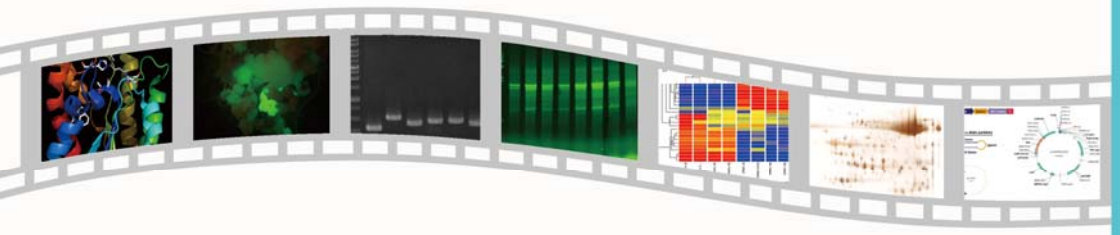
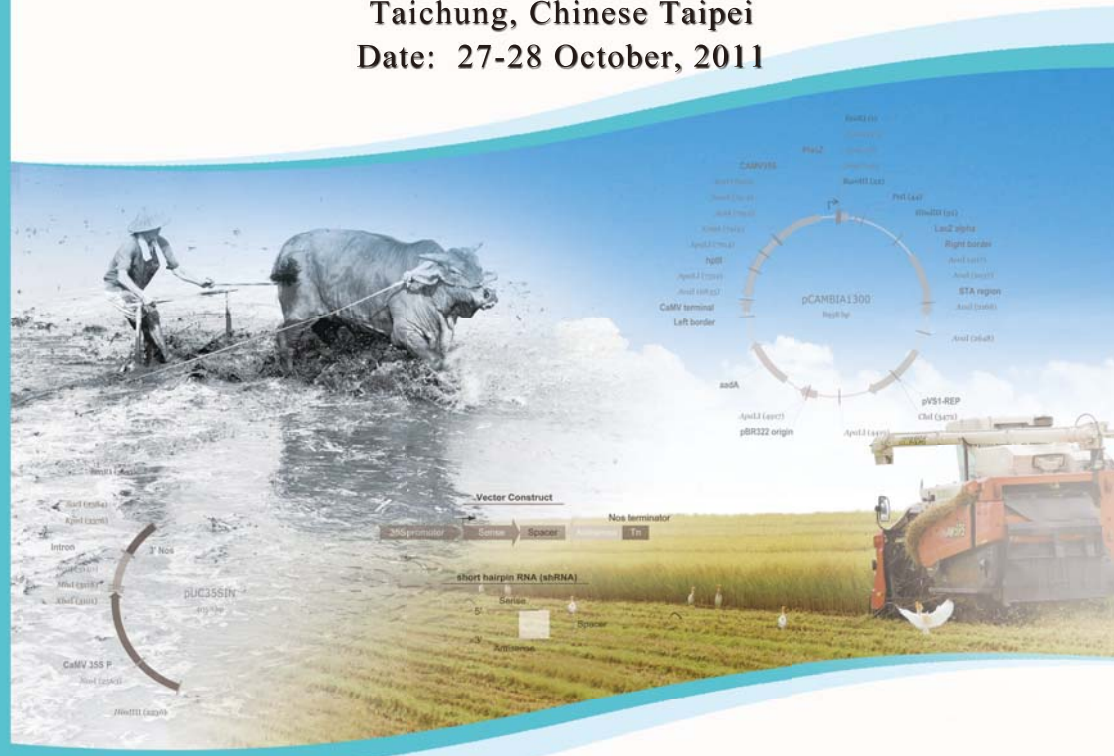


Implemented by Taiwan Agricultural Research Institute

Expert Consultation on Agricultural Biotechnology, Biosafety and Biosecurity

Venue: Taiwan Agricultural Research Institute (TARI), Taichung, Chinese Taipei

Date: 27-28 October, 2011



Council of Agriculture (COA)

Taiwan Agricultural Research Institute (TARI)

Asia-Pacific Association of Agricultural Research Institute (APAARI)

Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB)

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I. Messages from organization committee

Minister of Council of Agriculture (COA), Chinese Taipei

It is my great pleasure to welcome you all in opening the 2011 Expert Consultation on Agricultural Biotechnology, Biosafety and Biosecurity organized by APAARI. On behalf of the host country, I would like to offer all participants from abroad a heartfelt greeting. The Council of Agriculture has been cooperating very closely with APAARI since it joined the association in 1999. I am very pleased that the Taiwan Agriculture Research Institute of my council has the honor to work together with APAARI again in organizing this meeting after the last one on biopesticides and biofertilizers held here two years ago. I trust this year's Expert Consultation will prove a great success.

Agriculture is facing numerous problems and challenges in this century, such as soil erosion, dwindling water resources, global warming, and population growth. The FAO estimates that agricultural productivity must be doubled by 2025 to meet the increasing food demand from a growing population, and to cope with the decreasing agricultural resources. Thus the greatest challenge for agriculture is how to produce more food with higher efficiency, yet with less environmental impact.

Biotechnology has developed rapidly in recent years. It has become one of the most promising technologies to deal with many emerging challenges facing human beings. The improved productivity and nutritional value of crops brought about by the latest developments in genetic engineering and molecular marker-assisted breeding have a positive effect on alleviating the food crisis and combating climate change.

Considering the profound impact of climate change on agricultural production, Chinese Taipei has developed multidisciplinary biotechnology-based research programs in recently years. The program activities include breeding and selection of new crop varieties to cope with changing environmental conditions, identification and integrated management of major pests and diseases, and utilization of microbial agents for manufacturing biofertilizers and biopesticides. Other measures have also been taken to ensure a continuous growth in the agricultural sector.

Genetically modified crops such as corn, soy beans and cotton that resist pest attacks or adverse effects have been developed by employing

biotechnology and grown in many developed and developing countries. The GM crops require less chemical use but have better yields. Biotechnology can indeed help cope with the issue of food supply.

Nevertheless, GM technology is also facing strong opposition because of the great concern about possible harmful effects on human health and risks to the environment. Therefore, the biosafety of GM crops should be addressed based on sound scientific risk assessment and effective management in the field and on the market. In the meanwhile, effective communication with the general public is also necessary.

Biosecurity is another important issue relating to the movement and trade of GM crops or products. It aims to reduce the risk of transmission for GM organisms by adopting a set of preventive measures, such as laboratory biosecurity, transport security and material control. Biosecurity requires cooperation of scientists, policy makers, law enforcement officials and other people who may be involved. It will not only be managed at the national level, but also need international cooperation to harmonize approaches to achieve desired biosecurity. This Expert Consultation is therefore very important in that it allows participants to exchange opinions and suggest approaches to regional cooperation in biotechnology, biosafety and biosecurity in the Asia and Pacific region.

This Expert Consultation is attended by 100 participants from 22 different countries, representing a wide variety of stakeholders including policy makers, scientists, technical experts, representatives of NGOs and farmers. I am confident your participation and your recommendations will help researchers and policy makers in developing appropriate policies and strategies for accelerating agricultural development and enhancing biosafety and biosecurity through cooperation in the Asia Pacific region.

Finally, I wish the meeting great success and our guests from abroad an enjoyable stay in Taiwan.

Wu-Hsiung Chen
Hon'ble Minister
COA

I. Messages from organization committee

Director General of Taiwan Agricultural Research Institute

On behalf of Taiwan Agricultural Research Institute (TARI), it is my great pleasure and honor to welcome all of you to this “Expert Consultation on Agricultural Biotechnology, Biosafety and Biosecurity”, which is co-sponsored by Asia Pacific Association of Agricultural Research Institution (APAARI) and Council of Agriculture (COA) of Chinese Taipei. My warm welcome is especially extended to those who travel a long distance from abroad to visit Chinese Taipei and the campus of TARI.

Biotechnology is considered as one of the key technologies for the improvement of human life in the 21st century. Its advantages to the functional operation of agriculture and fishery have been widely acknowledged for past decades. Through the use of agricultural biotechnology, quite a few of significant breakthroughs have made in many developed countries; for example, the development of transgenic variety for corn, cotton and canola, with a higher yield and a better resistance to pests and diseases. However, progress in research and application of agricultural biotechnology in the Asia and Pacific region remains relatively slow, and benefits of such an advanced technology has not yet appreciated by the majority of farmers as well as general public.

Despite the success in developing genetically modified (GM) crops, consumption of GM foods is still skeptical and has been faced with some doubts, including legal, ethical and safety issues. As general public accepts only a biotechnology that is economical, environmentally safe and socially acceptable, risk assessment should be included in the research and development of every new biotechnology and product. With such an idea in mind, our government as well as TARI has implemented policies to regulate development of agricultural biotechnology, allocate funding and manpower for R&D, and support the setup of several biotechnology facilities/parks; one of them is located at TARI.

Due to increased international trade of agricultural produces, biosecurity has become an important issue in recent years. The prevention and control of invasive species, including pests, diseases, animals and plants, is now considered urgent and critical. There is a need for international cooperation to develop proper approaches for ensuring biosecurity within the Asia and Pacific region without creating unnecessary barriers to international trade on agricultural

commodities. I am glad to learn that there are 17 experts invited to deliver the related lectures covering topics of agriculture biotechnology, biosafety and biosecurity in the meeting. I trust that all the participants will benefit from their presentations and the collective discussions arranged in the program.

Before closing, I would like give thanks to my colleagues for their time and efforts to organize this special event, and also express my sincere gratitude to all the speakers and participants for your contributing and active participating at the meeting in advance. I wish all the success for this meeting. Enjoy the warmth and hospitality rendered by TARI and have a good time while your stay in this beautiful island Taiwan.

Dr. Junne-Jih Chen
Director General
TARI

I. Messages from organization committee

Chairman of APPARI

I am extremely pleased to welcome you all to the Expert Consultation on Biotechnology, Biosafety and Biosecurity being organized by the Asia-Pacific Association of Agricultural Institutions (APAARI) in collaboration with Council of Agriculture (COA). The topic is assuming increasing importance in the context of present need for food and nutrition security along with security from agricultural diseases, pests and alien invasives. With ever increasing population particularly in the developing countries, there is an urgent need to improve productivity of agricultural systems, including animals and fisheries, with adoption of modern genetic improvement technologies and efficient farm management. Experience of some Asian countries with genetically modified crops and reproductive interventions in farm animals suggest that biotechnology has the potential to raise farm output and enhance farmers' incomes, including those of small and marginal farmers.

Biosafety related to GM technology is, however, becoming a significant issue in many countries, including those in Asia and the Pacific. The need to address genuine environmental issues while generating science-based public awareness cannot be overemphasized. There is a similar need to develop adequate infrastructure and capacity to meet other biosecurity threats to agriculture like outbreaks and transboundary movement of serious diseases and pests. The emergence of some diseases of crops and farm animals as global biosecurity risks calls for international cooperation in controlling and eradicating them.

I am happy that the expert consultation has brought together a galaxy of experts and other stakeholders from around the globe. I greatly appreciate the support of Dr. Su-san Chang, Director General, International Cooperation, COA in hosting this meeting as well as a number of other collaborative programs with APAARI. I extend warm welcome to all the participants whose contribution will be invaluable in evolving an effective work plan to address biotechnology and biosafety in the broader context of biosecurity.

Dr. S. Ayyappan
Chairman
APAARI

I. Messages from organization committee

Executive Secretary of APAARI

It gives me immense pleasure to welcome all the participants to this Expert Consultation on Biotechnology, Biosafety and Biosecurity being jointly organized by the Asia-Pacific Association of Agricultural Institutions (APAARI) and Council of Agriculture (COA), Chinese Taipei. This is one in a series of APAARI-COA joint activities comprising expert consultations and training program being conducted since the last more than three years. In 2009, an Expert Consultation on Biopesticides and Biofertilizers was held at the same venue, the Taiwan Agricultural Research Institute (TARI).

The biotechnology program of APAARI, Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB) has been engaged in promoting safe and environmentally friendly biotechnologies in the Asia-Pacific region. With regard to biosafety, APCoAB organized Workshop on Harmonization of Biosafety Regulations in the Asia-Pacific Region in 2006 and Expert Consultation on Agricultural Biotechnology for Promoting Food Security in Developing Countries in 2008.

Biotechnology has important implication on the emerging concerns about biosecurity. It offers tools to enhance biosecurity through improved disease diagnosis and surveillance and to develop crops and animals resistant to diseases and pests. While some countries of Asia-Pacific have made significant advances in adoption of biotechnology including genetic modification technology for agricultural improvement, several other countries have still not been able to reap its full potential. Biosafety is one of the important biosecurity issues that many countries are concerned about and which needs to be addressed through knowledge sharing, proper understanding, capacity building and infrastructural development.

On behalf of APAARI, I convey my sincere thanks to Dr. Su-San Chang, Director General, International Cooperation, COA for co-organizing this meeting. Our thanks are due to Director General and staff of TARI for hosting this important event. I am sure, the deliberations at this regional expert consultation will pave the way for enhanced adoption of biotechnology and biosecurity measures through strengthened cooperation at the national and regional levels.

I look forward to a very productive and interactive meeting.

Raj Paroda
Executive Secretary
APAARI

II. Corporate Profiles of implementation organizations

Taiwan Agricultural Research Institute, TARI

This institute was established in 1895 by the then Taiwan Gubernatorial Government under Japanese rule. After the World War II, it was placed under the Department of Agriculture and Forestry of Taiwan Provincial Government. Subsequently, the institute was renamed as Agricultural Research institute (ARI) and has been operated under the supervision of COA since 1999.

The headquarters of this institute was originally located in the suburb of Taipei City. Due to a rapid urbanization of Taipei in 1960's, which inevitably caused a space constraint for expansion, the Institute was, therefore, moved to Wufeng, Taichung in Central Taiwan in December 1977.

The new headquarters occupies 145 ha including 17 ha of building and various constructions and 128 ha of experimental farms served by a complete irrigation and drainage system.

This Institute conducts both basic and applied research for , agronomic and horticultural crops in the fields of breeding and genetics, physiology, tissue culture, biotechnology, soils fertility and plant nutrition, diseases and pest managements, farm machineries, meteorology, agricultural economics, and extension. The varieties and technologies developed by the institute in the last fifty years have contributed greatly to agricultural productions in Taiwan and a rapid progress in rural economic development. In future, TARI will adopt more advanced, integrated, and global strategies for research to continuously assure her perspective which will include:

1. Improvement of crop breeding and cultivation techniques;
2. Strengthening research and application of biotechnology;
3. Germplasms collection and preservation for biodiversity;
4. Improvement of post-harvest techniques;
5. Development of non-chemical measures and new quarantine techniques and strengthening research on cooperation, technology transfers, and international agricultural exchange.

We expect these advanced technologies could upgrade agricultural industry and maintain a prosperous development in Taiwan.

II. Corporate Profiles of implementation organizations

Asia-Pacific Association of Agricultural Research Institutions, APAARI

Asia-Pacific Association of Agricultural Research Institutions (APAARI), established in 1990 at the initiative of FAO, is an apolitical, neutral, non-profit forum of Agricultural Research Institutions, National Agricultural Research Systems (NARS) in the Asia-Pacific region, in the pursuit of common objectives. Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB) and Asia-Pacific Agricultural Research Information System (APARIS) are its two main programs. APAARI has a membership of 56 institutions including NARS, CG Centres and other regional organizations.

The mission of APAARI is "to promote the development of national agricultural research systems in the Asia-Pacific region through facilitation of intra-regional, inter-institutional, and international cooperation/partnership".

The overall objectives of APAARI are to foster agricultural research for development in the Asia-Pacific region so as to help address the concerns of hunger, poverty, environmental degradation and sustainability of agricultural production. More specifically, the objectives are:

- Promote the exchange of scientific and technical know-how and information in agriculture;
- Encourage the establishment of appropriate co-operative research and training programs in accordance with identified regional, bilateral or national needs and priorities;
- Assist in prioritizing NARS/regional needs, strengthening of research organizational and management capabilities of member institutions including information and communication technology;
- Strengthen cross-linkages among national, regional and international research centres and organizations, including universities, through involvement in jointly planned research and training programs; and
- Promote collaborative research among member institutions, including need based support to regional research networks.

II. Corporate Profiles of implementation organizations

Asia-Pacific Consortium on Agricultural Biotechnology, APCoAB

Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB) was established in 2003 under the umbrella of Asia-Pacific Association of Agricultural Research Institutions (APAARI). APCoAB has the mission to "harness the benefits of agricultural biotechnology for human and animal welfare through the application of latest scientific technologies while safeguarding the environment for the advancement of society in the Asia-Pacific Region".

APCoAB's main objectives are:

- To serve as a neutral forum for the key partners engaged in research, development, commercialization and education/learning of agricultural biotechnology as well as environmental safety in the Asia-Pacific region;

- To facilitate and promote the process of greater public awareness and understanding relating to important issues of IPRs, sui generis systems, biosafety, risk assessment, harmonization of regulatory procedures, and benefit sharing in order to address various concerns relating to option of agricultural biotechnology; and

- To facilitate human resource development for meaningful application of agricultural biotechnology to enhance sustainable agricultural productivity, as well as product quality, for the welfare of both farmers and consumers.

III. About the Expert Consultation

About the Expert Consultation

Raj Paroda and J. L. Karihaloo

Asia-Pacific Association of Agricultural Research Institutions

The “Green Revolution” of 1970s and 1980s, saw several Asia-Pacific countries making substantial progress in enhancing crop productivity, which led to greater availability of food, higher farm incomes and improved human development. However, emerging challenges to agricultural growth have renewed concerns about food security, poverty and hunger. The last few years have seen a slow down or even stagnation in crop productivity leading to alarmingly low grain reserves and spiralling food prices. Along with, increasing diversion of food grains for livestock feed and biofuels, and relentless growth in population of some countries is adding to the already difficult food situation. Under the prevailing conditions, most of the developing countries in Asia will not be able to meet the Millennium Development Goals of halving poverty and hunger by 2015. Accordingly, there is an obvious call for the second “green revolution” the technological component of which would be driven by new biology, especially biotechnology.

GM technology is globally recognized as a powerful means of improving productivity, profitability and sustainability of farm production systems, including those of small farm holdings. Since the first farm level cultivation of GM crops in 1996, the global area under these reached 148 million hectares (mha) in 2011 with 29 countries growing them. In India, the area under Bt cotton has reached a staggering 9.4 mha in just 8 years since its first release, comprising nearly 86% of the total 11 mha cotton area. Bt maize in the Philippines, grown for the first time in 2003, covered an area of 0.5 mha in 2010. In China, GM cotton, papaya, tomato, sweet pepper and poplar are being grown over 3.5 mha while approval was granted in 2009 to GM rice and maize. The latter are likely to be commercialized soon following completion of routine field trials. GM fish and clones farm animals are being pushed for release. Several studies made on the performance and impact of GM crops in India and China have shown that farmers, irrespective of their farm size, have benefited through increased yield

and reduced pesticide use which converted into higher profits and increased household incomes as well as increased aggregate employment.

Several developing countries of Asia-Pacific support significant programs on GM-based crop improvement in a wide range of crops and some have made policy statements asserting biotechnology as being integral to priority planning for agriculture and national development. However, few have been able to follow a policy of steady support to GM technology. Most countries of the Asia-Pacific have adopted precautionary principle towards biosafety risk assessment and management in conformity with the Cartagena Protocol on Biosafety and have developed their regulatory systems accordingly. However, practical implementation of the biosafety regulations has often been hampered by lack of preparedness in terms of infrastructure and capacity, as well as due to social, economic and political reasons. Perceived and often unsubstantiated adverse environmental and health impacts of GM technology have influenced public opinion and decision making, thus delaying the adoption of promising technologies that could address sustainability issues. The need to base regulatory decisions on sound science and creating public awareness was duly highlighted in “Expert Consultation on Agricultural Biotechnology for Promoting Food Security in Developing Countries” organized by APAARI in 2008.

Biotechnology has important implications on the recently emerging concerns about biosecurity. The prevention and control of alien agricultural diseases and pests is now assuming urgency due to increasing international travel and trade in agricultural products including food, and fears of deliberate spread of diseases and pests with the purpose of compromising food security of nations. Biosecurity in its broad sense is a strategic and integrated approach that encompasses the policy and regulatory frameworks for analyzing and managing relevant risks to human, animal and plant life and health and associated risks to environment. Biotechnology offers means to enhance biosecurity as also poses challenges to it. Biotechnological techniques like ELISA and PCR have vastly improved disease diagnostics and surveillance in animals and plants. Recombinant vaccines are superior to conventional vaccines in terms of specificity and safety. On the other hand, as detailed above, GM crops and animals raise issues of food and environment safety, a biosecurity concern.

Traditionally, biosecurity is managed at the national level on sectoral basis with sector related agencies developing individual policies and implementing them. However need is being expressed for a more holistic approach involving harmonization and integration to ensure effective prevention and control of biosecurity risks, including those related to biotechnology. Integration encompasses the joint setting of priorities and allocation of resources, joint planning and implementation of activities, and integrated systems for monitoring and review of outcomes. Such an approach would also make biosecurity implementation more affordable, a concern of several developing countries. In addition, in view of increasing trade and transboundary movement of biological materials including food, there is a need for regional cooperation and harmonization of approaches to achieve desired levels of control without creating unnecessary barriers.

Keeping in view the abovementioned needs, the Steering Committee of Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB), a program of APAARI, in its meeting held on 14 January 2011 decided to hold Expert Consultation on Biotechnology, Biosafety and Biosecurity in Chinese Taipei, as a part of the ongoing APAARI-Council of Agriculture, Chinese Taipei (COA) collaborative program. The meeting will be held at Taiwan Agricultural Research Institute (TARI), Taichung on 27 – 28 October 2011.

Objectives of the Expert Consultation:

1. Review the status of biotechnology and biosafety adoption in the Asia-Pacific countries;
2. Deliberate on harmonization of national biosafety system in the broader context of biosecurity; and
3. Suggest approaches to regional cooperation in biotechnology and biosafety in the context of biosecurity.

IV. PROGRAM

27 October 2011

08:00 – 09:00 **Registration**

09:30 – 10:30 **Inaugural Session**

Welcome Address: Dr. Raj Paroda, Executive Secretary, APAARI
Welcome Address: Dr. Junne-Jih Chen, Director General, TARI, COA
Opening Remarks & Release of Publication:
Dr. Wu-Hsiung Chen, Hon'ble Minister, COA
Vote of Thanks: Dr. J. L. Karihaloo, Coordinator, APCoAB-APAARI

10:30 – 11:00 **Group Photograph & Tea Break**

Session I: Status of Biotechnology, Biosafety and Biosecurity R&D in Asia-Pacific- Country Status

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Chair: Dr. Dyno Keatinge
Co-Chair: Dr. Su-San Chang

11:00-11:20	India	-	Dr. Ravi Khetarpal, CABI
11:20-11:40	Malaysia	-	Dr. Abd Shukor Abd Rahman, MARDI
11:40-12:00	Nepal	-	Dr. Dinesh Pariyar, NARC

12:00-13:00 Lunch Break

13:00-13:20	Philippines	-	Dr. Patricio Faylon, PCARRD
13:20-13:40	Sri Lanka	-	Dr. M. T. K. Gunasekare, SLCARP
13:40-14:00	Chinese Taipei	-	Dr. Kuo-Yun Fang, COA
14:00-14:20	Vietnam	-	Prof. Vu Manh Hai, VAAS
14:20-15:00	**Discussion**		

15:00-15:30 Tea Break

Session II: Status of Biotechnology, Biosafety and Biosecurity R&D in Asia-Pacific- Regional Status

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Chair: Dr. Abd Shukor Abd Rahman
Co-Chair: Mr. Mason Smith

15:30-15:50	Pacific	-	Dr. Raghunath Ghodake, NARI
15:50-16:10	WANA	-	Dr. Ahmad Abdul Kader, AARINENA
16:10-16:30	Africa	-	Prof. Walter Alhassan, FARA
16:30-16:50	Asia	-	Dr. J. L. Karihaloo, APCoAB-APAARI
16:50-17:10	**Discussion**		

18:30 Dinner hosted by COA

IV. PROGRAM

28 October 2011

Session III: Advances in Biotechnology for food security

Chair: Dr. Nicomedes P. Eleazar
Co-Chair: Dr. Dinesh Pariyar

09:00-09:20 Contribution of Biotechnology to Stress Tolerant Vegetable Crops
- Dr. Roland Schafleitner, AVRDC

09:20-09:40 Development of Genetic Engineering Technology Aimed to Produce Crops Tolerant to Environmental Stresses
- Dr. Kazuo Nakashima, JIRCAS

09:40-10:00 Biotechnology: An Imperative in Sustainable Food Production
- Dr. Francis C. Ogbonnaya, ICARDA

10:00-10:15 **Discussion**

10:15-10:45 Tea Break

Session IV: Advances in Biosafety and Biosecurity

Chair: Dr. Thomas Lumpkin
Co-Chair: Dr. Raghunath Ghodake

10:45-11:05 Biosecurity in Asia-Pacific - Status and Future
- Dr. Ravi Khetarpal, CABI

11:05-11:25 Developing Functional Biosafety Capacity to Support Agricultural Innovation: Approach and Lessons learned from IFPRI's Program for Biosafety Systems - Dr. Judy Chambers, IFPRI

11:25-11:45 Organizing Biotech Research for Biosafety Compliance: Experiences at IRRI - Dr. Ruaraidh S. Hamilton, IRRI

11:45-12:00 **Discussion**

12:00 – 13:00 Lunch

13:00 – 16:00 Group Discussion

Topics		***Facilitators***
Promoting Biotechnology for Food Security	-	Dr. Roland Schafleitner, AVRDC
Facilitating Biosafety Adoption	-	Dr. Judy Chambers, IFPRI
Building Biosecurity Systems	-	Dr. J. L. Karihaloo, APCoAB

16:00 – 16:20 Tea Break

16:20 – 17:00 Plenary Session

Chair: Dr. Raj Paroda, APAARI
Co-Chair: Dr. Su-San Chang, COA

V. Abstracts

Status of Agricultural Biotechnology, Biosafety and Biosecurity in India

R K Khetarpal
CABI South Asia, NASC Complex, Pusa Campus, New Delhi 110 012, INDIA
Email: r.khetarpal@cabi.org

The recent rapid growth of Indian agriculture has opened up new dimension of opportunities and challenges. The impetus given to biotechnology to meet food production demands and the development and release of transgenics opened up a plethora of issues related to biosafety. The increasing imports of agricultural commodities being made under WTO regime has led to enhanced danger of introducing exotic pests and diseases of plants and animals thus highlighting the importance of biosecurity.

India's agricultural biotechnology scenario is getting rapidly transformed. In order to ensure comprehensive safety assessment of organisms and products of modern biotechnology and to increase the public confidence, India has initiated the process of setting up of a statutory independent regulator that is the Biotechnology Regulatory Authority of India (BRAI). India has a well established framework for regulation of genetically modified (GM) crops under the 'Rules for the Manufacture, Use/Import/Export and Storage of Hazardous Micro Organisms/ Genetically Engineered Organisms or Cells' notified by the Ministry of Environment and Forests (MoEF) under the 'Environment (Protection) Act', 1986, commonly referred as Rules 1989. These Rules cover areas of research as well as large scale applications of genetically modified organisms and its products. Rules, 1989 are implemented by MoEF, Department of Biotechnology (DBT) and State Governments through six statutory committees. In 2008, a series of guidelines were issued to strengthen the conduct of confined field trials of GM crops by MoEF and DBT. The Indian Council of Medical Research also prepared guidance for safety assessment of GM crops.

The import of plants (including transgenics) is governed by the Plant Quarantine (Regulation of Import into India) Order 2003 under the Directorate of Plant Protection Quarantine and Storage which operates through a network of 35 plant quarantine stations of the Ministry of Agriculture. Attempts are made to

comply with Standards of International Plant Protection Convention as per SPS/ WTO norms. The regulations of import and export of livestock and livestock products, control of exotic diseases and certification as per World Organization for Animal Health (OIE) regulations are carried out through the Animal Quarantine and Certification Services, under the Department of Animal Husbandry and Dairy, located at New Delhi, Kolkata, Chennai and Mumbai. India has well-developed laboratories and manpower in the field of plant and animal sciences but they are scattered and not converging for a common cause. There is a dire need to work in a networking mode for diagnostics and control of diseases/ pests in cases of emergency. The establishment of a National Agricultural Biosecurity System comprising a network of Institutes to deal with plants, animals and living aquatic resources is in place. Awareness and capacity building on biotechnology, biosafety and biosecurity is being enhanced at various fora for different levels of stakeholders for ensuring food and nutritional security of the growing population.

V. Abstracts

Status of Agricultural Biotechnology, Biosafety and Biosecurity in Malaysia

Datuk Dr. Abd Shukor Abd Rahman
Malaysian Agricultural Research and Development Institute (MARDI), MALAYSIA

Biotechnology is one of the most dynamic fields of economic development in the world today, and its rapid advances over the last two decades have created new opportunities for Malaysia to increase food production towards enhancing its food security. Biotechnology has also been identified as one of the core technologies to accelerate the transformation of Malaysia into a knowledge-based economy and developed nation by year 2020, capable of providing employment to 280,000 people, contributing to 5% of the Nation's GDP and generating RM248 billion in revenue.

Agricultural biotechnology (agric biotech) development has been given the highest government support and commitment since the launching of the National Biotechnology Policy in 2005. Agric biotech research, development and commercialization (R, D&C) are being actively pursued by MARDI and other public research institutes, universities and agric biotech companies with BioNexus status. Both applied and fundamental research are conducted to generate biotechnological innovations and solutions relevant to the entire agriculture value chain, from production to distribution, to ensure competiveness, sustainability and wealth creation for the agriculture sector.

For application of GM technology in local crop improvement, transformation systems have been developed for rice, papaya, banana, pineapple, citrus, mangosteen, passion fruit, orchids, oil palm, rubber and forest species as an initial step to producing GM crop varieties with high quality and resistant to pests and diseases. Transgenic papaya for shelf-life improvement and rice for higher yield, drought tolerance and disease resistance have been produced by MARDI and are ready for confined field trials. R&D on non-GM biotechnology, such as tissue culture and DNA finger printing of crops are still relevant and being pursued. For improvement of livestock production, advanced reproductive biotechnology is being adopted and further enhanced by the recent

establishment of the National Animal Embryo Centre at MARDI. R&D in the frontier areas such as functional genomics, metabolomics and bioinformatics on crops, livestock and microbes are also being actively conducted to generate fundamental knowledge and understanding to meet current demand and challenges for superior crops, livestock and value added products. Till date, oil palm and rubber plant genome have been fully sequenced. To fulfill the needs for advanced genomic applications, a Centre for Marker Discovery and Validation (CMDV) has been set up in MARDI. This centre-of-excellence is to provide high throughput molecular marker platforms for genotyping of crop and livestock for high speed and precision breeding as well as enabling high throughput screening of local germplasm and biodiversity.

R&D on bioprocessing, involving the use of biological materials such as microorganisms, cells and enzymes for the conversion of raw materials or substrates from local abundant bioresources are also being carried out to generate value-added food or non-food products and ingredients such as functional food, nutraceuticals, enzymes, biofeed, biofertilizers, bioenhancers and biopesticides. Significant progress in diagnostics and biosensor R&D have accelerated the development of a wide variety of kits and biosensor devices for reliable and rapid detection of chemical residues, plant and animal diseases as well as detection of heavy metals, food-borne pathogens, mycotoxins and GMOs and GMF in the food industry.

To fulfill Malaysia's obligation under the Cartagena Protocol on Biosafety for a national legal instrument to regulate the release, importation, exportation and contained use of any living modified organism derived from modern biotechnology and products of such organisms, the Malaysian Biosafety Act 2007 was passed in the Parliament on July 2007 and came into force on 1st December 2009. Under this Act, the National Biosafety Board (NBB) was established under the Ministry of Natural Resources and Environment (NRE) which will be responsible for the implementation of the Biosafety Act and Regulations. The Genetic Modification Advisory Committee (GMAC) consisting of experts from various science-based and other relevant disciplines has also been established to provide scientific, technical and other relevant advice to the Minister of NRE and to NBB. The Biosafety Regulations also require all organizations which undertaking R&D activities on modern biotechnology to establish an Institutional Biosafety Committee (IBC) for advisory and monitoring roles at the institutional level to ensure compliance to the Biosafety Act and

Regulations. As of June 2011, thirteen organizations including MARDI had officially registered their IBC with NBB.

Biosecurity is relatively new in Malaysia. Realizing the growing importance and urgent need of the region and nations to protect and manage various institutions, national interests and natural resources, the Malaysian government had co-organized and hosted two international events on biosecurity namely the International Conference on Biosafety and Biosecurity Asia (BBA) in May 2007 and International Congress on Biosecurity, Biosafety and Biofence (BioSSD) in July 2011. These events were successful in bringing together 11 relevant departments and agencies in Malaysia to look at the current status of development and technology in the field of biosafety and biosecurity and to develop a roadmap for a national plan. As an initial step, the Ministry of Science, Technology and Innovation (MOSTI) Malaysia will spearhead a 5 year national R&D program on biosurveillance with the goal to enhance the existing R&D in biodiagnostics and biosensors in food, medical and agriculture for effective biosurveillance. The short-term goal is also to develop a mobile biosurveillance unit of Biosafety Level (BSL) 3 for effective early warning and on-site identification of biological threats.

The future for agric biotech development is Malaysia is bright. With positive government policies in the areas of science and technology, biotechnology, agriculture, biodiversity, intellectual property protection and commercialization and relevant regulatory frameworks in place, strong support on R, D&C in agric biotechnology will be ensured. The new economic model to support innovation economy will ensure a healthy growth of the innovation ecosystem in which biotechnology will play a significant role. In-line with the current government Economic Transformation Program (ETP) and the National Key Economic Area (NKEA) which has put priority on the agriculture sector, biotechnology as enablers will continue to provide the needed boost for agric biotech to move forward and contribute significantly towards a sound development of bioeconomy in Malaysia.

V. Abstracts

Status of Agricultural Biotechnology, Biosafety and Biosecurity in Nepal

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Nepal's agricultural biotechnology, biosafety and biosecurity policies are based on conservation and protection of biodiversity and indigenous agricultural system, and regulation in GMO, LMO and quarantine pests. In this regards, Nepal has signed Cartagena Protocol in 2002. A number of biosafety-related policies, plans and strategies, including Nepal Biodiversity Strategy, 2002; Biosafety Guidelines, 2005; National Biosafety Policy, 2007 have been prepared. Also, over 17 Acts, which are related to biosafety and biosecurity issues, including Plant Protection Act, 1972; Seed Act, 1989; Food Act, 1966; Animal Health and Livestock Service Act, 1998 are in place. A framework for biosafety and biosecurity for the country has been worked out. In case of biotechnology, Nepal Agricultural Research Council (NARC) established Biotechnology Unit during 1997 realizing the importance of traditional as well as modern biotechnology aiming to facilitate plant and animal breeding programmes. Since then, NARC has optimized several tissue culture media and used molecular (omic) based tools and techniques for several crop species. Following tissue culture approach, NARC recovered DH lines and distant and rare hybrids in several cereal crop species. Virus free mini potato tubers propagated through micro-propagation is being distributed every year for commercial production. Protocol optimization for genetic transformation in rice has been completed. DNA- and RNA-based molecular marker system has been routinely exploiting to assess the extent of potential genetic diversity as well as to identify the resistance germplasm for biotic and abiotic stresses. NARC research experiences on biotechnology have shown that integration of plant tissue culture and molecular marker technology in mainstream breeding work has a great value to share the advantages of biotechnology in developing countries like Nepal. Therefore, there is an urgent need to initiate biotech research and development work through establishing strong international collaboration in those commodities where traditional technology is inefficient to minimize the

adverse effect of rapidly changing climate. Implementation of the technological developments is gradually progressing and the country needs assistance and support in this regard. Moreover, there is an emerging need to include other areas of biotechnology, biosafety and biosecurity research using high throughput technology to grab the advantages in agriculture.

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Status of Agricultural Biotechnology, Biosafety and Biosecurity in Philippines

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Biotechnology in the Philippines, as a developing country focuses more on agricultural biotechnology. Agricultural inputs are optimized while conserving natural resources by improving crop and its management systems, livestock production and forest ecological functions. Moreover, for the country to respond to the impacts of climate change, issues and strategies on adaptation and resilience must be integrated in the agriculture, forestry and natural resources (AFNR) research and development (R&D) programs.

The Department of Science and Technology (DOST), the country's premiere science and technology body through its council, the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD) has supported biotechnology through R&D funding and provision of enabling policies and pronouncements coupled with facility enhancement and manpower development. Its biotechnology R&D program covers the AFNR sector. For crop improvement, employment of biotechnology tools is geared towards insect pest and disease resistance, delayed ripening characteristics, optimization of tissue culture techniques and protocols, development of diagnostic kits and cloning of economically important genes. The status of these undertakings varies from laboratory level to field-testing. In livestock, biotechnology tools have proved valuable in terms of genome characterization, rapid screening of semen for viruses, and cloning through somatic cell nuclear transfer. Optimization of micropropagation protocols for several forestry species has been the focus in forest biotechnology.

The Philippines has a functional biosafety regulatory system and a robust science-based assessment. In 1990, President Corazon Aquino issued the Executive Order 430 (EO 430) that created the National Committee on Biosafety in the Philippines (NCBP) which is commissioned to identify the potential hazards posed by experiments on genetic engineering and recommend

measures to minimize risks. To further boost the country's biosafety regulatory system, the Executive Order 514 was issued in 2006 that established the National Biosafety Framework. This strengthens the NCBP for it to coordinate and harmonize inter-agency and multi-sector efforts to develop biosafety policies in the country and set scientific, technical and procedural standards on actions by agencies and other sectors to promote biosafety in the Philippines. Also, the Philippine Senate has signed the Cartagena Protocol on Biosafety to the United Nations Convention on Biological Diversity.

The ultimate success of agricultural biotechnology is for its products to be used for human and animal consumption while keeping the environment safe and biodiversity conserved. It is already proven that biotechnology can be a tool to provide better and safer crops towards food security and sustainable agriculture. Hence, agricultural biotechnology programs need to be strengthened and supported.

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Status and Future Perspectives in Agriculture Biotechnology, Biosafety and Biosecurity in Sri Lanka

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Agriculture is the mainstay of Sri Lanka and has contributed immensely to the economic development and in enhancing rural livelihood of the country. The Government of Sri Lanka has a strong agriculture focus embraced within its 10-year comprehensive national development program (2006-2016) with the goal of ensuring food security and improving income for farmers. The country has recognized the use of novel technologies as a major driving force in increasing productivity and agricultural products to address numerous challenges faced by the farmers. As reflected in the current national policies, strategic plan and R&D programs in the country, R&D in biotechnology is one of the key areas for agriculture development.

Biotechnology applications based on tissue culture and other related techniques have made significant impact on agricultural production. More emphasis has now been placed on molecular based (non-transgenic) techniques. On the other hand, genetic engineering has progressed at a very slow pace and no commercialization of GM crops or animals has taken place so far. Setting up of an enabling environment to conduct R&D in biotechnology has lagged behind over the years owing to the absence of need identification and priority setting at the national level. However, the recently formulated five year plan on National Biotechnology R&D program and an Investment Plan offer clear directions and priorities for proper decision making while rationalizing resource utilization.

Sri Lanka ratified Cartagena Protocol of the CBD in 2004 and the Ministry of Environment and Natural Resources as the national focal point for biosafety is the controlling authority for all issues relating to biosafety in Sri Lanka, including R&D, development of industry linkages, establishment of relevant legislations, protocols and guidelines. National focal point for Biosafety had formulated the National Biosafety Policy and established a Biosafety Clearing-House while facilitating to set up accredited laboratories for GMO testing and detection.

Ministry of Technology & Research was involved in formulating the National Biotechnology Policy and both the above policies were approved by the Government. In Sri Lanka legislations imposed by various types of ordinance and acts such as Plant Protection act, Plant Quarantine act, Wide life Ordinance, Fauna & Flora Protection Ordinance, Fisheries and Aquatic Resources Act, Intellectual Property act, to name few, deal with biosecurity issues to a greater extent and covers cross-cutting areas related to biosafety and biosecurity aspects. Sri Lanka is in the process of finalizing the Plant Variety Protection act to safeguard new varieties produced by the breeders also considering farmers rights. While appreciating the significant progress made in formulating policy framework and guidelines by different ministries and agencies in relation to biosafety and biosecurity, the implementation remains a challenge and the need to enhance public awareness is strongly felt. It is proposed that the country could adopt policies to derive benefits from biotechnology by promoting public-private partnership and by working in a multi-disciplinary, cross-sectoral manner and by fostering regional collaborations to harness agricultural developments and economic prosperity.

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Status of Agricultural Biotechnology, Biosafety and Biosecurity in Chinese Taipei

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Agricultural biotechnology has great potential to facilitate agricultural development. The policy of Chinese Taipei is to promote agricultural R&D by employing biotechnology and for efficient management of biosafety and biosecurity issues. In order to develop agricultural biotechnology industry, the Council of Agriculture (COA) has specified main research in the areas of plant seedling, aquaculture, livestock, food, bio-fertilizer, bio-pesticide, animal vaccine, and testing and diagnostics. Many projects are in progress/ completed on promotion of the quality of agricultural products, development of pest-resistant GM crops to reduce the use of chemical pesticides, production of GM organisms with ornamental value such as fluorescent fish, development of GM pigs for organ transplanting, development of model animals for biomedical research, and use of bioreactor technology for producing medicinal proteins such as vaccines, growth factors and coagulation factor, etc. In Chinese Taipei, there are 52 companies in the agricultural biotechnology industry, with an output value of $154 million, which accounts for 6.25% of Chinese Taipei's biotechnology industry in 2010.

In 2009, the government approved the "Development Program of Industrialization for Agricultural Biotechnology" for a five-year period (2009-2013). The development program included six development strategies, namely setting up an intergovernmental task force for promotion, forming demand-oriented S&T policy, linking industry-academia R&D system, building up commercialization platform, training of business talents, and speeding up agricultural transformation. The COA proposed a strategic framework for industrialization, on the basis of Chinese Taipei's current agricultural advantages and future development opportunities, to integrate the agricultural biotechnology industry's upstream, midstream and downstream R&D capacities. The

development scheme designated aquaculture, plant, livestock, microorganism and interdisciplinary biotechnology as the five key target industries for development through innovative R&D projects, industry-academia collaboration, industry promotion, etc.

The major concerns for developing GMOs in Chinese Taipei are the release of GMOs, the possible transfer of the engineered gene(s) into related species or wild populations, the effect on non-target organisms (e.g. insects which are not pests), and the reduction in the spectrum of other plants (loss of biodiversity). For the management of GMOs, Chinese Taipei has established regulatory system to ensure biosafety and biosecurity. At the stage of basic research, National Science Council (NSC) regulates R&D activities based on Laboratory Guidelines, which is for regulating the use of genetic modification technology. At the stage of field testing, the COA has established relevant laws and regulations for GM crops, fowl, aquaculture and feeds, bio-pesticides, bio-fertilizers and veterinary drugs; Environmental Protection Agency (EPA) is in charge of testing items for microbial preparations used as environmental pest control agents. Accordingly, the COA and EPA also have regulations to approve for marketing / sales and import / export of the items mention above. As for GM food, Department of Health (DOH) is in charge of GM food safety. Chinese Taipei has established science-based assessment to evaluate the characteristics of the GMOs and their effect and stability in the environment, and to determine the unintended effects resulting from the transgenic organisms. The risk assessment emphasizes the detrimental effect on beneficial insect, fast adaptation of resistant insect, potential generation of new plant pathogens, potential adverse consequences for plant biodiversity and wildlife, and transfer of herbicide tolerant gene to other plants, etc. Chinese Taipei would develop agricultural biotechnology through innovative R&D and under efficient management to ensure biosafety and biosecurity to meet the requirement of relevant laws and regulations.

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Vietnam Policies on Biotechnology and Biosafety Development and Application

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Biotechnology has the technical basis of the biological industry. The process of development of biotechnology is the process of converting the technical knowledge and industrial life into biology. Accordingly, industry is the biological process of mass production, large-scale biological products include living organisms (hundreds of millions of plant and animal), cell biomass of plants and animals and micro- organisms, the biological products, vaccines and other medicines.

Realizing the importance of the Biotechnology that is identified as an essential prerequisite for achievement of national goals and prioritized firstly for scientific research, various policies concerned have been made on the biotechnology development and application recently. Followings are some main ones:

- Directive No. 50-CT/TW of the Party Central Committee's Secretariat on March 4, 2005: Accelerating the biotechnology for the industrialization and modernization
- Decision No. 188/2005/QD-TTg of Primer Minister on July 22, 2005: Promulgating the Government's program of action for the implementation of Directive No. 50-CT/TW
- Decision No 11/2006/QĐ-TTg of Primer Minister on January 12, 2006: Key program on research and application of biotechnology in agriculture and rural development
- Decision No 14/2007/QĐ-TTg of Primer Minister on January 25, 2006: Key program on the development and application of biotechnology in industrial processing
- Decision No 97/2007/QĐ-TTg of Primer Minister on June 29, 2007: Key program on the development and application of biotechnology in fishery
- Decision No 14/2008/QĐ-TTg of Primer Minister of SR Vietnam on January 21, 2008: General program on the development and application of biotechnology in VN

Considering Biotech is one of four leading technological areas that play important roles in national industrialization and modernization, different scientific programs at the national level have been established and implemented successfully during the past decades.

- 1986-1990: Program of biology applied in agriculture (52D)
- 1991-1995: Biotechnology program (KC08)
- 1996-2000: Biotechnology program on sustainable development of agriculture-forestry-fisheries, environment protection and healthcare (KHCN02)
- 2001-2010: Program of biotechnology research and development (KC04)

Going along with the Biotechnology, The government of Vietnam has also paid great attention to the Bio-safety, considers it as a key issue to keep the development of national economy sustainable. Up to now, various legal documents concerning Bio-safety have been approved by the summit agencies of Vietnam, eg. National Assembly, Government, Ministries...

Bio-safety system is also clarified clearly in terms of functions and responsibilities of the institutions related that was presented in the Food safety Law approved by the National Assembly in June, 17, 2010

- Import GM food to be have the food safety certification or medical certification and meet all requirement of food including quality parameters, packaging, preservation and labeling;
- GM food should be label as GM food. Government will regulate labeling of GM food (what for food should be label, content of label) based on the economic – sociality situation;
- MARD is responsible for the management of GM food from production, processing, preservation, commercialization, import and export

The GM feed safety is also obviously regulated by the Minister of Agriculture and Rural Development of Vietnam, in which the GM product to be introduced must have following documents:

1. Application for GM Feed already certified as food safety in Vietnam

    a. Application form;

    b. Food safety certification.

2. Application for GM Feed already certified as food safety in 5 countries

a. Application form;

b. Risk assessment report;

c. Food/feed safety certifications of 5 countries and documents related to the risk assessment and management.

3. Application for GM Feed conducted the risk assessment

a. Application form;

b. Risk assessment report;

c. Documents to satisfy the risk assessment conducting in the laboratory;

d. Documents to satisfy the legal status of laboratory conducted the RA.

It is obvious that although good efforts have been made and remarkable results were achieved, following challenges and constraints of Biotechnology and Bio-safety must be accordingly solved:

- Lack of understanding, misunderstanding of bio-safety among scientists & media
- Lack of well-trained personnel & experience
- Insufficiency of monetary & enforcement systems
- Lack of facilities for risk analyze, risk assessment (trials)
- Inadequate institutional capacity

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Status of Biotechnology, Biosafety and Biosecurity in the Pacific Region

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Biotechnology has a potential to benefit economies and welfare of the people through innovation in agricultural, medical and environmental research. On the other hand, it raises biosafety and biosecurity issues that were not envisioned in the past. For the 22 Pacific countries including 8 dependent territories with a population of 13 million and covering vast and scattered areas, it is a challenge to adopt biotechnology and implement updated biosafety and biosecurity measures. This is especially so, considering most countries are small and not adequately equipped with the necessary capacity. However, the issues of biotechnology and biosafety are global in nature and the Pacific countries are not immune to these problems.

This presentation takes stock of the current status and development in the areas of biotechnology, biosafety and biosecurity in the Pacific Region. Most countries in the region do not have the capacity to perform research in biotechnology and are at a receiving end of this technology, mainly due to the lack of human talent, infrastructure and financial resources. Fourteen out of the 22 Pacific countries have ratified the Cartagena Protocol, and submitted drafts of National Biosafety Framework to CBD. However, local legislations that are required for its implementation have been slow to come by. As a result, there is no proper regulation concerning LMOs and thus posing continued biosecurity risks. Capacity building for biotechnology and biosafety is under progress in some Pacific countries. However, strict, efficient, and immediate implementation of Cartagena Protocol is necessary regardless of the varying levels of capacity development in the Pacific countries. Such actions would streamline commerce and encourage collaborative research with the rest of the world, and contribute to improved food security and welfare in the region.

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Current Status of Biotechnology Research and Development (R&D) in West Asia and North Africa (WANA) Region

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Many WANA countries have made good progress in biotechnology and biosafety. This is reflected by the increase in the number of functional biotechnology laboratories and research staff in most Association of Agricultural Research Institutions in the Near East and North Africa (AARINENA) member countries. Many countries have nucleus of basic infrastructure and trained personnel for tissue culture, molecular biology in plants, animals and biomedicine. Along the gradient of biotechnology tools, tissue culture and molecular markers are commonly used in WANA Region, while more upstream technologies (genomics, proteomics etc.) are restricted to a few institutes. Also, genetic engineering is increasingly finding wider applications in the region where some countries have capacities for producing GM crops (for example, Egypt, Iran, Morocco, Tunis, Turkey, Syria). But, transgenic plants produced in laboratories are still confined in growth chambers or greenhouses under containment conditions. On the other hand, AARINENA countries do not import, grow, adopt or export GMOs.

Most of the countries of the region have their primary biosafety legislations in place and are currently developing specific implementing regulations in line with the international obligations.

National and Regional Perspectives of the applications of biotechnologies concerning the biosecurity measures in AARINENA countries emphasize on the integrating the best outputs of plant sciences, understanding the societies' expectations and international regulations on handling GMOs, genes conferring

drought and salt tolerance to elite cultivars of agronomic importance, promoting the application of biotechnology as a tool for sustainable development, as well as to make use of all options for food security and to increase food production in a sustainable way, including genetic engineering. In brief, it can be highlighted that:

- Biotechnology applications in AARINENA countries are widely increasing to support solving constraints of agricultural production in the region, but with adequate investments.
- Biosafety regulations and NBFs have been developed or under way in most AARINENA countries, but, with difficulties in the implementation of the Cartagena Protocol because appropriate structures for evaluation of risk assessment are not available.
- Priority has been accorded for an enabling environment for investment in agricultural biotechnology in the region (policy and investment environment, strong collaboration between public and private sectors, target products, marketing etc.
- AARINENA countries need to make use of all options to increase food production in a sustainable way, including tissue culture, genetic engineering and GM crops.

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Status of Agricultural Biotechnology, Biosafety and Biosecurity in Africa

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There is growing confidence in the use of genetically engineered (GE) or genetically modified (GM) crops in Africa following 15 years of safe commercial use of GM crops globally. Various candidate GM crops are receiving attention in Africa by its own scientists. The efforts to build the capacity to deploy the biotechnology in agriculture are on-going albeit, slowly. African countries are gradually building the legal framework and the technological capacity to harness modern biotechnology for their agriculture.

A 2010 survey report by FARA on sub-Sahara Africa excluding South Africa revealed that Burkina Faso, Ghana, Kenya Nigeria, Uganda and International Centers had the largest number of institutions engaged in biotechnology research activities. The numerical strength of biotech staff (10-40) per country was relatively high for Ghana, Burkina Faso, Nigeria and Uganda. Molecular biology laboratories were the ones more commonly available followed by tissue culture, GM and fermentation laboratories while fungal and bacterial infections received the most attention.

Three African countries (Burkina Faso, Egypt and South Africa) are in commercial GM crop production and at least 14 have the legal framework to be able to conduct confined field trials on GM crops but only 6 are engaged in it. The absence of enabling GE laws was mostly as a result of lack of capacity for GE policy-making.

Six African countries at least operating at the confined field trial stage are receiving training under the Forum for Agriculture Research in Africa (FARA)'s project on strengthening capacity for safe biotechnology management in sub-Sahara Africa (SABIMA) in biotechnology stewardship and its application to GM crop development and use.

African countries can jump start the application of modern biotechnology through the use of existing legislation supporting research into science and technology.

Biosecurity as a component of general biosafety activities and the need to harmonize such activities across state agencies within the country and in the region is not practiced.

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Status of Agricultural Biotechnology, Biosafety and Biosecurity in Asia

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Asian region contributes to more than 50% of the world's population and it is expected to increase significantly in the next twenty years. For achieving the common goals of food security and poverty alleviation, countries of Asia have accorded high priority to agricultural biotechnology. Nearly a dozen countries have ongoing programs on biotechnology R&D comprising genetic modification (GM), chromosome number manipulation, biotechnology based diagnostics and vaccines, animal reproductive biotechnologies, micropropagation, in vitro hybridization, conservation of genetic resources, mutagenesis, fermentation, and biopesticides and biofertilizers. Micropropagation for production of high quality planting material has been adopted in several countries; in crops like potato, sugarcane, banana and oil palm micropropagation has been a commercial success. More than 50 crops and forestry trees are being targeted for genetic modification for diverse traits, most prominent among which are resistance to diseases and pests, and abiotic stress tolerance. Most of these researches are in laboratory or greenhouse phase while some are in advanced field trial phase. China, India, Philippines and Pakistan, which have released GM crops have in general experienced benefits through increased yields, fewer applications of pesticides and higher farmers' income. Molecular markers are being used to develop new varieties with desirable characteristics. Among the animal biotechnologies, application of assisted reproductive biotechnologies such as artificial insemination, oestrous synchronization and embryo transfer have had the most pronounced impact livestock productivity. Molecular based serological techniques using monoclonal antibodies and recombinant antigens as well as PCR-based methods are being used for diagnosis of diseases together with conventional and recombinant vaccines for controlling diseases.

With respect to adoption of biosafety systems, most countries are party to or have ratified the Cartagena Protocol on Biosafety of the UN Convention on

Biological Diversity. In several, biosafety regulatory systems in the form of framework, laws, regulations, rules and guidelines have been developed while in a few these are operational. Biosafety and biodiversity conservation concerns are being expressed strongly in several countries which has somewhat impeded commercialization of GM crops and products.

There is growing recognition of the threats to agricultural biosecurity in the region. Liberalization of global trade while opening new avenues for growth and diversification has also increased the risk of new diseases and pests. Highly virulent Ug99 race of wheat stem rust, Maize streak virus, Bromus secalinus (a noxious weed), Brontispa lonissima (coconut beetle) and Avian influenza are some of the biosecurity threats that could cause severe loss to agricultural economy of this region. Further, climate change has the potential to alter the habitat of known pests and even cause introduction of new pests. Biotechnological tool are being used for disease surveillance in China and Japan. Pest and disease resistant crops can be used for post-border biosecurity thereby reducing the pests' effects on agricultural systems. However, biotechnological tools to strengthen biosecurity through rapid and accurate detection of quarantine pests and diseases, and surveillance remain mostly underutilized.

Agricultural biotechnology in all countries, except a few, faces challenges of limited infrastructure, technical and regulatory capacity. Biosecurity is mostly managed on a sectoral basis through separate policy and legislative frameworks (e.g. for animal and plant life and health). Along with addressing infrastructural and capacity issues, there is need for a more harmonized and integrated approach to biosafety and biosecurity with competent authorities responsible for different sectors working together towards common goals. Further, cooperation at the regional level for harmonized approaches would greatly facilitate sharing the benefits of biotechnology while ensuring transboundary biosecurity.

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Contribution of Biotechnology to Stress-Tolerant Vegetable Crops

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To meet the increasing demand for food from a growing world population, agricultural output must increase by more than 50% by the year 2050. At the same time, changing precipitation patterns, shifting temperature zones, and emerging plant diseases are lowering yield or leading to crop failure. Sustaining, let alone augmenting, agricultural production under rapidly changing environmental conditions requires continuous delivery of new biotic and abiotic stress-tolerant crop varieties.

Biotechnology offers two avenues for developing stress-tolerant crops: marker-assisted breeding and genetic engineering. Marker-assisted breeding accelerates the introgression of tolerance traits from wild relatives or germplasm into cultivated varieties. Improved access to genomic resources including full genome sequences and high throughput marker systems, together with new tools such as genomic selection, extend its applicability to complex multigenic traits. Genetic engineering provides industrial agriculture with crops for more cost-effective production with less environmental impact. New developments such as genetically engineered drought-tolerant or disease-resistant crops have great potential to improve food security in developing countries.

This presentation will outline the contribution of biotechnology in the development of tomato plants resistant to Tomato yellow leaf curl virus (TYLCV), one of the most devastating emerging diseases of this crop. Viral evolution and new invasive whitefly biotypes dispersed TYLCV throughout the world, making tomato cultivation impossible in many regions. Resistance genes against TYLCV were identified in wild tomato and were successfully introduced into elite varieties. Marker-assisted breeding fostered host resistance through pyramiding several different resistance genes in one line, and largely facilitated early generation selection of resistant plants, resulting in the restoration of tomato production in TYLCV-affected areas.

The second approach to obtain TYLCV-resistant plants is based on transgenic expression of fragments of the TYLCV genome causing RNAi-mediated silencing of TYLCV genes upon infection. Testing of several different TYLCV gene fragments revealed that the C1 and C2 gene region of TYLCV is most promising to induce RNAi-mediated resistance against the virus. Multiple C1/C2 gene fragments derived from different viral strains can be expressed simultaneously in one plant to extend resistance to a broader range of viral strains.

A comparison of both methods showed that the genetic engineering approach consumed less time and resources than resistance gene introgression from wild relatives through breeding. However, under the current regulatory framework for genetically engineered crops, the cost and time advantage of the transgenic approach might be nullified or even reversed due to the requirements of the regulatory compliance before commercialization. International compliance of national biosafety regulations would facilitate the use of genetic engineering for crop improvement. Nonetheless, the quicker and more cost-effective genetic engineering approach for producing disease-resistant crops could provide crucial advantages, especially if timely delivery of stress-tolerant varieties becomes a more urgent priority.

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Development of Genetic engineering technology Aimed to produce crops tolerant to environmental stresses

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Agricultural damages caused by extreme weather have become a problem worldwide. For this reason, it has been strongly desired to develop crops tolerant to environmental stresses such as drought. We conducted research on the molecular mechanisms of environmental stress tolerance of plants using Arabidopsis and rice. It was found that stress-responsive transcription factors such as DREB, AREB, and NAC have important roles for stress response and tolerance in plants. We have shown that the over-expression of the stress-responsive transcription factors such as DREB can improve tolerance to a wide range of environmental stresses including drought and high salinity. Presently, international joint research is being conducted to introduce stress-tolerant genes to important crops, produce stress-tolerant lines, and examine stress-tolerance in fields. Stress-tolerant genes combined with stress-inducible promoters have been sent to IRRI, CIAT, CIMMYT, and Embrapa, Brazil to produce transgenic rice, wheat, and soybean lines tolerant to environmental stresses. By developing crops tolerant to environmental stresses through international collaboration, we aim to reduce agricultural damage and ensure stable yield in many parts of the world, especially in the developing regions.

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Biotechnology: An Imperative for Sustainable Food Production

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Advances in agricultural research and development over the past five decades resulted in the productivity gains including the development of improved cultivars resulting in increased yield in food crops. Recently, the momentum of productivity gains has slowed raising concerns in human kind's ability to meet its food security needs. The world population is expected to reach 9.1 billion in 2050, and FAO forecasts that a 70% increase in global food production would be required to feed this population. Thus, humanity faces the challenge of feeding a growing population with increasing demands in both quantity and quality of food. This is further heightened by the projected impact of climate change. Reports from studies in 16 developing countries suggest that, "heat waves in the Mediterranean showed a potential 2,700% increase". This places even more pressure on our natural resource with degradation of the resources on which agriculture depends threatening the food and nutritional security of the future generations.

In order to meet the food and fiber needs of this ever increasing population, far-reaching increases in agricultural output are required. As in the past, there is a need to explore novel opportunities for increasing the productivity of food crops, one of which is through the deployment of agro-biotechnology tools that would complement the conventional methods to address these challenges.

ICARDA holds more than 1,35,000 germplasm accessions of agriculturally important crops in its genebank, including large collections of landraces and wild relatives. These provide the genetic resources essential for achieving higher and stable gains in yields and quality. This coupled with rapid advances in sequencing technology have opened new possibilities for using genomic information in breeding, providing tools that permit far more rapid and comprehensive analysis of these resources and their potential for use in improving the productivity of food crops. A major example of such introgression is our work on the use of wild *Triticum* and *Aegilops* species, which has enlarged the genetic base of bread wheat and provided access to novel sources of

resistance to drought, rusts, *Septoria*, Russian wheat aphid, Sunn pest and Hessian fly, and the identification of promising lines in wheat for higher yields under optimum and drought conditions.

Molecular markers that are tightly linked to agronomically important traits have been identified in wheat (resistance to diseases and pests), durum wheat (grain quality, physiological responses to major abiotic stresses), barley (drought tolerance, resistance to diseases and pests, and grain quality traits), chickpea (drought tolerance, and resistance to ascochyta blight and fusarium wilt) and lentil (cold tolerance and resistance to *Fusarium* wilt, *Stemphylium* blight and rust). These developments have made it possible, using marker-assisted selection (MAS), to rapidly and precisely transfer the desirable genes between genotypes and to introgress the novel genes into elite germplasm from wild species without noticeable linkage drag. It also allows the development of strategies for gene deployment in elite breeding material. Further, genome-wide association studies in wheat and barley at ICARDA have facilitated mapping, greater understanding of the genetic bases, and gene mining of complex traits including yield, yield stability, drought adaptation and some of the underlying physiological traits and disease resistance. ICARDA has identified DArT markers with significant association to grain yield across diverse environments, while some other DArT markers were site-specific, offering further insights into the genetic bases of genotype x environment interactions in these crops. The DArT markers identified could be used to efficiently pyramid multiple loci associated with increased yield into locally adapted varieties through marker-assisted backcrossing or marker-assisted recurrent selection to develop improved germplasm.

Currently, more than 120 million ha of transgenic crops are grown worldwide, with more than half in the developing world. At ICARDA, transformation events in wheat, lentil and chickpea have been demonstrated successfully and established protocols are available for barley, which open a new vista in genetic improvement of these crops. Other important interventions used by ICARDA, that compliment conventional breeding include tissue culture techniques, such as doubled haploid production in barley and wheat; and the exploitation of *in vitro* selection and somaclonal variation, for example in the development of grass pea germplasm with lower ODAP-neurotoxin content. It is believed that integration of these approaches with appropriate farming systems would contribute to improved agricultural productivity that negates potential stagnation.

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Biosecurity in Asia-Pacific - Status and Future

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The importance of agricultural biosecurity in Asia-Pacific needs special attention in the WTO regime. The region which is a key player in global agriculture with more than half of global production and trade in processed and high-value food products, is facing serious threats with a number of transboundary pests taking a toll of food security and other economically important crops. Regional cooperation and coordination are critical in reducing the impact of trans-boundary pests and diseases. Various organizations are committed to play a major role in strengthening the regional plant protection system. FAO's Emergency Prevention System for Transboundary Animal and Plant Pests and Diseases (EMPRES) provides support to Governments in all of these areas. The International Plant Protection Convention (IPPC) with Secretariat at FAO has a strong presence in each of the FAO regions, and the Regional Office for Asia and the Pacific provides the Secretariat for the Asia and Pacific Plant Protection Commission (APPPC) which has 24 countries from Asia-Pacific as members. It works with NPPOs to review the state of plant protection in the region and is actively participating in development of international and regional standards for phytosanitary measures. It also coordinates a regional response to plant protection issues including transboundary pests. The Commission is active in capacity building in the implementation of international and regional phytosanitary standards and in promoting information exchange among its members and other countries in the region. This is leading towards an increasing attention both by public sector and the international donor agencies in developing the SPS action plans for augmenting capacity and expertise in excluding or managing the transboundary pests. The role of APPPC and contracting parties further increases by envisaging a greater role in managing the transboundary movement of pests in the region. It needs to ensure proper compliance to International and Regional Standards of Phytosanitary Measures with special reference to pest risk analysis, pest surveillance and pest reporting.

It is imperative to have regional cooperation and coordination, information sharing about new diseases and pests in the area and the successful management strategy to reduce the spread and adverse impact of trans-boundary pests and diseases. The contracting parties of APPPC also need to be proactive in having an early warning mechanism, in strengthening of domestic quarantine programmes for pests with restricted distribution, in developing Regional and National Pest Diagnostic Network and in promoting interdisciplinary research and development for ensuring biosecurity and conserving biodiversity. Presently APPPC is proactive in facilitating to prevent the introduction of dangerous pests not know to occur in the region like South American leaf blight *of rubber (Microcyclus ulei),* South American fruit fly *(Anastrepha fraterculus),* Mexican cotton boll weevil (*Anthonomus grandis),* Ergot of maize (*Claviceps gigantean), Rice yellow mottle virus* and *Maize streak virus*. Among emerging problems the Hispine beetle *Brontispa longissima*, the coconut mite, papaya mealybug, *Paracoccus marginatus* and cassava mealy bug *Phenacoccus manihoti* are fast spreading emerging pests for which APPPC is working to prevent and regulate its further spread. The challenges in the region stem from the fact that the member countries experience different categories of development which results in different organizational arrangements to execute the various plant protection functions. This makes the system insufficient to enable legislation and resources allocated to surveillance and monitoring, border control and inspections, expertise in risk assessment, diagnostic tools for early detections, expertise in diagnosis (taxonomy), data collection and access to information, tools for rapid response to entry, establishment and spread and control measures at the source of the produce. It has a direct impact as the non symmetrical compliance to implementation of international standards within the region. Looking to the need of a fortified biosecurity system, there has to be focus on certification and good agricultural practices backed up by harmonised legislative and quarantine and set up.

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