

Introduction

Agriculture Sector in the Economy of Sri Lanka

Agriculture sector which consists of several sub sectors including food crops, plantation crops, livestock and poultry, forestry, fisheries and aquaculture, is the cornerstone of the Sri Lanka's economy. Agriculture sector contributes nearly 8 % to the total Gross Domestic Product (GDP), 33% of employment opportunities (Central Bank of Sri Lanka, 2015) and 24% (Performance of Export Sector Sri Lanka) of total exports. Consequently, agriculture plays an important role either directly or indirectly in improving the livelihoods of the Sri Lankans.

Sri Lanka annually spends a considerable amount of the country's foreign exchange on importing a vast array of food items which could be produced locally. In 2015 nearly US\$ 18,935 million which accounts for 14% of the total import expenditure (Central Bank of Sri Lanka, 2010) has been spent on importing agricultural food commodities. It is thus evident that a rapid growth of the domestic food production is essential to achieve food security, increase farmers' income and the living standards, reduce rural poverty and save a significant amount of foreign exchange. In addition, the development of the plantation and export agriculture crop sectors contributes to increased foreign exchange earnings. Thus, the development of the agriculture sector in the country will pave way for improvement in the supply of food and nutrition for the people, enhanced employment opportunities and increased foreign exchange earnings while cutting down the foreign exchange spent on food imports. However, the assistance of the government to enhance agricultural production in the country is crucial and essential. In this context, the government has declared the year 2017 as the year for launching a sustainable programme for poverty alleviation and accordingly various policies, plans and programs are being implemented for sustainable increase of agricultural production.

Challenges of the Agriculture Sector

The development of the agriculture sector in the country is vital for its economic development. The identification of the major challenges of the agriculture sector is important in addressing the problems and determining the appropriate approaches to achieve

agricultural development. In this regard, the followings are listed as the apparent and important challenges hindering such development in the agriculture sector.

- Continuous increase in demand for food due to increasing population growth
- Shrinking of cultivable land due to urbanisation and population growth
- Low crop productivity and production
- Increasing biotic and abiotic stresses due to climate changes
- High cost of cultivation due to escalating cost of inputs
- Declining overall soil fertility status
- Increasing demand for high-quality agricultural products
- Negative impact of indiscriminate use of agrochemicals on environment
- Inadequacy of improved varieties /other appropriate technologies
- Inadequacy of quality seed and planting material of improved varieties
- Inadequate supply of spice and beverage crops to meet the increasing demand in the export market
- Lack of stable government policies towards agriculture
- Limited allocation of government funds for agricultural R&D

Research and Development in the Agriculture Sector

Research and development (R&D) activities of the different sub sectors of agriculture play a significant role in addressing the above-mentioned challenges. The R&D institutions and the relevant faculties of the national universities engaged in R&D on food and plantation crops, livestock and poultry, forestry, fisheries and aquaculture sub-sectors function under several cabinet ministries. These R&D institutes are coordinated by the Sri Lanka Council for Agricultural Research Policy (SLCARP) which is the apex body of the National Agricultural Research System (NARS) of Sri Lanka. Agricultural Biotechnology has been identified by the SLCARP as one of the major thrust areas to effectively address the key challenges in agriculture sector.

Considering the importance of Agricultural biotechnology, a National Committee on Plant Breeding and Biotechnology (NCPBB) was appointed by the SLCARP in 1998. Later, in mid-2009, this committee was abolished to form two national committees; Plant Breeding and Agricultural Biotechnology for focussing better on these two important disciplines in agriculture.

National Committee on Agricultural Biotechnology

The National Committee on Agricultural Biotechnology (NCAB) was established on 31st July 2009 bestowing the mandate to identify and formulate policies and strategies related to Agricultural Biotechnology. It was also entrusted to set national research priorities following the agricultural development policies of the government. The national committee is responsible for the following:

1. To identify and formulate national policies, strategies and priority research needs required to develop the discipline
2. To evaluate research proposals, and make recommendations for funding
3. To monitor and evaluate the progress of the funded research for tangible outputs
4. To identify the institutes which could undertake such research, and support them to become Centers of Excellence and publish relevant information for wider use by the clients and other interested groups
5. To identify the human resource (HR) development needs and the mechanisms in Agricultural Biotechnology for the development of HR at various levels
6. To develop and maintain the databases in collaboration with SLCARP conduct workshops, seminars, training programmes, exhibitions *etc*, to disseminate and update the stakeholders on the latest advances in that discipline
7. To conduct regular skills development workshops for practicing agriculturists, particularly the farmers and to identify the ways and means of linking farmers/producers to markets
8. To provide an independent forum to meet stakeholders to discuss issues in relation to the development of the discipline

The members of the NCAB are shown in Annexure 1. In line with the above-mentioned responsibilities, the present assignment has been focused on formulating National Agricultural Biotechnology Research Priorities for the five-year period from 2017 to 2021.

**Identification of
National Research Priorities: 2017-2021
Agricultural Biotechnology**

The Agricultural Biotechnology R&D programmes conducted by public R&D institutions and the national universities have made a significant contribution to the development of Agricultural Sector to raise both crop production and productivity in the country. The priorities in Agricultural Biotechnology activities in each sector/crop are primarily identified by the relevant R&D institution based on the national agricultural policies. Accordingly, a coherently developed document on national level biotechnological priorities is a pre-requisite to provide guidelines to develop priorities at the institutional level for optimum allocation of physical and human resources and effective carrying out of national level Agricultural Biotechnology R&D programs. The national priorities thus developed need be periodically updated to cater for the current trends in the national development and for the efficient and effective adoption of novel technology. Accordingly, the focus of the current exercise was to update and develop the national biotechnology priorities in consultation with relevant stakeholders and end users.

Overall Objective

Facilitate the application of appropriate biotechnologies in Sri Lanka to improve agricultural production and consequently contribute to the enhancement of food security and socio-economic standards in the country

Specific Objectives

- a) Implement a National Research and Development (R&D) Programme based on the assessment of present capacities, and on the needs and priorities of the country in the area of agricultural biotechnology research.
- b) Strengthen the Institutions' capacities including infrastructure and favourable administrative procedures related to agricultural biotechnology R&D.
- c) Capacity building of human resources related to agricultural biotechnology R&D.
- d) Promote the use of biotechnology in the development of agriculture sector through productivity enhancement.

- e) Increase the public awareness and public participation related to agricultural biotechnology.

Methodology

In order to achieve the above objectives the following methodology was followed in identifying and updating the current national Agricultural Biotechnology research priorities in Sri Lanka.

- 1) Recording the current status and the priorities of each sector of Agricultural Biotechnology in Sri Lanka.
- 2) Analysis of current status and the priorities of agricultural Biotechnology in Sri Lanka.
- 3) Documenting the national priorities of agricultural Biotechnology in Sri Lanka for 2017-2021.

Step 1: Recording the Current Status and Identifying the Priorities of Each Sector of Agricultural Biotechnology in Sri Lanka

A comprehensive process was followed on recording the current status and the future potential of Agricultural Biotechnology and identifying the current priorities of each sector. Firstly an expert from each sector was nominated from each sub-sector to record the status and priorities in agricultural biotechnology. Each speaker, in consultation with the researchers and relevant stake holders, from within the relevant R&D institutions, identified and recorded the current status and the priorities of each sector of Agricultural Biotechnology. The presentations were structured to give a brief introduction to the sector, the current status of biotechnological research, future potential and the plans and strengths and limitations with regard to human resources & infrastructure in achieving the proposed targets. The stake holder workshop was held in mid-August, 2016, with the participation of the researchers of NARS, national universities and private sector, representatives from funding bodies of research and other relevant stakeholders in Sri Lanka. The list of topics covered by each of the expert is given in annexure 02. Presentations on each discipline were intended to make the stakeholder groups aware on the current status of the following areas:

- a) Agricultural Biotechnology Policy in Sri Lanka
- b) Food Crop Sector in Sri Lanka
- c) Plantation Crop Sector in Sri Lanka
- d) Export Agriculture Crops Sector in Sri Lanka
- e) Ornamental Crops Sector in Sri Lanka
- f) Fisheries & Aquatic Resources in Sri Lanka
- g) Livestock & Poultry Sector in Sri Lanka
- h) Private Sector in Sri Lanka
- i) National University system in Sri Lanka

Step 2: Analysis of the Current Status and the Priorities of Agricultural Biotechnology in Sri Lanka

An in-depth analysis was carried out by break-out groups at the stakeholder workshop with the information derived from each of the presentations. Based on this analysis, future priorities were identified and recommendations of each sub-sector were made. Also the existing priorities were revised with the newly identified priorities considering the current trends and the needs of the country.

Step 3: Finalizing the National Priorities of Agricultural Biotechnology in Sri Lanka for 2017-2021

The recommendations resulted at the stake holder meeting were critically evaluated by the National Committee on Agricultural Biotechnology at several rounds of discussions held at SLCARP to determine and update the national research priorities of agricultural Biotechnology for 2017-2021, based on the current status and the economic needs of the country.

National Research Priorities: 2017-2021

Agricultural Biotechnology

The agricultural biotechnology research priorities identified for each sector are listed below.

1. Plantation Crop Sector

- a. Genetic characterization of crop germplasm
- b. Marker aided selection for crop improvement (yield, biotic and abiotic stresses with special reference to heat and drought)
- c. *In-vitro* conservation (cryopreservation and tissue culture) of crop germplasm
- d. Mass production of planting material via *in vitro* techniques
- e. Detection and identification of pathogens of economically important diseases and pests
- f. Production of disease free high quality planting material

2. Food Crop Sector

- a. Molecular characterization of genetic resources of important food crops
- b. Gene/QTL mapping and Marker Assisted Selection for important traits on yield, biotic and abiotic stresses and nutritional qualities
- c. Use of novel molecular techniques for crop improvement
- d. Development and application of disease diagnostic tools for major food crops using molecular tools
- e. Production of high quality and disease free planting materials of major food crops
- f. *In-vitro* conservation (cryopreservation and tissue culture) of crop germplasm

3. Livestock, Poultry & Fisheries Sector

A. Fisheries Sector

- a. Development of biotechnological protocols for marine micro algae propagation
- b. Extraction of bioactive compounds from marine micro algae and other marine organisms
- c. Development of resistant brood stocks of shrimp for white spot disease using molecular markers
- d. Marker Assisted Selection for selected aquatic plants of ornamental value: *Cryptocoryne* (leaf colour and leaf shape) and *Anubias* (leaf shape)
- e. Stock identification for economically important marine food fish using molecular tools
- f. Development of barcoding database for endangered, endemic and threatened fish species
- g. Molecular identification of antimicrobial resistant pathogens along fish product supply chain (especially targeting export industry)
- h. Molecular identification of parasites in food fish (targeting export industry)
- i. Molecular characterization of lactic acid bacteria and other commercially important micro-organisms applicable in processing industry

B. Livestock and Poultry Sector

- a. Development and application of Biotechnologies related to animal feed and nutrition
 - i. Molecular identification and quantification of Mycotoxin producing micro-organism in poultry feed
 - ii. Intestinal microbe population identification in poultry

- iii. Improvement of nutrient availability of animal feed through manipulation of rumen microbes
 - iv. Micro-propagation of hybrid grass varieties
- b. Improvement of molecular technologies for disease diagnosis for viral, bacterial, fungal and parasitic diseases
 - c. Vaccine production for viral, bacterial and parasitic diseases for emerging needs

4. Export Agricultural Crops/Ornamental Crops

A. Export Agricultural Crops

- a. Molecular characterization of important export agricultural crops
- b. Pest and disease diagnosis of Cinnamon using molecular techniques
- c. Molecular evaluation of germplasm and Geographical Indicator fixing in Black pepper and Coffee
- d. Development of biotic and abiotic tolerant varieties of Pepper and Arabica coffee using reverse genetics approaches

B. Floricultural Crops

- a. Production of commercially viable new varieties through genetic engineering in Orchids, Anthuriums and other indigenous species
- b. Indexing for quality of planting material during import and export
- c. Mass production of planting material via *in-vitro* techniques - Orchids, Anthuriums, Ornamental flowering plants and foliage
- d. Pest and disease diagnosis of ornamental crops through molecular techniques

5. Other Crops and Organisms

- a. Commercial propagation of, Oil palm and Bamboo using *in-vitro* techniques
- b. Screening and improving microorganisms and their products either for direct consumption as food, or in agro-industries for sustainable agriculture

5. Other

- a. Policy Research to enhance the application of biotechnology in agriculture
- b. Application of genetic engineering tools to achieve resistance for biotic and abiotic stresses
- c. Bio-prospecting for agricultural use
- d. DNA fingerprinting/bar-coding of important plants and varieties

Summary of National Research Priorities in Agricultural Biotechnology

The national priorities in agricultural biotechnology for the period of 2017-2021 are summarized in table 01.

Table 01: National Priorities in Agricultural Biotechnology for 2017-2021

Major Thrust / Priority Areas	Thrust /Priority areas	Sector
A. Germplasm Conservation and characterization	1) Genetic characterization of germplasm of important crops 2) <i>In-vitro</i> conservation (cryopreservation) 3) DNA fingerprinting/bar-coding of important plants and varieties 4) Stock identification for economically important marine food fish using molecular tools	1) Plantation, Export agriculture & Food crops 2) Plantation crops, Food crops 3) Food crops, Fisheries sector 4) Fisheries sector
B. Genetic Improvement	1) Marker aided selection for crop improvement (yield, biotic and abiotic stresses (heat & drought)) 2) Production of commercially viable new varieties through genetic engineering 3) Marker Assisted Selection for selected aquatic plants of ornamental Value	1) Plantation, Export agriculture & Food crops 2) Floricultural crops 3) Fisheries sector
C. Tissue Culture & Mass Propagation	1) Mass production of planting material via <i>in vitro</i> techniques 2) Production of disease free high quality planting material 3) Development of biotechnological protocols for marine micro algae propagation 4) Embryo rescue techniques	1) Plantation, Food & Floricultural crops, Bamboo, oil palm 2) Plantation crops, Food crops 3) Fisheries sector 4) All crops
D. Detection and Identification of Pathogens and Pests	1) Indexing for quality of planting material during import and export 2) Detection and identification of pathogens of diseases and pests 3) Development of resistant brood stocks of shrimp for white spot disease by molecular tools 4) Molecular detection of antimicrobial resistant pathogens along fish product supply chain	1) Floricultural crops 2) Plantation, Export agriculture, Floricultural crops & Food crops. 3) Fisheries sector 4) Fisheries sector

	5) Molecular identification of parasites in food fish (targeting export industry) 6) Molecular tools for disease diagnosis for viral, bacterial, fungal and parasitic diseases	5) Fisheries sector 6) Livestock and poultry sector
E. Biotechnological Industrial Application	<ol style="list-style-type: none"> 1. Extraction of bioactive compounds from marine micro algae and other marine organisms 2. Development and application of Biotechnologies for animal feed and nutrition 3. Vaccine production for viral, bacterial and parasitic diseases 4. Screening microorganisms & their products either for direct consumption as food, or use in agro-industries for sustainable agriculture 5. Bio-Prospecting for agricultural crops 	<ol style="list-style-type: none"> 1) Fisheries sector 2) Livestock and poultry sector 3) Livestock and poultry sector 4) Micro organisms 5) Plantation, Export agriculture, Floricultural crops & Food crops
F. Genetic Engineering	1) Production of commercially viable new varieties through genetic engineering	1)All Crops.

Annexure

Annexure 1: Members of the National Committee on Agricultural Biotechnology

Dr. W L G Samarasinghe (Chairman)
Additional Director
Plant Genetic Resources Centre
Department of Agriculture
Gannoruwa
Peradeniya

Dr. S A C N Perera
Principal Scientist
Genetics & Plant Breeding Division
Coconut Research Institute
Bandirippuwa Estate
Lunuwila

Dr. C M Nanayakkara
Senior Lecturer
Department of Plant Sciences
Faculty of Science,
University of Colombo

Prof. Pradeepa Silva
Professor in Animal Science
Department of Animal Science
Faculty of Agriculture
University of Peradeniya

Dr. Priyani Seneviratne
Deputy Director Research (Biology)
Rubber Research Institute of Sri Lanka
Dartonfield
Agalawatta

Dr Pradeepa C. G. Bandaranayake
Director
Agricultural Biotechnology Centre
Faculty of Agriculture
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Dr D M J B Senanayake
Additional Director, National Plant Quarantine Service
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Dr S K Wasala
Assistant Director of Agriculture (Research)
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Department of Agriculture
Gannoruwa, Peradeniya

Dr. Vindhya Basnayake
Deputy Director (Research)
Plant Virus Indexing Center
Department of Agriculture
Homagama

Mrs. Malika Perera
Senior Research Officer, Crop Improvement Division
Sugarcane Research Institute
UdaWalawe

Ms Deishini Herath
Senior Scientist
National Aquatic Resources Research and Development Agency
Mattakkuliya

Dr S. A. Krishnarajah
Director (Research & Technology Transfer)
Department of National Botanic Gardens
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Mr Dilip de Silva
Chairman/CEO
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Dr S. S. Iddamaldeniya
Veterinary Research Officer
Veterinary Research Institute
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Dr. V. R. M. Vidhanaarachchi
Head/Tissue Culture Division
Coconut Research Institute
Bandirippuwa Estate
Lunuwila

Dr Padmini C. Girihagama (Secretary)
Senior Scientist
Sri Lanka Council for Agricultural Research Policy
Wijerama Mawatha
Colombo07

Annexure 2: List of the Speakers at the Stake Holder Workshop

1. Dr. W. L. G. Samarasinghe, Chairman, NCAB & Additional Director, Plant Genetic Resource Centre, Department of Agriculture -Introduction/Opening Remarks; Current Status & Future Directions in Agricultural Biotechnology Research in Sri Lanka
2. Dr. K. K. S. Fernando, Former Director, Agricultural Biotechnology Centre, University of Peradeniya & Former Director, Seed Certification & Plant Protection Centre, Department of Agriculture -Key note address on Current Status & Future Directions in Agricultural Biotechnology Research in Sri Lanka
3. Dr. C. M. Nanayakkara, Member, NCAB &Senior Lecturer, University of Colombo- Agricultural Biotechnology Policy in Sri Lanka
4. Dr. Jayantha Senanayake, Member, NCAB& Additional Director / National Plant Quarantine Service, Department of Agriculture- Current Status & Future Directions in Agricultural Biotechnology Research in Food Crop Sector
6. Dr. S.A. C. N. Chandrika N. Perera, Member, NCAB & Principal Research Officer, Coconut Research Institute of Sri Lanka-Current Status & Future Directions in Agricultural Biotechnology Research in Plantation Sector
7. Dr. J.M. Seneviratne, Assistant Director/Department of Export Agriculture - Current Status & Future Directions in Agricultural Biotechnology Research in Export Agriculture Crops Sector
8. Dr. Shelomi Krishnarajah, Member, NCAB & Director (Research)/ National Botanic Gardens- Current Status & Future Directions in Agricultural Biotechnology Research in Floricultural Crop Sector
9. Ms. Deishini Herath, Member, NCAB & Senior Scientist/National Aquatic Resources R& D Agency- Current Status & Future Directions in Agricultural Biotechnology Research in Fisheries & Aquatic Resources Sector

10. Dr. S.S. Iddamaldeniya, Member, NCAB & Senior Veterinary Research Officer, Veterinary Research Institute- Current Status & Future Directions in Agricultural Biotechnology Research in Livestock & Poultry Sector
11. Mr Dilip de Silva, Member, NCAB & Chief Executive Officer, Serendib Horticulture Technologies Pvt. Ltd - Current Status & Future Directions in Agricultural Biotechnology Research in Private sector
12. Dr. Pradeepa C. G Bandaranayake, Member, NCAB & Director, Agricultural Biotechnology Centre, University of Peradeniya- Current Status & Future Directions in Agricultural Biotechnology Research in National University System

Annexure 3: Key Cross Cutting Areas

The key cross cutting areas which are essential for the successful implementation of Agricultural Biotechnology research were also identified at the stake holder workshop as critical for the success of biotechnology R&D programmes. Important cross cutting areas are listed below under capacity building in human resources, infrastructure, technology transfer and constraints in each sector.

A. Capacity Building: Human Resource Development

1. Plantation Sector

- a. Bioinformatics (NGS), genomics and functional analysis
- b. Molecular pathology
- c. Studies on cry-bank
- d. Molecular pathogen detection and vector studies
- e. Proteomics
- f. Training for research supporting staff on molecular techniques

2. Food Crop Sector

- a. Molecular breeding (Long Term/Short term)
- b. Gene editing (Short Term)
- c. Bio-informatics (Post Graduate level)
- d. Tissue culture techniques for crop improvement and propagation
- e. Training on functional genomics
- f. Proper use and maintenance of molecular lab equipment and lab safety
- g. Regulatory issues

3. Livestock, Poultry & Fisheries Sector

- a. Trainings in Biotechnology, Bio-informatics and genomics
- b. Micro-propagation techniques for marine micro algae
- c. Techniques in extraction of Bioactive compounds
- d. PhD level and short term training for scientists and supporting staff
(Parasitology, Bacteriology, Animal Breeding, Marine biotechnology, Aquatic disease diagnosis)

4. Other crops: Export Agriculture/Ornamental/Sugarcane & Bambo

- a. Visiting Ongoing projects of oil palm and bamboo in India & Malaysia.
- b. Molecular techniques in characterization and others relevant to floriculture sector.
- c. PhD level training for scientists and short term training for supporting staff relevant to novel biotechnological approaches in export agricultural crop sector. Bio-tech. Training for floriculture sector.
- d. Training on recent advancements in floriculture techniques in domestication wild flora for floriculture sector.
- e. Training on quality testing and certification to Export Agricultural crop sector.
- f. Training supporting staff on quality testing GI fixing and germplasm.

Table 02: Capacity Building: A. Human Resource Development

Discipline	Training type	Sectors
Bioinformatics (NGS), genomics and functional genomics and analysis	RPG	Plantations Food crops Livestock, poultry & Fisheries
Molecular breeding	RPG & STT	Food crops
Gene editing	STT	Food crops
Molecular pathology	STT	Plantations
Studies on cry-bank	STT	Plantations
Molecular pathogen detection and vector studies	STT	Plantations
Proteomics	STT	Plantations
Tissue culture/micro propagation techniques for crop improvement and propagation	STT	Food crops Livestock, Poultry & Fisheries Sector (marine micro algae)
Techniques in extraction of Bioactive compounds	STT	Livestock, Poultry & Fisheries Sector
Parasitology, Bacteriology, Animal Breeding, Marine biotechnology, Aquatic disease diagnosis	RPG & STT	Livestock, Poultry & Fisheries Sector
Molecular techniques in characterization	STT	Ornamentals
Biotechnology in floriculture - recent advancements in floriculture techniques in domestication wild flora for floriculture sector	STT	Ornamentals
Proper use and maintenance of molecular lab equipment and lab safety	STT	Food crops
Quality testing and certification of produce	STT	Export agriculture crops
Regulatory issues	STT	Food crops
Training for research supporting staff on molecular techniques,	STT	Plantations
Familiarization of Oil palm and Bamboo cultivations in India & Malaysia	FV	Other crops (Bamboo)
Training supporting staff on quality testing GI fixing and germplasm	STT	Export agriculture crops

Training Types Abbreviations:

RPG = Post Graduate by Research, Mac = Mac (course work), STT = Short term training, FV = Familiarization visits

B. Capacity Building: Infrastructure Development

- a. Center of excellence at National level (NGS, high throughput genotyping and sequencing, RT-PCR).
- b. Provision of basic molecular biological equipment for institutional laboratories
- c. Bio-tech lab facilities for production of quality planting material in floriculture sector
- d. Controlled environment facilities for research purposes
- e. Certification lab for GI fixing of black pepper and coffee

C. Technology Transfer:

Initiate Private Public Partnerships (PPT) on Technology transfer(especially Oil palm/Sugarcane)

D. Constraints:

- a. Lack of awareness of policy makers on importance of Biotechnology in economic development
- b. Non availability of laboratory supplies on time due to procurement delays
- c. Poor Inter-institutional collaborations
- d. Lack of incentive to develop floriculture sector through molecular techniques due to indiscriminate importation of new varieties of Anthuriums and orchids
- e. Delays in fund disbursement

E. Any other comments

- a. CARP to organize forum for discussion among researchers, private sector and Policy makers.
- b. Awareness programmes on multi-disciplinary research
- c. CARP to collaborate among relevant authorities (NRC, NSF, NASTEC, COSTI, Other relevant ministries) dealing with different aspects in research on biotechnology
- d. Interaction among other national committees functioning under CARP on cross cutting issues
- e. Formation of a National Plant breeding and Bio-tech Society