniques for their production have been standardized. Field multiplication of *Azolla* (biofertilizer) has been established. Ten students have been enrolled for Ph D in agri-biotechnology.

Fisheries and aquaculture biotechnology – Centre of Excellence

For strengthening the fisheries and aquaculture biotechnology (FAB) related R&D activity in NER, DBT has established a FAB-Centre of Excellence (FAB-COE) at the College of Fisheries, Central Agricultural University, Lembucherra, Tripura. The main objectives include improving the yield of fish production in NER, exploring the fish biodiversity across all the eight NE states, understanding the lineage of species diversity, development of protocols for breeding, seed production and faming of economically viable species, fish resource management education and capacity building, and R&D on feed development.

Centre for Augmenting Clean Pork Production and Value Addition

In the animal biotechnology sector, DBT-supported programme on Augmenting Clean Pork Production and Value Addition, is being implemented at the National Research Centre for Pig, Guwahati. The programme is designed to develop shelf-stable pork products, and to refine and standardize the technologies for producing a wide range of value-added pork products to provide variety to the consumers. Production of pork sausages has already been initiated. With more than 75% non-vegetarian population (with special attraction towards pork and pork products) in NER, the technologies developed herein could be taken up at commercial scale with possible turnover of about 150–200 tonnes of pork products per annum in the coming years.

Unit of Excellence Programme

With a view to recognize promising mid-career scientists in NER, a programme of awarding Unit of Excellence (U-Excel) grant to them has been initiated so as to enable them to pursue innovative research in frontier areas of biotechnology. Out of about 45 applications received under two phases of this programme so far, 20 U-Excel grants have been sanctioned in Assam, Manipur, Mizoram and Nagaland.

Programmes on infrastructure support

In addition to various R&D programmes described above, DBT has also taken the initiative to provide sophisticated laboratory infrastructure and to facilitate additional high-value projects in niche thrust areas in different branches of biotechnology, as briefly described below.

Updradation of infrastructure in medical colleges in NB states of India

In the healthcare/medical biotechnology sector, in order to enhance the quality of patient care and diagnostic services, DBT has provided substantially significant support towards strengthening and up-gradation of laboratory infrastructure in 11 medical colleges/institutions spread across Assam, Manipur, Nagaland and Tripura, involving 21 Principal Investigators (PIs) drawn from the Departments of Pathology, Biochemistry, Microbiology and Anatomy in Gauhati Medical College, Guwahati; Dr B. B. Cancer Institute, Guwahati; Assam Medical College, Dibrugarh; ICMR-Regional Medical Research Centre, Dibrugarh; Silchar Medical College, Silchar; Cachar Cancer Hospital and Research Centre, Silchar; Assam University, Silchar; LGB Regional Institute of Mental Health, Tezpur (all in Assam); Regional Institute of Medical Sciences, Imphal (Manipur); Agartala Government Medical College, Agartala (Tripura), and the Naga Hospital. Authority, Kohima (NHAK; Nagaland). Under this programme, diagnostic infrastructure facilities have been upgraded by providing state-of-the-art high-value

equipments like flow cytometer, PCR machine, HPLC set-ups, high-end phase contrast and fluorescent microscopes, automated histopathology processing units, etc.

As part of this programme, an impressive six-storey DBT Healthcare Laboratory established at NHAK is the first of its kind facility in Nagaland, bringing efficient diagnostic services to the doorstep of patients in the state. The programme has not only significantly improved diagnostic services provided by biochemistry, microbiology and pathology laboratories, but has also enabled several PIs to compete for funding for R&D projects under the Twinning Programme.

Facility for Diagnosis and Management of Genetic Disorders at Dibrugarh, Assam

A 'Comprehensive Facility for Diagnosis and Management of Genetic Disorders' has been established at the Assam Medical College and Hospital, Dibrugarh, facilitating studies in biochemical genetics, molecular genetics and cytogenetics, as well as providing genetic counselling services to the families at risk. This facility will provide timely and accurate diagnosis of genetic diseases due to chromosomal aberrations, single-gene mutations, haemoglobinopathies, etc. This facility is now fast emerging as a COE for quality education and research in medical genetics in NER.

Molecular oncology laboratory at Aizawl, Mizoram

A 'Molecular Diagnostic Laboratory' has been established at the Mizoram State Cancer Institute, Aizawl. Recognizing that accurate and precise diagnosis is the cornerstone of any successful cancer treatment, DBT has established this laboratory which will not only enhance the quality of comprehensive cancer care, but will enable quality research to understand the factors underlying high incidence of cancer in the state. The initial focus of the research project would be on three cancer types commonly encountered in Mizoram: chronic myeloid leukaemia (BCR-ABL translocation); breast cancer (HER2/neu) and lung cancer (EGFR).

Sophisticated diagnostic infrastructure at Shillong, Meghalaya

DBT has provided crucial support for establishing sophisticated infrastructure for improved diagnostic services in pathology, hematology and genetics departments at the North Eastern Indira Gandhi Regional Institute of Health and Medical Sciences (NEIGRIHMS), Shillong, Meghalaya. This is contributing to significantly improve the efficiency of the diagnostic services of the institute, and help generate credible statistics about various diseases as well. These laboratories are specifically involved in establishing viral etiology of nasopharyngeal carcinoma (EBV), and oral squamous cell carcinoma (HPV); in unravelling the pattern of neoplastic renal diseases and hematolymphoid neoplasma, and in the molecular typing of minor blood group antigens in NER.

Infrastructure support to ICAR institutions in Arunachal Pradesh and Nagaland

Sophisticated biotech infrastructural facilities have been created at National Research Centre on Yak at Dirang, Arunachal Pradesh, for strengthening research dynamics for desirable gains in yak husbandry, and at National Research Centre on Mithun at Medziphema, Nagaland for improving research activities on mithun husbandry, genomics and conservation.

Capacity building and human resource development

DBT has also made intensive inputs in human resource development (HRD) and capacity building for the benefit of the entire NER as mentioned below.

Biotech Hubs programme

DBT has established a network of 124 Biotech Hubs across NER, providing necessary infrastructure in universities/colleges/institutions, and the required training in sophisticated technologies so as to support and promote biotechnology education and research. At present, there are six state-level and 118 institutional-level vibrantly active Biotech Hubs spread across all the eight states of NER. Together these Hubs have conducted more than 300 training programmes and supported more than 300 PG and Ph D students.

More than 30 research papers, published in reputed peer-reviewed journals, underline the quality of research being undertaken at some of these Biotech Hubs. Research papers include those published in reputed peer-reviewed journals like *Eur. J. Exp. Biol.*, *Indian J. Plant Sci.*, *Curr. Sci.*, *Indian J. Microbiol.*, *PLoS One*, *IJEB*, *Frontiers in Microbiology*, etc.

Research grants to postgraguate students in medical colleges for MD–MS thesis

A programme to provide 'research grants for MD–MS thesis' has encouraged PG medical students in NER to learn and apply the biotechnology research strategies in their thesis projects; nearly 200 students have benefitted from this programme.

Training programme in biomedical research methodology

DBT has supported INCLEN International to conduct three training workshops on the principles and practices of clinical epidemiology in Assam, Manipur and Tripura; more such training workshops are in the pipeline. Two short-term, hands-on training workshops on 'Recent technique in infectious disease diagnostics for mid-career scientists from NER' have been held at the All India Institute of Medical Sciences, New Delhi. Nearly 200 medical students and their mentors have benefitted from these workshops. A programme on a series of workshops regarding Good Clinical Practices, Good Laboratory Practices and Ethics in Biomedical Research, is also being formulated to be launched soon.

Training programme on genomics-driven research in human health and disease

This programme, being conducted by NIBMG, Kalyani, is aimed at providing comprehensive training to NER scientists, research students (doctoral and postdoctoral) and clinicians engaged in 'biomedical research', to better equip them to undertake focused research leading towards understanding the molecular basis of diseases prevalent in NER. The programme comprises three annual workshop capsules on genomics, epigenomics and functional analysis with focus on biomedical research. Each capsule includes two workshops, one of which will be held in a NER institution and the other at NIBMG. The first capsule has been successfully implemented by imparting training to about 30 young investigators at workshops held in Assam University, Silchar and NIBMG.

DBT animal house facility at Dibrugarh, Assam

In order to give a strong fillip to research in experimental medical sciences and herbal medicine, DBT has initiated establishment of state-of-the-art Regional Animal House Facility at Regional Medical Research Centre, Dibrugarh. It will provide well-equipped and fully-functional laboratory space to researchers from the entire NER for carrying out critical experiments in disease biology, molecular medicine, immunology/vaccinology, drug development and molecular pharmacology. This facility will facilitate availability of specific-pathogen-free (SPF) and genetically defined laboratory animals. Imparting training to the biomedical research staff regarding standard procedures in animal experimentation will be yet another important activity of this facility.

Biotechnology Overseas Associateship programme

The Overseas Associateship Scheme for NER scientists aims to promote capacity building in cutting-edge areas of biotechnology and life sciences. The award promotes and supports scientists of merit in their pursuit of skill enhancement in scientific research/training in reputed overseas laboratories (Figure 8) both short term (up to 6 months) and long term (one year).

So far, 130 scientists have been awarded the Associateship and more than 100 have availed the same. The Overseas Associateship has resulted in more than 15 research papers in high-ranking peer-reviewed journals and has also enabled more than 10 laureates in getting extramural funding for their R&D projects.

Biotechnology Labs in Senior Secondary Schools in NER

An unprecedented growth in the field of biotechnology makes it imperative to create awareness about it at the school level and also to provide access to a well-equipped laboratory. Recognizing this need, DBT has initiated a scheme for establishing 'Biotechnology Labs in Senior Secondary Schools (BLiSS)' across all eight states of NER. In the first round, 88 senior secondary schools from NER have been selected by DBT for support under this scheme.

Visiting Research Professorship scheme

DBT has also initiated a 'Visiting Research Professorship (VRP)' scheme to utilize the expertise of outstanding biotechnology professionals for bringing advancement in the biotechnology and life sciences related activities in various institutions of research and higher learning in NER. Scientists/faculty from reputed institutions in India have shown interest in sharing their domain expertise with NER institutions through this scheme. In the first phase, 14 scientists/faculty have been selected under the scheme.

Bioinformatics facilities

DBT has established 29 bioinformatics centres in all the eight states of NER, networked as the North Eastern Bioinformatics Network (NEBINet). These bioinformatics centres are provided with latest IT equipment to support the research activities of the host institutions in NER. Recently, two new bioinformatics centres have been established at the College of Fisheries, Central Agricultural University, Lembucherra, and National Research Centre on Mithun (ICAR), Medziphema.

DBT's e-Library Consortium for North Eastern Region (NER-DeLCON) was established in 2010, through which access to more than 900 high-impact e-journals has been made possible. The facility is being offered to 18 selected NER institutions free of cost; it is being extensively used by scientists, faculty and students of all these 18

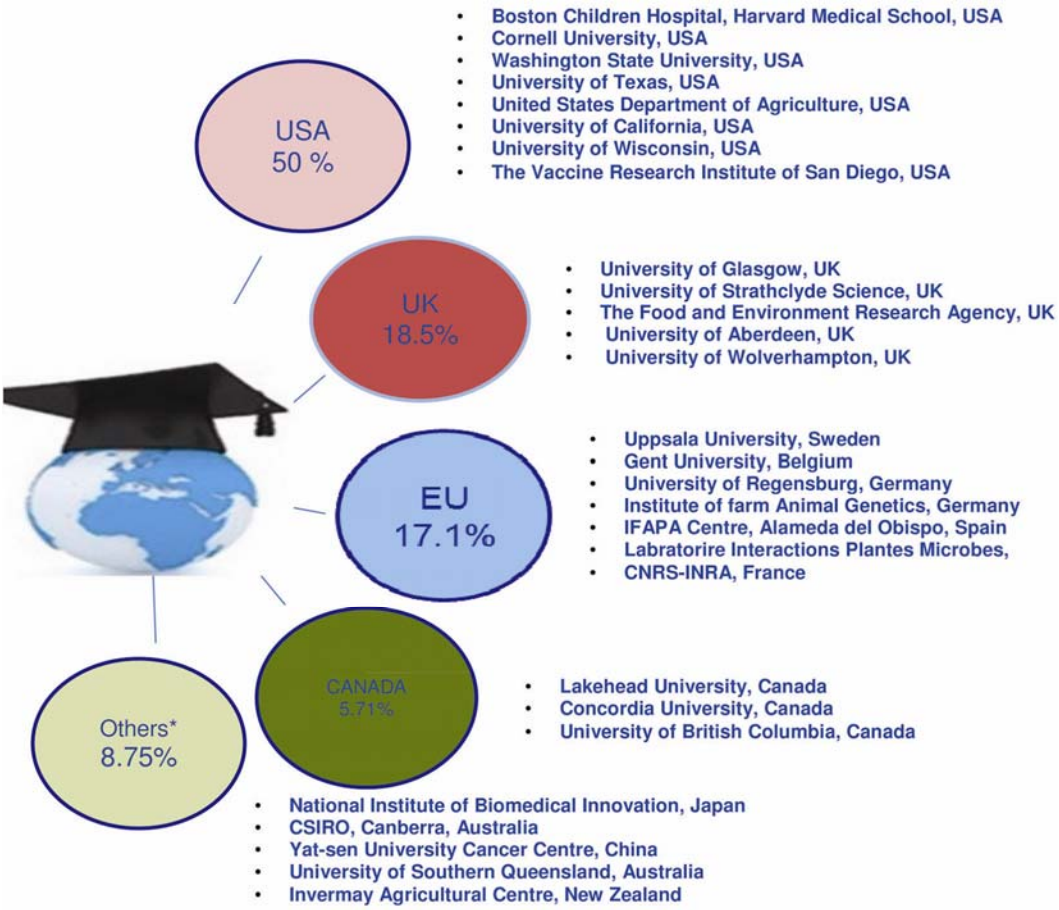

Figure 8. Major overseas institutions visited by NER scientists for training.

institutions. A separate website – www.delcon.gov.in has been created for DeLCON.

An on-line human resource repository of Biotechnology and Bioinformatics Resources of North East India (BABRONE) has been created and located at College of Veterinary Sciences (AAU), Guwahati. It is a freely accessible e-learning server developed as a common platform for uploading learning materials, sharing of information and as an on-line discussion forum at www.babrone.edu.in.

In collaboration with the Government of Assam, DBT has established a Biotech Park at Guwahati, as a meeting point of technological innovation for knowledge-based biotechnology enterprises and to provide sustainable linkages between the industry, research institutions and academia to boost the competitiveness of the region. Its main objectives are to encourage and support the start-up, incubation and development of innovation-led, high growth knowledge-based business in the multidisciplinary area of biotechnology. The Park will promote formal and operational links between centers of knowledge creation such as national R&D laboratories, universities, medical institutions, and research organizations in India and abroad, and create a strong network.

In conclusion, DBT's proactive policies have given rise to a number of well-thought-out programmes in various areas of biotechnology in NER. This has not only laid a strong foundation for future growth of biotech R&D and industry in NER, it has also created a wave of enthusiasm and optimism among the young investigators for undertaking high-caliber innovative projects and finding global solutions for local problems.

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ACKNOWLEDGEMENTS. We thank our colleagues at DBT, BCIL, and NER-BPMC for support in implementing various programmes.

doi: 10.18520/cs/v110/i4/562-572