SOUTH ASIAN ASSOCIATION FOR REGIONAL COOPERATION

STATE-OF-THE-ART REPORT ON BIOTECHNOLOGY

Prepared By

THE NATIONAL SCIENCE FOUNDATION (NSF)

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MINISTRY OF SCIENCE & TECHNOLOGY

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1. **Name of the country**

Sri Lanka

2. **Name of the concerned Ministry (Ministries)**

- The Ministry of Public Administration, Home Affairs & Plantation Industries
- The Ministry of Agriculture & Lands
- The Ministry of Education & Higher Education
- The Ministry of Fisheries & Aquatic Resources Development
- The Ministry of Forestry & Environment
- The Ministry of Health & Indigenous Medicine
- The Ministry of Industrial Development
- The Ministry of Livestock Development and Estate Infrastructure
- The Ministry of Science & Technology

3.Names of the R&D organizations involved in Biotech activities

- Department of Agriculture (DOA)
  - Plant Genetic Resources Centre (PGRC)
  - Horticultural Research and Development Institute (HORDI)
  - Department of Export Agriculture (DEA)
- Institute of Fundamental Studies (IFS)
- Tea Research Institute (TRI)
- Rubber Research Institute (RRI)
- Coconut Research Institute (CRI)
- Sugarcane Research Institute (SRI)
- Rice Processing Research & Development Centre
- Medical Research Institute (MRI)
- Veterinary Research Institute (VRI)
- Industrial Technology Institute (ITI)

4.Present status of different areas of Biotech

Tissue culture is one of the most applied areas in Biotechnology in Sri Lanka. In 1976 the Department of Agriculture (DOA) pioneered a programme to support the demand for rapid clonal micropropagation of orchids and anthuriums for cut flower industry. In 1984 the programme was expanded to propagate disease free planting material of fruit plants such as pineapple (*Ananas comosus*), banana (*Musa spp.*), citrus spp., passion (*Passiflora edulis* Sims) and papaya (*Carica papaya*). Subsequently, the programme was further expanded to include micropropagation of rambutan (*Nephelium lappaceum* L.), strawberry (*Fragaria vesca*) and ginger (*Zingiber officinale*) etc.

In 1987 a project was initiated at the Regional Agricultural Research Centre in Bandarawela to produce disease free planting material through apical meristem culture for potato. The project included the production of nematode resistant varieties also. The mass propagated disease free stem cuttings are distributed to farmers for their own seed production programmes since 1989. Research on minituber production of potato varieties was also undertaken and technology has been perfected. This technology is also being used in the seed production programme of the Centre.

With the assistance of Food and Agricultural Organization (FAO) a tissue culture laboratory was established at the Central Agricultural Research Institute (CARI) which is now called the Horticultural Research and Development Institute (HORDI) to fulfil the needs in propagation of fruits and flower plants. In 1987 the Plant Genetic Resources Centre (PGRC) was established under the DOA with the assistance of Japan International Cooperation Agency (JICA). This Institution has embarked on a very successful genetic resources management and research programme involving collection, introduction, evaluation, conservation and data management to strengthen the crop development activities of the DOA. In order to conserve genetic resources both *in vitro* and *in vivo* methods are established. However, for long term conservation further investigations are required to perfect the methodologies with respect to each crop.

The research conducted at the PGRC has also helped to develop *in vitro* technologies for several vegetatively propagated plants such as *Cassava*, potato, sweet potato (*Ipomea batatus* (L.) Lam), yams, *Colocasia*, innala (*Coleus rotundifolius*) and banana. In order to support crop improvement programmes in genetic enhancement aspects strategic research are being conducted on callus culture, embryo culture, anther culture, protopast culture on a number of crop species and suitable protocols have been established for some of the species. Among these technologies embryo culture can be considered to have an immediate impact on a number of hybridization programmes.

Currently, the methodologies are perfected for the mass propagation of various other fruits, medicinal plants, woody plants etc. by different research organisations in Sri Lanka. For instance, avocado (*Persea americana*), cashew (*Anacardium occidentale & A. microcarpum*) , sugarcane (*Saccharum officinarum*), mangosteen (*Garcinia mangostana*) cardamom (*Elettaria cardamomum Maton.*), nutmeg (*Myristica fragrance*), clove (*Syzygium aromaticum*), cinnamon (*Cinnamomum zeylanicum* Bl.), black pepper (*Piper Nigrum*), betel (*Piper betle* L.), komarika (*Aloe vera*), niyangala (*Gloriosa superba*), jak (*Artocarpus heterophyllus*), nadun (*Pericopsis mooniana*), bamboo (*Dendrocalamus giganteus*), rubber (*Hevea brasiliensis*), tea (*Camellia sinensis L.*). The rapid propagation of elite tea clones now appears to be feasible using tissue culture techniques and this can be used for the commercial production of millions of plants annually for replanting low yielding seedling tea. Successful propagation of tea by tissue culture techniques using single node explants of field grown plants of tea (clone TRI 2025) has been reported from Tea Research Institute, Talawakele. Nodal explants have been successfully established and about 3-6 fold multiplication has been achieved every 6 weeks. Accordingly, from 50 established cultures they obtained 36,153 shoots after 12 months. Shoots produced in culture have acclimatized to field conditions and have been planted out in the field in a small demonstration plot. Further attempts are being made to improve the multiplication rate of various clones and further improvement of rooting before commercialization.

It is difficult to assess the amount of research involving plant molecular biology and genetic transformation being carried out in Sri Lanka successfully. However, some progress have been achieved in the following areas of research..

- Identification of genetic markers for detection of suitable genotypes for breeding of coconut and rubber.
- Identification of genes for iron resistance in some rice varieties.
- Analysis of QTLs using RFLPs as molecular markers in rice.
- The use of RFLP and RAPD technologies to identify useful genes in the plant genomes.
- Development of DNA probes to detect fungal pathogens.
- *Agrobacteriam* mediated genetic transformation.

The lack of established protocols for regeneration perfected from callus or cell suspension cultures and protoplast culture limits further improvements in genetic transformation related research.

Micropropagation of coconut is a priority area of research in the CRI. However, the application of *in vitro* methods were not successful due to the recalcitrant nature of the crops. A considerable progress has been made in perfecting the technique of embryo culture of coconut to screen drought-tolerant local varieties.

The Sugarcane Research Institute (SRI) has perfected a technique to regenerate sugarcane plantlets via callus culture of unexpanded leaf segments and undifferentiated floral tissues successfully.

Despite various crop improvement programmes being carried out at a number of research institutions and universities during the last few

decades the progress achieved in developing plant varieties resistant to environmental stresses is not significant. Therefore, in order to increase the agricultural productivity in Sri Lanka we need to undertake rapid crop improvement programmes using biotechnological approaches may be in collaboration with international research institutions to develop plant varieties in the following aspects:

- Tolerant to high salinity or flooding
- Drought resistant varieties
- Resistant to diseases and pests
- Tolerant to herbicides
- To modify amino acid composition storage proteins in cereals and legumes to improve the nutritional value
- To improve the composition of storage life of foods and vegetables

Research in Sri Lanka involving the production of secondary metabolites via cell cultures is still in its primary stages. The Industrial Technology Institute (ITI), the successor to the Ceylon Institute of Scientific and Industrial Research (CISIR), in collaboration with the University of Sri Jayewardenepura is conducting research into the production of phytochemicals of antitumour antileukemic, and antiviral activities by cell cultures of Dathketiya *(Ophiorrhiza mungos* L.)

Despite the fact that much attention is focussed on the research and development of Agricultural Biotechnology which is moving rapidly a considerable amount of progress in research involving biotechnological approaches has been achieved in the fields of Medicine, Microbiology, Veterinary Sciences, Biological control of plant pests, diseases, and weeds, Biofertilization and Biological nitrogen fixation, Food science etc. Research in these areas is mainly guided by the interests of the individual researchers. Therefore, the strategies are lacking in most projects at the pilot schemes and final implementation stages.

Apart from the research conducted at the universities and the State sector institutions the private sector companies/industries are also involved in biotechnological research and development.

The most developed private tissue culture laboratory in Sri Lanka is the Ceylon Tobacco Company (CTC) laboratory. The plant tissue culture laboratory at Kalagedihena under CTC was set up in 1980, initially as a research and development laboratory to explore possibilities for commercial application of tissue culture to economically important plants. The company has a production capacity of 1.6 million plants per year. At present, the laboratory produces over 1 million plants annually. A large number of ornamental species are supplied to the foreign market by them such as *Syngonium, Spathiphyllum, Ficus, Zantedeschia* and ferns. Tissue culture systems have been successfully developed for species of *Dracaena, Cordyline, Anthurium andreanum, Pleomele* and *Aglaonema* by CTC. The company produces high quality disease free elite planting material of various fruit plants such as pineapple, banana, strawberry, passion fruit etc. to help in achieving national targets of fruit production. The commercial quantities of strawberry plants have been exported to Holland by the CTC. The company has also established a system to select *in vitro* micro-tubers for seed potato production.

Other private tissue culture laboratories in the country mainly produced ornamental plants, namely, orchids, foliage plants etc. either for the local or the foreign market.

The company John Keells Agro Products Ltd. industrially cultivates mushrooms using biotechnological methods and export 70% of its production in its fresh form and 30% in dehydrated form.

Sri Lanka is already involved in several types of fermentations especially solid state fermentation, alcoholic fermentation and biogas production. Alcoholic fermentation is the most mature area of biotechnology in Sri Lanka. There are many examples of domestic, small and medium scale industries applying the techniques which had been available for centuries. Sri Lanka has an extensive alcohol and beer industry (alcoholic fermentation)

5.Government policy regarding application of Biotech in national development

Sri Lanka is moving towards an open market economy. Government therefore, facilitates liaison of universities and research institutions with the private sector industries. Research activities in Sri Lanka including Biotechnology is mainly funded by the Government. The National Science Foundation (NSF) is the main Government sponsored research funding organization in Sri Lanka. The NSF has also made available funds for research through foreign grants mainly from SAREC/SIDA for Biotechnology related research including manpower development in the area. Since 1992 the institution has awarded research grants worth of **Rs.11,870,508.00** through foreign and local resources for biotechnology research. The NSF plays the key role in coordinating and promoting biotechnology related activities through its Committee on Biotechnology which was formed in 1992. On the recommendation of this Committee the NSF has completed a survey and setup a database of the science & technology personnel and facilities available for research in the area. The Committee has also mentioned the need of a national policy on Biotechnology and also strict regulations for handling of genetically modified organisms (GMOs) for research and other activities.

The NSF recently initiated a new research grant scheme in order to facilitate research cooperation between the private sector and the universities and research institutions to harness innovative technology for increasing national productivity. Some progress has been achieved in this endeavour. Nevertheless, a suitable mechanism has to be established to ensure proper integration of outcome of biotechnology into existing and new agricultural and industrial practices. The priority areas for biotechnology research had been listed by the NSF Committee on Biotechnology. Research organisations have also identified priority areas for research in biotechnology.

CRI: Development of a tissue culture technique for vegetative propagation of coconut and crop improvement.

RRI: Development of vigorous, high yielding and disease resistant rubber clones. Development of mass propagation for *Hevea.*

TRI: Development of tissue culture technique for rapid multiplication of planting material.
Development of tissue culture techniques for crop improvement.

DOA: Development of micropropagation technique for fruit crops (banana, pineapple, strawberry), annuals (potato) and ornamental plants (orchids and anthurium); preservation of germplasm (sweet potato, cassava, other yams), crop improvement (rice).

DEA: Development of micropropagation techniques for nutmeg, pepper, cinnamon and cardamom.
Improvement of EA crops through tissue culture.

SRI: Development of high yielding varieties with moderate fibre and pest and disease resistance.
Selection of improved strains of yeast for fermentation of molasses.

VRI: Developing improved breeds of livestock, particularly cattle, through cross breeding of selected indigenous and exotic breeds.
Studies on the causes of infertility in livestock with a view to improving reproductive efficiency.
Prevention of livestock diseases through improved vaccines, immunization methods and management systems.

Forest Department:
Development of tree improvement and breeding programme and propagation of some woody and non-woody species through tissue culture methods.

Sri Lanka has also looked into the modalities of technology transfer and associated problems involving intellectual property rights in respect of the advances in Biotechnology through the concerned organisations.

Besides the NSF research funding schemes, the institution serves as the national focal point for many international bodies such as the International Centre for Genetic Engineering and Biotechnology

(ICGEB) and promotes biotechnology activities of the country through the system.

The Council for Agricultural Research Policy (CARP) was setup in 1987. Financial assistance for research in Agricultural Biotechnology has also been made available through this Council.

6.Status of Biotech information network

The Sri Lanka Scientific & Technical Information Centre (SLSTIC) was established under the Natural Resources, Energy & Science Authority of Sri Lanka (NARESA), the predecessor of the National Science Foundation (NSF) in 1979. SLSTIC is the national focal point for information networks on science & Technology and functions through the Sri Lanka Scientific & Technical Information Network (SLSTINET). About 120 S&T libraries are members of the SLSTINET. It is the umbrella network of all S&T information networks in Sri Lanka.

The key objectives of SLSTINET are to:

1. support to build an effective information infrastructure in the field of S&T
2. take the lead in the organisation of information on the S&T subset of the national information super highway
3. help end users to define their needs, learn to use the available system and gain access to the information need
4. share resources available at member libraries

As the National Information Centre SLSTIC's main emphasis is to collect, process and disseminate S&T information among scientists. In order to achieve this objective the SLSTIC has established the following databases.

1. UNILIST - Union list of periodicals available in the libraries in Sri Lanka
2. SLSTEP - Directory of S&T personnel in Sri Lanka

3. SLSI - Sri Lanka Science Index (includes local pamphlets, reports and seminar proceedings on S&T)
4. DBSOR - Ongoing research in Sri Lanka
5. SLSTIC - SLSTIC library collection
6. RGRA - S&T research sponsored by the National Science Foundation (the database can be accessed through the internet - Vidya)
7. FLORA - Database on plants exported from Sri Lanka

The following CD-ROM databases are also available for general access.

1. SIRS Researchers - A reference tool that contains full text article on wide variety of science, social science and world affairs topics.
2. Dissertation Abstracts
3. Derwent Biotechnology Abstracts - information derived from primary journals, conference proceedings and patents provides in-depth coverage of the most current and leading edge scientific and technical research with an emphasis on commercial and industrial applications
4. Life Sciences Collection
5. EI Energy & Environment
6. S&T Encyclopaedia

The SLSTIC has developed a local area network (LAN) facilitating access to the above information resources. All the members of the staff of the NSF have been assigned with access facilities to the network with exclusive working space on the network. Apart from that the SLSTIC/NSF has also fully established the connectivity to the internet through a 64 kbps data leased line, thus providing staff and SLSTIC users with access to Biotechnology information resources including www and Usenet (Newsgroups). It is planned to develop a Wide Area Network (WAN) among SLSTINET libraries through a dial-in facility, enabling other S&T institutions to access the resources available at SLSTIC.

7.Status of different areas of Biotech in Academic Institutions

The subject Biotechnology is not specifically included in the undergraduate or graduate programmes in any of the universities in Sri Lanka. It is offered at basic levels and often in combination with the other subjects such as, Genetics, Basic Biology, Food Science/Technology etc. Molecular biology is often offered in courses of Cell Biology, Biochemistry or Physiology. The table in annexure 1 provides the details on number of lectures offered for some of the above subject areas in various universities in Sri Lanka at undergraduate level.

An M.Sc course in plant tissue culture has been conducted at the University of Colombo since 1996.

The Department of Biochemistry, University of Colombo, in 1984, established a unit on Molecular Biology and Gene Technology with collaborative assistance from the University of Uppsala, Sweden, a leading scientific institution in this field. Under this programme several research projects relevant to the development strategy of Sri Lanka were identified and presently under investigation. A postgraduate course in Biochemistry, Molecular biology and gene technology at the level of M.Sc was initiated in 1986. This is aimed at the training of manpower resources to undertake research in gene technology relevant to Sri Lanka. However, the resources available for the expansion of the activities of this unit have become limited. The first batch of M.Sc graduates with sufficient training in gene technology were passed out in 1988.

8.Possible impact of Biotech in the country

There is a great potential for agricultural Biotechnology in Sri Lanka as a tool in crop improvement programme. The future developments in the other fields like medicine, natural resources, industry, food science, waste management etc. will depend to a great extent on advances made through novel biotechnological approaches.

9.Any other relevant information

Nil

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ANNEXURE 1

Approximate number of lectures offered in some areas in various university B.Sc. courses (General and Special)

University/ Department and Subject	Biotechnology / Molecular Biology		Food Technology / Microbiology		Environmental Sc. / Ecology		Aqua culture / Fisheries		Remarks
	General Degree	Special Degree	General Degree	Special Degree	General Degree	Special Degree	General Degree	Special Degree	
Colombo / Botany	15	30	10	30	30	-	-	-	It is difficult to assess the exact depth in each subject area, because they are offered with other units ex: Aquaculture may be offered with Fisheries
Colombo / Zoology	-	30	-	-	-	30	30	30	
Kelaniya /Botany	30/40	-	15	-	30/40	48	-	-	
Kelaniya /Zoology	-	30	-	-	40	48	40	48	
Kelaniya / Microbiology	30	48	60	48	40	40	-	-	
Peradeniya / Botany	30	30	30	30	30	30	-	-	
Peradeniya / Zoology	10	10	-	-	30	30	10	20	
*SJP / Botany	10	-	45	25	25	20	-	-	
*SJP / Zoology	-	10	-	-	10	60	20	60	
Ruhuna / Botany	15	15	15	30	30	30	-	-	
Ruhuna Zoology	30	-	-	-	30	60	30	60	

*University of Sri Jayewardanapura