Virtual Regional Workshop on

INVESTMENT IN MODERN AGRICULTURAL BIOTECHNOLOGY AND ITS SOCIO-ECONOMIC IMPACT ON LIVELIHOODS OF FARMERS IN ASIA-PACIFIC

August 2-3, 2021 *via* zoom

PROCEEDINGS AND RECOMMENDATIONS

ASIA-PACIFIC ASSOCIATION OF AGRICULTURAL RESEARCH INSTITUTIONS

Virtual Regional Workshop on

Investment in Modern Agricultural Biotechnology and its Socio-Economic Impact on Livelihoods of Farmers in Asia-Pacific

August 2-3, 2021 *via* zoom

PROCEEDINGS AND RECOMMENDATIONS

Asia-Pacific Association of Agricultural Research Institutions

Citation: Rishi K. Tyagi, Alissa Carol M. Ibarra, Abigail May O. Retuta, Allan B. Siano, Reynaldo V. Ebora and Ravi K. Khetarpal (2022). Regional Workshop on Investment in Modern Agricultural Biotechnology and its Socio-Economic Impact on Livelihoods of Farmers in Asia-Pacific – Proceedings and Recommendations. Asia-Pacific Association for Agricultural Research Institutions (APAARI), Bangkok, Thailand, xv+53 p.

Published by:
Asia-Pacific Association of Agricultural Research Institutions (APAARI)
182 Larn Luang Road, Klong Mahanak Sub-District, Pomprab Sattrupai
Bangkok 10100, Thailand

ISBN: 978-81-85992-50-1

For copies, please contact:
The Executive Secretary
Asia-Pacific Association of Agricultural Research Institutions (APAARI)
182 Larn Luang Road, Klong Mahanak Sub-District, Pomprab Sattrupai
Bangkok 10100, Thailand
E-mail: apaari@apaari.org

Website: www.apaari.org; www.apcoab.org

Printed in November 2022

Published at Angkor Publishers (P) Ltd.

Contents

Foreword

The role of application of agricultural biotechnology in facing the challenges of food security and nutrition and so also the environmental protection has been highlighted time and again by the Food and Agriculture Organization of United Nations and other global agencies. It has been thus realized that we need to give increased attention to biotechnology knowledge and innovation and make it accessible and applicable to smallholder farmers. In case of agricultural biotechnology though attempts to commercialize various technological innovations have been done for many years, there had been unexpected difficulties as there had been voices, often unfounded, raised on these technologies per se by many sectors of the societies for its adoption. This was unfortunately more pronounced with the advent of transgenic crops in the market. In general, there had been issues of lack local scientific talent, public perception, lack of entrepreneurial skills among the academics, financial assistance, and lack of political will of governments for adoption of biotechnological research and innovation outputs.

It was thus considered imperative to gain more insight on the investment in agricultural biotechnology R&D by public and private sectors and its impact in the region and identify potential areas for investment/co-investment in the field. Thus, a *Regional Workshop on Investment in Modern Agricultural Biotechnology and its Socio-Economic Impact on Livelihoods of Farmers in Asia-Pacific* was organised by The Asia-Pacific Association of Agricultural Research Institutions (APAARI) in a virtual mode, under its programme Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB). It was heartening to see a larger number of participants from diverse sectors belonging to 33 countries in the two-day virtual workshop. Some very useful recommendations have emerged emphasizing notably the importance of research prioritization, capacity building, knowledge management, education and communications, awareness generation and more specifically on revisiting the risk assessment guidelines and policy. It was also emphasized that a Global/Regional Consortium of private sectors with a more innovative funding system that can trigger regular investment in biotechnology research to fund the public sector biotechnology research in partnership mode is needed to help researchers; investment in modern agricultural biotechnology and its socio-economic impact on livelihoods of farmers in Asia-Pacific. Finally, the importance of enabling policy environment with specific areas that may be addressed was highlighted. It was thus concluded that for promoting the adoption of biotechnological innovations, the issues need to be tackled strategically by countries in the region which are at different stages of development.

On behalf of APAARI and on my personal behalf, I express my deep sense of gratitude to Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), Philippines; Council of Agricultural (COA), Taiwan; CropLife Asia (CLA), Singapore; and Federation of Seed Industry of India (FSII), India for their active collaboration in organizing the workshop. Finally, I thank Dr Rishi Tyagi (APCoAB Coordinator) for his hard work and excellent networking with members and other stakeholders to organize and make the workshop a great success. My sincere thanks also to all the co-authors of the proceedings, namely, Alissa Carol M. Ibarra, Abigail May O. Retuta, Allan B. Siano and Reynaldo V. Ebora for the meticulous task done.

I must add here that APAARI remains committed to its members in the region to facilitate further uptake of the recommendations through collaborative efforts.

Ravi K. Khetarpal
Executive Secretary, APAARI, Thailand

Acknowledgements

On behalf of Asia-Pacific Association of Agricultural Research Institution (APAARI), and its programme Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB) and my own behalf, I would like to thank Dr Ravi Khetarpal, Executive Secretary, APAARI, Thailand and Dr Reynaldo V. Ebora, Executive Director, Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD), Philippines, for delivering their opening remarks to set the tone of the deliberations of the workshop and their unstinted administrative support in organization of the workshop as and when needed. Thanks are due to Mr Vincent Lin, Director General, Council of Agriculture (COA), Taiwan, for sparing his valuable time and delivering his valuable remarks in the opening session.

I thank immensely to the Co-Organizers, DOST-PCAARRD, Philippines; COA, Taiwan; CropLife Asia (CLA), Singapore; and Federation of Seed Industry of India (FSII), India; for whole-hearted support in organization of the Virtual Regional Workshop on Investment in Modern Agricultural Biotechnology and its Socio-economic Impact on Livelihoods of Farmers in Asia-Pacific, which was held on August 2-3, 2021.

While organizational support was important, strategic and technical inputs of individuals were also very critical. Special thanks are placed on record to Ms Alissa Carol M. Ibarra, Science Research Specialist, Crops Research Division (CRD), DOST-PCAARRD, Philippines; Ms Abigail May O. Retuta, Science Research Specialist, CRD, DOST-PCAARRD, Philippines; Dr Sonny Tababa, Director, CLA, Singapore; and Dr Shivendra Bajaj, Executive Director, Federation of Seed Industry of India (FSII), India, for their whole-hearted cooperation and support to develop the technical programme, identifying the experts and mobilizing the participation across the Asia-Pacific region and beyond. The contribution of Dr Allan Siano, Officer-in-Charge, CRD, DOST-PCAARRD, Philippines, is also gratefully acknowledged for his support whenever was needed.

My sincere thanks to all the co-chairs to conduct the session efficiently. Special thanks to the rapporteurs, namely, Mr Gil Marlov C. Alacantra, Mr Ryan Lawrence A. Polinag, Ms Jean Claudine P. Guelos, Ms Farah Y. Sevilla and Mr Ian Bernard M. Ines – all from DOST-PCAARRD, Philippines, who recorded the proceedings during the sessions meticulously. Thanks to all the speakers for making the presentations and panelists for presenting their views on the defined topics during panel discussion and participants to engage in lively discussion during the workshop.

I am thankful to all my colleagues in APAARI, especially Mr Jack Lin, Technical Associate, APCoAB, for his intense engagement and logistic support extended by him in organizing the workshop.

Sincere thanks are accorded to all the co-editors, especially Ms Alissa Carol M. Ibarra, Science Research Specialist, CRD, DOST-PCAARRD, Philippines, and Ms Abigail May O. Retuta, Science Research Specialist, CRD, DOST-PCAARRD, Philippines, and Mr Angelito T. Carpio, Executive Officer, Philippine Agriculture and Resource Research Foundation Inc. (PARRFI), Philippines, for their intensive involvement in collation and compilation of the proceedings of the workshop.

I hope that the recommendations presented in this document will draw attention of the policymakers, administrators, researchers, donors and other stakeholders towards enhancing the investment in agricultural biotechnology to harness its maximum potential for the benefits of the farmers in the Asia-Pacific region.

Rishi K. Tyagi
Coordinator, APCoAB, APAARI, Thailand

Organizers and Collaborators

Asia-Pacific Association of Agricultural Research Institutions (APAARI)

http://www.apaari.org

The APAARI, with its headquarters in Bangkok, Thailand, is a unique voluntary, membership-based, self-mandated, apolitical, and multi-stakeholder regional organization in the Asia-Pacific region. It promotes and strengthens agriculture and agri-food research and innovation systems through partnerships and collaboration, capacity development, and advocacy for sustainable agricultural development in the region. Since its establishment in 1990, APAARI has significantly contributed towards addressing agricultural research needs and enhancing food and nutritional security in the region. The close links, networks, partnerships, and collaboration with stakeholders that APAARI has developed over the years, as well as its goodwill, authority and focus on results, make the Association an important organization in the region. The ultimate aim of APAARI is to help realize sustainable development goals in Asia and the Pacific.

Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB)

http://www.apcoab.org

The APCoAB, established in 2003 under the umbrella of APAARI, has the mission to harness the benefits of agricultural biotechnology and bioresources for human and animal welfare through the application of the latest scientific technologies while safeguarding the environment for the advancement of society in the Asia-Pacific region. APCoAB's main objectives are to (i) 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; (ii) 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 access and benefit-sharing to address various concerns relating to the adoption of agricultural biotechnology and sustainable use of bioresources; and (iii) facilitate human resource development for meaningful application of agricultural biotechnology and use of bioresources to enhance sustainable agricultural productivity, as well as product quality, for the welfare of both farmers and consumers.

Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD)

ISO 9001:2015

http://www.pcaarrd.dost.gov.ph/

The PCAARRD is one of the sectoral councils under the Department of Science and Technology (DOST) formed on June 22, 2011. The Council formulates policies, plans, and programmes for science and technology-based R&D in the different sectors under its concern. It coordinates, evaluates, and monitors the national R&D efforts in the agriculture, aquatic, and natural resources (AANR) sector. It also allocates government and external funds for R&D and generates resources to support its programme. As the apex Council of the AANR sector, PCAARRD is engaged in active partnerships with international, regional, and national organizations and funding institutions for joint R&D, human resource development and training, technical assistance, and exchange of scientists, information, and technologies. The Council is implementing its programme primarily through its Research and Development and Extension Consortia which are located all over the country. It also supports the National Agriculture, Aquatic and Natural Resources Research and Development Network (NAARRDN) composed of national multi- and single-commodity and regional R&D centers, cooperating stations, and specialized agencies. Being an ISO 9001:2015-certified agency for its quality management system, PCAARRD is committed to achieving sustained dynamic leadership in science and technology (S&T) innovation in the AANR sectors by providing strategic leadership in promoting S&T as a platform for AANR products innovation and environmental resiliency. Guided by its core values of relevance, excellence, and cooperation, PCAARRD will remain steadfast in catalyzing the Philippine AANR sector toward self-sufficiency and global competitiveness.

Council of Agriculture (COA)

http://www.tari.gov.tw/english

The COA, Taiwan, is the competent authority on agricultural, forestry, fishery, animal husbandry, and food affairs in Taiwan. Its responsibilities include guiding and supervising provincial and municipal offices in these areas. Under the council, there are Department of Planning, Department of Animal Industry, Department of Farmers' Services, Department of International Affairs, Department of Science and Technology, Department of Irrigation and Engineering, Secretariat, Personnel Office, Accounting Office, Civil Service Ethics Office, Legal Affairs Committee, Petitions and Appeals Committee and Information Management Center respectively in-charge of related affairs.

CropLife Asia (CLA)

CropLife ASIA

http://www.croplifeasia.org/

CropLife Asia, based in Singapore, is a non-profit organization dedicated to promoting plant science. Being part of the global federation, CropLife International advocates crop protection and plant biotechnology to enhance sustainable farming and benefit farmers, governments, consumers, and the environment. Sustainable agriculture means employing a wide range of solutions that incorporate nature and technology. Mission of CropLife Asia is to help farmers grow sufficient amounts of food for a growing population through access to innovative technologies. This means (a) growing more food for more people, on less land with greater efficiency to obtain a safe, secure food supply; (b) practicing crop protection, biotechnology, and seeds stewardship for sustainable and safe farming and production while minimizing environmental impact; and (c) protecting intellectual property to foster continuous innovation and its effective deployment for food, animal feed, fiber, and renewable energy.

Federation of Seed Industry of India (FSII)

https://fsii.in/

The FSII is a 40-member led association of the R&D-based plant science industry, engaged in the production of high-performance quality seeds for food, feed, and fiber in the country. Member companies are engaged in research-based breeding applications and seed technologies, enabling farmers to adopt technology-driven farming solutions to improve agricultural productivity sustainably, minimizing pre- and post-harvest losses. FSII is affiliated with international associations including International Seed Federation (ISF) and The Asia and Pacific Seed Association (APSA). Its vision is to increase focus and investment in seed research undertaken by the member companies and promote their innovative products for improving farm productivity. Through seed research, seed commercialization, and working closely with Indian farmers, FSII members aim to contribute towards realizing the vision of doubling the farmers' income.

Acronyms and Abbreviations

AANR	:	Agriculture, Aquatic, and Natural Resources
ABSP	:	Agriculture Biotechnology Support Project
AcE	:	Accelerating Entrepreneurs
ACIAR	:	Australian Centre for International Agricultural Research
ADB	:	Asian Development Bank
AFMA	:	Agriculture and Fisheries Modernization Act
AIIP	:	Agri-Innovation Immersion Programme
AIR	:	Academic Innovation Research
APAARI	:	Asia-Pacific Association of Agricultural Research Institutions
APCoAB	:	Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources
APSA	:	Asia and Pacific Seed Association
ASCA	:	Asian Short Courses on Agri Biotechnology and Biosafety
ASF	:	Australian Seed Federation
ASTI	:	Agricultural Science and Technology Indicators
AUSAID	:	Australian Agency for International Development
B	:	Billion
BARI	:	Bangladesh Agricultural Research Institute
BADC	:	Bangladesh Agricultural Development Corporation
BCP	:	Biotechnology Coalition of the Philippines
BFSB	:	Brinjal Fruit and Shoot Borer
BIG	:	Biotechnology Ignition Grant
BIPP	:	Biotechnology Industry Partnership Programme
BIRAC	:	Biotechnology Industry Research Assistance Council
Bt	:	*Bacillus thuringiensis*
CGIAR/CG	:	Consultative Group for International Agricultural Research
CLA	:	CropLife Asia
CLI	:	CropLife International
COA	:	Council of Agriculture
COVID	:	Coronavirus Disease
CPB	:	Cartagena Protocol on Biosafety
CPD	:	Crop Protection Department
CRD	:	Crop Research Division
CRISPR	:	Clustered Regularly Interspaced Short Palindromic Repeats
CRS	:	Contract Research Scheme
DAE	:	Department of Agricultural Extension
DNA	:	Deoxyribonucleic Acid
DOST	:	Department of Science and Technology
E-YUVA	:	Empowering Youth for Understanding Value-Added Innovative Translational Research
EIQ	:	Environment Impact Quotient

EU	:	European Union
FAO	:	Food and Agriculture Organization
FIRST HUB	:	Facilitation of Innovation and Regulation for Start-Ups and Innovators
FSII	:	Federation of Seed Industry of India
FtFBP	:	Feed the Future Biotechnology Partnership
GAB	:	Genomics-Assisted Breeding
GABA	:	Gamma-Aminobutyric Acid
GDP	:	Gross Domestic Product
GE	:	Genome Editing
GEAC	:	Genetic Engineering Approval Committee
GM	:	Genetically Modified
GMO	:	Genetically Modified Organisms
Ha	:	Hectare
HDL	:	High-Density Lipoproteins
HGP	:	Human Genome Project
HT	:	Herbicide Tolerance
IARI	:	Indian Agricultural Research Institute
ICRISAT	:	International Crops Research Institute for the Semi-Arid Tropics
ICU	:	International Christian University
IEC	:	Information, Education and Communication
INR	:	Indian Rupee; ₹
IP	:	Intellectual Property
IPR	:	Intellectual Property Right
IR	:	Insect Resistance
IRRI	:	International Rice Research Institute
ISAAA	:	International Service for the Acquisition of Agri-biotech Applications
ISF	:	International Seed Federation
ISO	:	International Organization for Standardization
KM	:	Knowledge Management
LDL	:	Low-Density Lipoproteins
LEAP	:	Launching Entrepreneurial Driven Affordable Products
LMO	:	Living Modified Organisms
M	:	Million
MABIC	:	Malaysian Biotechnology Information Centre
MARDI	:	Malaysian Agricultural Research and Development Institute
MARD	:	Ministry of Agriculture and Rural Development
MT	:	Metric Ton
NAARRDN	:	National Agriculture, Aquatic and Natural Resources Research and Development Network
NARS	:	National Agricultural Research System
NBT	:	New Breeding Technique
NGO	:	Non-Governmental Organization
NUQ	:	National University of Quilmes
OPERA	:	Open Innovation Platform with Enterprises, Research Institute, and Academia
PACE	:	Promoting Academic Research Conversion to Enterprise
PATH	:	Patenting and Technology Transfer for Harnessing Innovations

PCAARRD	:	Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
PCP	:	Product Commercialization Program
PhilRice	:	Philippine Rice Research Institute
PHP	:	Philippine Peso
ppm	:	parts per million
PPP	:	Public-Private Partnership
R&D	:	Research and Development
rDNA	:	Recombinant DNA
RIS	:	Research and Information System
ROI	:	Return on Investment
Rs	:	Rupees; ₹
S&T	:	Science and Technology
SABC	:	South Asia Biotechnology Centre
SAEIP	:	South Asia Eggplant Improvement Program
SBIRI	:	Small Business Innovation Research Initiative
SDG	:	Sustainable Development Goals
SDN	:	Site Directed Nucleases
SEED	:	Sustainable Entrepreneurship Enterprise Development
SIP	:	Strategic Innovation Promotion Program
SME	:	Small and Mid-Size Enterprises
SPARSH	:	Social Innovation programme for Products: Affordable & Relevant to Societal Health
STRIVE	:	Society Towards Reinforcing Inherent Viability for Enrichment
t	:	ton
TRL	:	Technology Readiness Level
UK	:	United Kingdom
US/USA	:	United States of America
USAID	:	United States Agency for International Development
USD	:	United States Dollar
UT	:	University of Tokyo
VSTA	:	Vietnam Seed Trade Association

Executive Summary

Agricultural biotechnology offers innovative technologies and applications in many key aspects of agriculture and environmental protection. While supporting sustainability, agricultural biotechnology provides technically and commercially viable solutions to mitigate the challenges of food and nutritional security to the burgeoning population which is expected to increase to 8.6 billion by 2030 (about 60% in the Asia-Pacific region), thereby, contributing significantly towards achieving the 2030 Sustainable Development Goals (SDGs).

Agriculture plays a significant role in the economy for the countries along the Asia-Pacific region but there were challenges in attaining sustainable production of agricultural products such as climate change, increasing population, health and environment-related issues, among others. Agricultural biotechnology is a modern solution that has been proven to: (a) improve farm productivity, (b) enhance capacities, (c) generate revenues and employment and, (d) promote nutrition security and environmental sustainability. Despite the benefits of this modern technology, there are still challenges that need further discussions and deliberations especially in terms of investment from both the public and private sectors for the continued support to agricultural biotechnology research and development.

The Asia-Pacific Association of Agricultural Research Institutions (APAARI), under its programme Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB), organized a Virtual Regional Workshop on Investment in Modern Agricultural Biotechnology and its Socio-Economic Impact on Livelihoods of Farmers in Asia-Pacific, in collaboration with the Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (PCAARRD), Philippines; Council of Agricultural (COA), Taiwan; CropLife Asia (CLA), Singapore; and Federation of Seed Industry of India (FSII), India, with the following expected outcomes:

- Provide a platform to have an overview of investment in agricultural biotechnology R&D by public and private sectors and its impact in the region and;
- Identify potential areas for investment/co-investment in modern agricultural biotechnology and ways forward on innovative funding mechanisms by public and private sectors.

The two-day virtual workshop was attended by a total of 424 participants belonging to 33 countries from Asia-Pacific region and beyond including researchers, representatives of various National Agricultural Research System (NARS) organizations (public sector) and private sector, policymakers, regulatory personnel, Consultative Group of International Agriculture Research (CGIAR, in short CG) Centers, advanced research institutes, funding/donor agencies, non-governmental organizations (NGOs) and Farmers Organizations as well as the recognized experts from 15 countries who made presentations and participated in the panel discussion.

Overall major recommendations that emerged out to strengthen the efforts towards agricultural biotechnology and investments therein within the region are as follows:

Prioritization of Areas for Investment

1. **Research** areas should be prioritized/identified by developing an agricultural biotechnology-focused road map for crop production at national/regional level as per their needs, capacities and infrastructure to attract the donor for investment;

2. **Knowledge Management and Communication** is an important area where more investment is needed to promote agri-biotechnology by addressing political and social concerns, and long-term benefits through enhanced information, education and communication (IEC);

3. Investment in **public awareness** is equally important to demystify the pre-conceived myths and explain various concepts and advantages of the biotech products using all media platform and clarity to avoid any mis-trust or mis-information and negative public perception with scientific evidence-based information before any harm is done to either producers or consumers;

4. Revisit and refine the **risk assessment guidelines** at national level considering the biosafety research conducted at regional/global level to save resources by avoiding repetition to conduct the same biosafety trials (same crop/trait) in several countries to get same results;

5. Investment is required for **capacity building** (technical and functional capacities) of scientists, prospective researchers, policymakers, and young biotech entrepreneurs to adopt more strategic processes and policy intervention to navigate complexities, learning and collaborations/partnerships;

Innovative Partnerships for Enhanced Investment

6. **Public-private partnership** (PPP) is one way to ensure investments in modern agricultural biotechnology. Through science communication, there is a need to create and nurture effective public-private and **private-private partnerships** to establish scientific consortia for fostering R&D activities at the national and regional level;

7. To develop synergies and **co-investment** by the organizations in modern agri-biotechnology, collaborations among local and international scientists and institutions (South-South and North-South) need to be promoted by creating enabling policy and research environment and empower the research community;

8. **Multi-stakeholder** initiatives through the partnership of equals with the certainty of the collaboration and commitment for investment by each party (public and private both) towards the completion of projects and adoption of the products should be maximized;

9. Both parties must commit to provide clarity in **IP sharing, funding, exchange of infrastructure resources** (public sector to provide field infrastructure, private sector to provide laboratory resources), ownership of the regulatory data, stewardship commitment, and freedom to use the technology in their programmes;

10. There is a need to develop **Integrative Project** through collaborations where use of biotechnology and issues of biosafety including scoping development, knowledge management and communication, impact on smallholder farmers and national economy are consolidated to avoid problems later specifically for adoption of the biotech products;

11. A **Global/Regional Consortium** of private sectors with a more innovative funding system that can trigger regular investment in biotechnology research to fund the public sector biotechnology research in partnership mode is needed to help researchers;

Enabling Policy Development

12. To ensure continuous economic benefits from agri-biotechnology, policies should meet the **"Gold Standard"** - predictable, transparent, and efficient; and

13. It is important to: (i) develop clearly streamlined science-based and consistent **Regulatory Policies** for risk assessment and long-term investment in biotechnology at national/regional level; (ii) share and mutually recognize the biosafety assessment data; (iii) promote regulatory harmonization across the region to avoid delay due to lengthy and costly trials, and; (iv) maximize the utilization of crops for harnessing the benefits of new breeding methods in order to enhance the trade between the countries in the region.

Background and Objectives

Agricultural biotechnologies are a diverse collection of appropriate technologies, ranging from low- to very high-level systems, applications, tools, or techniques. The development of climate change resilient and productive crops is necessary if we are to meet the challenge of feeding the growing world's population. We must be able to increase food production despite the projected decrease in arable land and unpredictable environmental conditions. Technological and conceptual advances in genomics have the potential to transform plant breeding, help to overcome the challenges of climate change, and initiate the next plant breeding revolution. Integration of genomic and phenotypic data provides an opportunity to identify new agronomically relevant genes and characterize their functions. This knowledge has direct practical implications and can be translated to crop plant improvement using genome editing[1,2,3].

Over the past two decades, as many as 10 genetically modified (GM) crops (soybeans, maize, cotton, alfalfa, canola, sugar beets, potatoes, papaya, squash, and apples), are being grown in 29 countries globally, some are being grown in Asia-Pacific region also (Australia, Bangladesh, China, India, Indonesia, Myanmar, Pakistan, Philippines, Vietnam). Genetically modified organisms (GMOs) have a deliberate controversial connotation due to fierce propaganda by antagonists of science and technologies. However, the fact remains that GM crops have been grown successfully on a total of 190.4 Million (M) hectares (ha) in 29 countries in 2019, contributing significantly to food security, sustainability, climate change mitigation, and uplifting the lives of up to 17 M farmers and their families worldwide. Double-digit growth rates in biotech crop areas were recorded in developing countries, particularly in Vietnam, the Philippines, and Colombia[4]. GM technology has had a significant positive impact on farm income derived from a combination of enhanced productivity and efficiency gains. In 2018, the direct global farm income benefit from GM crops was $18.95 Billion (B). This is equivalent to having added 5.8% to the value of global production of the four main crops of soybeans, maize, canola, and cotton. Since 1996, farm incomes have increased by $225 B[5].

Similarly, genome editing (GE) is gaining importance as one of the new plant breeding techniques (NBTs), since it provides opportunities to develop improved crops with high precision and speed. Several countries have viewed it positively and realized the potential of NBTs. A large number of genome-edited crops are on the verge of being placed on the market (few crops are already in market in Asia also) and their agricultural and food products will, thus, be internationally traded soon. National regulations, however, diverge regarding the classification of genome-edited crops. Most applications of genome editing entering the market in the near future selectively mutate or modify a few base pairs without adding foreign DNA to the genome (SDN-1). Market-oriented research has taken place in 99 different applications with 28 different plant species[6]. Most applications have been carried out in rice, followed by tomato, maize, potato, wheat, soybean, and rapeseed[7].

---

[1] *https://www.nature.com/articles/s41588-019-0401-3*
[2] *https://www.cell.com/action/showPdf?pii=S1360-1385%2821%2900090-X*
[3] *https://www.frontiersin.org/articles/10.3389/fpls.2020.00922/full*
[4] *https://www.isaaa.org/resources/publications/briefs/55/default.asp*
[5] *https://pgeconomics.co.uk/pdf/globalimpactfinalreportJuly2020.pdf*
[6] *https://www.econstor.eu/bitstream/10419/222972/1/1726752283.pdf*
[7] *https://environmentalevidencejournal.biomedcentral.com/articles/10.1186/s13750-019-0171-5*

Concomitant to the above-mentioned positive developments, there has been an expansion of investment portfolio to adopt the existing and new biotechnologies and innovations but despite the proven socio-economic benefits of these technologies, much more investment is need of the hour to promote agricultural biotechnology, which is still viewed as one of the major constraints. A committed research funding is required to address the risk analyses on future biotechnology products. In the changed new era, be it low-tech or high-tech biotechnology, political, economic, and business considerations (particularly return on investment) are playing an important role in taking the decisions for future investments. Although, Asia-Pacific region has a few countries who can make large investments over a long period, but fact remains that many countries are resource-poor in the region. Keeping the entire region in view, regional cooperation is imperative to attract investors from private sectors while ensuring the commitment of adequate availability of funds from the public sector. It also includes the pooling of resources to not only generate and adopt the innovations created through biotechnology but to develop the research and training institutions in form of the 'Centres of Excellence' to conduct research and develop the capacities in various areas of rapidly evolving agricultural biotechnology. This will help to harness the maximum potential of biotechnology for the farming community in different farming systems. In fact, both funding and regulations are the foundation for progress in biotechnology to realize maximum impacts on livelihoods of smallholder farmers in the region.

Public-Private partnership is considered very vital for an upward trajectory and is being advocated all over the world for successful transformation to innovation and technology-based new economy and farming sector. The public sector has been successful in creating trained human resources for GM research while the private sector has a focused approach to develop and commercialize GM crops with desired traits. Therefore, public sector funding in agricultural biotechnology is essential while the role of investment by the private sector is also equally important. The private sector needs to act as an active partner for publicly supported training and research programmes in agricultural biotechnology through direct grants and contracts to organizations, cooperative agreements with laboratories at the regional level, and education and communication strategies to create awareness to the general public about the impacts of agricultural biotechnology.

In the changing scenario and realization of the evidence-based potential of agricultural biotechnology research and innovation to contribute to the Sustainable Development Goals (SDGs), the Regional Workshop was organized with the following objectives:

1. Assess the investment in agricultural biotechnology and its impacts on livelihoods of farmers in the Asia-Pacific region;
2. Scope innovative ways of enhancing the investment in important areas of agricultural biotechnology in the Asia-Pacific region and;
3. Enable government policies to attract investors from the private sector for R&D and to promote agricultural biotechnologies in the region.

Following expected outcomes of the workshop were envisaged to:

- Provide a platform to have an overview of investment in agricultural biotechnology R&D by public and private sectors and its impact in the region and;
- Identify potential areas for investment/co-investment in modern agricultural biotechnology and ways forward on innovative funding mechanisms by public and private sectors.

Opening Session

The **Virtual Regional Workshop on Investment in Modern Agricultural Biotechnology and its Socio-economic Impact on Livelihoods of Farmers in Asia-Pacific** commenced with a warm welcome extended to all participants by **Dr Rishi K. Tyagi,** Coordinator, Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB) from Asia-Pacific Association of Agricultural Research Institutions (APAARI), Thailand. He also provided a brief set of ground rules for the smooth conduct of the virtual workshop prior to introducing the following executives who delivered their opening messages.

Dr Ravi Khetarpal, Executive Secretary, APAARI, Thailand, delivered welcome message to all the participants and set the tone of the workshop. He emphasized the three keywords of the workshop – biotechnology, impact, and farmers – which will be deliberated during the two-day workshop. For the information of all the participants, he provided a brief background of APAARI which is a membership-based, multi-stakeholder organization that aims to strengthen the agriculture research and innovation system in Asia-Pacific for sustainable agricultural development. APAARI has more than 80 members from countries in the Asia-Pacific region, national and international agricultural research organizations, universities, and some other higher educational institutions. APAARI works in accordance with a clear strategic plan with four thematic areas such as natural resource management and bioresources including biotechnology, risk mitigation, policy advocacy, and inclusive development. This workshop is being organized under the programme of APCoAB of APAARI which is one of the very important programmes generously funded by the Council of Agriculture (COA), Taiwan and Australian Centre for International Agricultural Research (ACIAR), Australia.

Agricultural biotechnology has come a long way covering areas such as tissue culture, genetic modification, and gene editing. Now, it is very evident how it holds promises for increasing agricultural production. In this workshop, the topics will focus mainly on the socio-economic impact on the livelihood of farmers in the Asia-Pacific region specifically the developmental outcomes. However, looking at the SDGs, the Asia-Pacific scenario is quite grim. The region has only reached half the mark of its target since the SDGs came into existence in 2017. With the onset of the COVID-19 over the last one and a half years, the performance of the region continues to decline as per the report of the United Nations Economic and Social Commission of Asia-Pacific. The COVID-19 has dominated the investment, attention, and all the researches everywhere, but the agricultural situation and investment need very special attention as well.

Dr Khetarpal recalled the organizations which played a very important role in bringing in a clear knowledge on the impact of biotechnology on socio-economic considerations for farmers and their livelihood. These organizations are: Asian Development Bank (ADB), Australian Agency for International Development (AUSAID), and ACIAR. In 2000, these agencies worked together to conduct a clear study on the impact of agricultural biotechnology on society, farmers, and policy issues. These agencies examined the risk and benefit of biotechnology, identified measures to minimize several impacts, explored the use of biotechnology to reduce poverty and achieve food security, and developed policies and strategies for ADB to support biotechnology in developing countries in Asia. This study has been a landmark that set the stage for this workshop, and later on, opened lots of studies from FAO and other international agencies. Among the solid recommendations that came out from that initial study are: (a) Focus on economically important orphan crops, sometimes called "forgotten food", or high-value crops and livestock to increase productivity; (b) Develop low-cost appropriate technologies for smallholder farmers; (c) Develop high yielding varieties adapted to rainfed and marginal areas; (d) Develop pest and diseases technologies that will pose minimal or no risk to human health and the environment; and (e) Strengthen the extension, delivery, and regulatory system. These recommendations to address the problems of the smallholder farmers in Asia had invited all kinds of stakeholders to come up with strategies to ensure that agricultural biotechnology will contribute to reduce poverty and improve food security and livelihood. In addition, the ADB developed a clear policy to work on biotechnology encompassing all the essential elements of the priority setting, policy, R&D agenda, human resource building, and more.

Looking at the regional scenario now, India, Taiwan, the Philippines, China, Malaysia, and Thailand have substantial investments in modern agricultural biotechnology comparable with nearby developed countries such as Australia, New Zealand, Japan, and Republic of Korea. However, the question remains – Are there enough agricultural R&D investments to date?

Thus, this workshop aims to address the impression that investment in agricultural biotechnology by both the public and private sectors is not enough and still viewed as one of the major constraints that limit the benefits of biotechnology to reach the farmers and improve their livelihoods. It has been highlighted often on many platforms that committed research funding on agricultural biotechnology is yet to come. There is hardly any investment in policy space and regulatory measures. Biotechnology does not mean just working in the laboratory and using biotechnology tools, it encompasses policy issues, innovations, and a lot of studies that need to be done and require investment. Policy space and regulatory measures are viewed as important areas in agricultural biotechnology that need attention for continuous investment. Unless we demonstrate the importance of biotechnology through proper impact studies, it would be difficult to mobilize more investment, catch global attention, and invite governments and international partners for more investment. The workshop is also timely because there is a need to share lessons learned among the countries within the region that can afford to invest long-term as compared to others who are not privileged. Likewise, there is a need for enhancing regional cooperation to attract investors from the private sector while ensuring the commitment of adequate availability of funds in the public sector. And lastly, the webinar will help identify potential areas for investment in modern agricultural biotechnology. Dr Khetarpal expressed his gratitude to the speakers and chairs that agreed to take part in this virtual workshop and share their knowledge on their areas of expertise. He also thanked the participants for showing their interest and attending the virtual workshop. And finally, he commended the organizers and collaborators for making this activity possible.

Dr Reynaldo V. Ebora, Executive Director, Department of Science and Technology-Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development (DOST-PCAARRD), Philippines, was also pleased to welcome all the participants of the two-day regional workshop. He agreed that the workshop is a relevant and timely opportunity for countries to keep abreast of the regional updates and encourage enabling policy environments.

He was thrilled to be part of this activity as the theme resonates well with mandated activities on agricultural biotechnology of DOST-PCAARRD. The Council takes advantage of the prospects of biotechnology to support food safety and food security as outlined in its Industry Strategic S&T Programmes. Currently, the Council supports two ongoing research initiatives on crop biotechnology — the first one focuses on capacity building for gene editing using CRISPR-Cas9, while the other one uses of new breeding techniques for eggplant.

Accordingly, the Philippines is gradually but steadily gaining ground in pushing for the gains of biotechnology in the Agriculture, Aquatic, and Natural Resources (AANR) sector. Recently, the International Service for the Acquisition of Agri-biotech Applications (ISAAA) reported that the Philippine government has approved

Bt eggplant event 'EE-1' for direct use as food, feed, or for processing. Meanwhile, the 'Golden Rice' developed by the Philippine Rice Research Institute (PhilRice) and International Rice Research Institute (IRRI) has been very recently cleared for commercial propagation, making the Philippines the first country to approve 'Golden Rice' for commercial cultivation. These milestones signal the dynamic progress in biosafety regulations in the country and this is a piece of exciting news for all institutions engaging in modern agricultural biotechnology. These recent developments on the Philippine regulatory system can be considered a big leap in both local and regional scientific scenes getting the traction needed to propel biotechnology further.

DOST-PCAARRD, being a funding agency, shares the enthusiasm of everyone in the workshop in discussing the current status of biotechnology investment in each country in the Asia-Pacific considering the complexities, promises, and risks of investing in agricultural biotechnology. Generally, investing in biotechnology comes with many fundamental risks. It requires high R&D investment but there is no assurance that the end products will reach the intended market, attributed mainly to the stringent regulation processes and other factors. This is a major concern especially so for public investment.

Confronted with this reality, the virtual workshop will serve as a venue to learn from each other's experiences, stimulate more ideas and innovations, draw possible areas of collaboration, and create value in the exchange of insights, plans, policies, and strategies. Dr Ebora hoped that each session will provide a pool of potential solutions that can be considered and evaluated against the needs and realities of each country. He wished that the exchange of information and insights in this workshop will deliver lasting impacts. Lastly, he wished this programme a great success, and may everyone remain steadfast in our goals as a community of practice. Dr Ebora assured that DOST-PCAARRD will steadily provide S&T solutions to support this agenda.

Mr Vincent Lin, Director General, Department of International Affairs, COA, Taiwan, also delivered his opening message and thanked APAARI, DOST-PCAARRD, CLA, and FSII for the meticulous preparations and for co-hosting this meaningful event.

Mr Lin emphasized that the agricultural production and food industries have changed dramatically over the past few decades. A range of pressures including rapid population growth, urbanization, growing wealth, extreme weather events, land degradation, and biodiversity loss, are challenging the agricultural and food systems. He believes that science, technology, and innovation are the key to accelerating the transformation of agri-food systems and combating hunger and malnutrition. Plus, the investment to adopt the existing and new biotechnologies and innovations both are necessary.

Taiwan has launched the "Programme for Promoting Agricultural Bioeconomy: Toward Global Competitiveness and Sustainability" in 2017. Applications of genomics and new varieties of animals and plants were included in the programme to strengthen basic R&D capabilities, and scientific research capabilities were directly linked to different industries to identify problems. It is estimated that the total value of the development of industries in Taiwan's agricultural bioeconomy is twice more than the amount invested. The positive effect of the application of relevant scientific research to the development of industrial chains is not limited to primary industries but has also driven associated effects in society and the economy.

Mr Lin was confident that this workshop will provide a great opportunity for all the participants to have an overview of investment in agricultural biotechnology R&D by public and private sectors and its impact in the region. With enough contributions and inputs, this workshop will yield fruitful outcomes and valuable suggestions. Finally, he thanked the participants for their gracious presence and wished the workshop a great success.

Technical Sessions

TECHNICAL SESSION 1A

INVESTMENT STATUS AND IMPACTS IN MODERN AGRICULTURAL BIOTECHNOLOGY

Chair : **Julianne Biddle**, ACIAR, Australia

Rapporteur : **Gil Markov Alcantara**, DOST-PCAARRD, Philippines

The first part of the first session consisted of three presentations that provided a brief background and information on the investment status and impacts of modern agricultural biotechnology. The proceedings of the Technical Session 1A are provided as follows:

Dr Krishna Ravi Srinivas (RIS, India), made a presentation on the *"Long-Term Investment in Agricultural Biotechnology for Feeding the Future Generation."* Over the past years, agricultural research and development have significantly shifted from high to middle-income countries. However, the gap among developing countries is still widening. This may increase the technological inequalities which may not result in equitable sharing of benefits and gains.

There is evidence that proves that agricultural R&D is not attracting investments. According to the Agricultural Science and Technology Indicators (ASTI), agricultural investments are either declining or not enough to support the new available technologies. Although, studies show that agricultural R&D investments have multiple benefits resulting from the significant increase in the total factor productivity in agriculture, the international agricultural research investments only generate a 10-to-1 return. In 2018, the FAO report on agricultural biotechnology in Asia-Pacific has highlighted the serious gap in capacities, enabling environments, and applications. Above all these, the real challenge is to ensure the long-term investment in agricultural biotechnology for harnessing the technological advances and translate this into tangible gains in output, health and nutrition, and sustainability of agriculture.

Over the years, there increasing trend is observed in public agricultural R&D, population, and agricultural output. Since 1990, the public sector expenditure on agricultural R&D significantly increased in China. There is also a substantial increase in public expenditure in India and Brazil, while public sector funding in the USA slightly declines. High-income countries were able to invest more, enabling them to gain more. Meanwhile, low-income countries are not capable of investing enough in agricultural R&D, thus they rely mainly on international collaborations and international agricultural research support and funding. Evidently, that is not sufficient. There should be indigenous agricultural capacities across countries, sectors, and crops to equally capacitate the developing countries. Although, there is a consensus that it should be supported, but research capacities and available investment support is still lacking. Bygone are the Green Revolution paradigm of R&D spending with the public sector dominating R&D. Since 1980s, it has been the private sector that has been leading the gene revolution in terms of products and services. The precision agriculture revolution seems to be in the same direction.

There are new technologies and applications of agricultural biotechnology. Faster development of varieties is now possible. However, being more R&D intensive, capacity is a must to realize the returns quicker. There are also risks such as delays in adoption, strict trade policies, and anti-GMO sentiments, among many others. Justifications for funding agricultural biotechnology initiatives are stronger than ever. But aside from this, it is also essential to really tackle many factors that come with the development and implementation of technologies, and have clear laid-out strategies to approach the risks.

Many countries have different models of support and a mix of policies to promote partnerships. China has a long-term commitment to agricultural biotechnology through clear vision and mission programmes as evident in the enhanced funding support which have been provided over the years. In Southeast Asia, countries have the policy to incentivize private sector R&D, while the government provides an enabling environment and conducive trade and regulatory policies. In India, the state invests in basic research and also supports private-sector R&D, commercialization, and setting up agencies to promote biotech innovation and investment. In the USA and Europe, the private sector is taking the lead in basic and applied research, while the public sector support is relatively declining. Nonetheless, enabling policies to promote biotechnology and a conducive environment is available. Lastly, in Singapore, the state promotes biotechnology in partnership with the private sector as part of its innovation strategy to become the global leader in biotechnology.

Evidently, there is a need to identify priorities for long-term investments and see whether the policies are conducive for that is the same or not. Long-term investments have to be complemented with short- and medium-term investments. Thus, a comprehensive policy on investments in agricultural biotechnology should be developed. Foreign direct investment can also be incentivized to promote long-term investment in agricultural biotechnology. Likewise, investors need policy coherence and guarantee that their investments will lead to the commercialization of innovation. The regulatory cost need not be a barrier to development. Another strategy is to link the long-term policy on agricultural biotechnology to SDGs and nutritional security. A roadmap that relates technology development, investment, and the outcome would provide a clear vision of the required investment, cooperation, and R&D that needs to be undertaken. Likewise, a synergized investment, IP protection, and trade promotion policies would also be helpful and strengthen collaborations among various stakeholders.

Identifying priorities for long-term investments would truly provide a clear direction that will enable countries to reap the benefit of global development through modern agricultural biotechnology.

Dr Rishi K. Tyagi (APAARI, Thailand), made a presentation on *"Investment by Public Sector in Agricultural Biotechnology in Asia-Pacific."* Among the top 20 populated countries, 10 countries are from Asia and about 60% of the world population are from the Asia-Pacific region. Most of these countries are greatly dependent on agriculture. However, the agriculture sector is faced with various challenges including climate change, water shortage and salinity, restricted arable land, and new biotic stresses. Thus, farmers tend to grow more food with fewer resources, including energy.

Through the years, the evolution of biotechnology and its application have proven its effectiveness in overcoming these agricultural problems. The evolution of plant breeding from selection breeding to precision breeding including gene editing and genomic selections has paved the way to new and improved agricultural products. Data from ISAAA have highlighted that how biotech crops contributed to achieving SDGs, from alleviating poverty and hunger, mitigating climate change, protecting the environment, securing food, feed and fiber, and conserving biodiversity.

Based on the 2017 data of the World Bank and the respective reports of selected countries in the Asia-Pacific Region, the following are the investment status of some countries in the region:

In South Asia, Nepal has the highest agriculture GDP share (27.04%) in its total GDP, followed by Pakistan (22.81%), India (22.89%), Bhutan (14.04%), Bangladesh (13.41%), and Sri Lanka (7.71%). In terms of investment, India has the highest investment in agricultural research ($1.09 B) of which 1.42% is invested as agricultural biotechnology research expenditures. Interestingly, Pakistan has the lowest total investment in agriculture research (USD 7.69 M) but almost 50.07% of this amount was invested in agricultural biotechnology research. While agricultural biotechnology policy is in place in most of the South Asian countries, but only India, Pakistan, and Bangladesh give high priority to agricultural biotechnology. These countries have at least one GM crop currently in cultivation. However, GM importation is still not being practiced in these countries.

In Southeast Asia, Lao PDR has the highest agriculture GDP share (16.20%) in its total GDP, followed by Vietnam (15.34%), Philippines (10.66%), Malaysia (8.78%), Thailand (8.43%), China (7.46%), and Taiwan (1.72%). However, China remains to have the highest investment in agriculture (USD 1.85 B) of which 31.53% of these were invested in agricultural biotechnology research. Taiwan and Vietnam also attach great importance to agricultural biotechnology research as evident from 17.36% and 10.71% investment, respectively, of total agricultural research expenditure. Most Southeast Asia countries already have agricultural biotechnology policies in place. However, despite allowing GM importation, governments of countries like Malaysia, Taiwan, and Thailand still did not allow GM crop cultivation, depriving their farmers to harness the benefits of the biotechnology.

In the selected Pacific countries, Papua New Guinea has the highest agriculture GDP share (19.04%) in its total GDP, followed by Samoa (10.88%), and Australia (2.70%). While Australia has the highest investment in agricultural research (USD 907M), only 7.31% was expended on agricultural biotechnology research. On the other hand, Samoa invested 66.67% of its total investment in agricultural research (USD 0.36 M) in biotechnology.

Despite efforts in the Asia-Pacific region, it is still evident that massive under-investment in agricultural biotechnology exists in most developing countries. Country-specific investments plans need to be developed based on respective analyses of policies and priorities. Investment opportunities involving the private sectors need to be encouraged as well since they can be partners in funding collaborative agricultural biotechnology research. Innovative funding mechanisms and mobilization for improved investments must be in place. It is important to increase the investment in agricultural biotechnology and prioritize research in this area.

Government policies should be able to attract private R&D investment in agricultural biotechnology by imposing lesser time of approval of biotech products, harmonization of regulatory processes, spreading awareness of actual benefits and risks of biotech effectiveness in food safety systems to address consumers' concerns, securing IPR protection and its enforcement, and encouraging PPP for biotech R&D.

Dr Rajeev K. Varshney (ICRISAT, India) presented the "*Investment vis-à-vis Benefits of Genomics on Smallholder Farmers, Science, Society and Environment.*" Genomic investments started to happen mainly in 1990 when the Human Genome Project (HGP) was launched in the USA. By 2000, several countries started investing more in the application of genomics in various agricultural crops. In 2005, a concept called genomics-assisted breeding (GAB) for crop improvement was published in "Trends in Plant Science'' which highlighted the benefits of providing a great number of investments in genomics researchers towards the breeding and development of better crop varieties. Over the past over 15 years, a lot of applications using GAB materialized.

ICRISAT together with its partners in Asia, North America, Europe, and Australia have been working together and making considerable investments in developing the genome assemblies of many ICRISAT mandate crops such as pigeonpea, chickpea, and pearl millet, among others, as well as other legume and oilseed crops (*e.g.* sesame, mungbean, *etc.*). The combined efforts of various experts from partner agencies across different regions have lessened the costs of most genomics research. Published genome assemblies serve as reference materials in various breeding processes. Decoding the genome sequences has become so cheap, that sequencing the whole germplasm collection of a certain crop is made possible.

From these genome sequencing efforts, different marker genotyping and both grounds and aerial phenotyping platforms were developed and found useful in many GAB efforts. These platforms can aid in developing markers targeting the genes associated with the trait of interest and use these data to screen the breeding population and germplasm line, as well as to develop new hybrids in a cost-effective manner.

The benefits from these efforts on GAB are evident in the numerous new varieties and hybrids that are now available in India. A large number of rice varieties are now disease resistant, abiotic stress-tolerant, and drought-tolerant. Also, a biofortified variety of wheat is now available which has high protein (12.82%), iron (39.5 ppm), and zinc (37.8 ppm). There are also wheat varieties that are rust resistant and have good quality for making *chapati*, pasta, and other traditional food products. Moreover, a wide range of GAB hybrids of maize with resistance to different diseases and rich with pro-vitamin A was also developed. Even orphan legume crops such as chickpea have GAB varieties that are drought-tolerant and *Fusarium* wilt resistant and are now available in Ethiopia and India. Likewise, the first set of high-oleic groundnut varieties was released in India.

Further, all the investments have positively impacted the yield and income of smallholder farmers. Tolerant varieties to abiotic and biotic stresses are found to be high yielding as compared to traditionally grown varieties. GAB varieties of chickpea yield 7-11.9% higher produce over the check varieties. Similarly, 'Geletu', the first-ever high yield chickpea variety developed through GAB and released in Ethiopia, has delivered the highest grain yield of 3,822 kg/ha at Arsi Robe, Ethiopia, which translates into a yield advantage of 15% over the check variety 'Teketay' and 78% more than the local check. The adoption of such high-yielding varieties developed through GAB translates to higher produce and income for the smallholder farmers.

An increased level of micronutrients in our diet can play a very significant role in maintaining good health. Also, GAB varieties deliver better nutrition to consumers and society with higher nutrient content. This is evident with 'Girnar 4' and 'Girnar 5' which have kernel oleic acid content of about 80% (of total fat content) as against 40-50% in the normal groundnut. It also reduces low-density lipoprotein (LDL) cholesterol (considered 'bad' cholesterol) and maintains high-density lipoproteins (HDL) levels or 'good' cholesterol, making it a far healthier option. In the case of maize, improved hybrids like 'Pusa Vivek QPM9', 'Pusa HQPM7' are pro-vitamin A-rich hybrids, while 'PMH1' and 'PMH6' are low phytate maize hybrids developed through the GAB approach.

Another benefit derived from genomics is that it generates revenues for national governments. The high-yielding varieties can help enhance crop production and the surplus produce can be exported to other countries, providing more revenues. Basmati, a bowl of high-quality rice, has been a major agricultural export commodity in India that has earned foreign exchange to the tune of USD 4.4 B during 2019-2020. Improved Basmati rice varieties (Pusa Samba 1850, Improved Samba Mahsuri, DRR DHAN 42, and DRR Dhan 57) have resistance to various diseases and improved yield will help in improving the revenues from the export. In the case a country spends money on importing a crop commodity, the higher production of GAB varieties can save public revenue. Large-scale adoption of improved chickpea varieties Pusa (BMG) 10216, Super Annigeri-1, and Pusa Chickpea Manav can help enhance the pulses production, thereby contributing to reducing the import burden of pulses which was around 3 MT in 2020-2021.

Varieties from one country can also be useful in other countries as evident with the translational genomics studies on pigeonpea that have helped the development of disease resistant soybean varieties. A pigeonpea gene confers resistance to Asian soybean rust in soybean. Interestingly, investment in orphan crops can help improve industrial crops.

Moreover, these investments can also help ensure environmental sustainability. Conventional varieties that are prone to biotic stresses cost a lot of money to smallholder farmers for treating them with fungicides, insecticides, and other pesticides. In addition to cost, their usage has a huge impact on the health of both humans and animals, as well as the loss of biodiversity and the environment. All these can be significantly reduced by deploying varieties that are resistant to biotic stresses. GAB has already delivered many varieties resistant to various biotic stresses in rice (bacterial wilt, blast, *etc.*), chickpea (*Fusarium* wilt), and many more. Deployment of such varieties can help smallholder farmers in reducing the application of pesticides, insecticides, and fertilizers thereby reducing the impact on the environment.

Currently, investments are still lesser but benefits are higher. Countries that have higher investments have good agricultural produce with more value. For some countries, several challenges hinder investments including historical baggage and negative propaganda on biotechnology products, as well as the R&D lag phase. Most government funding and private support on biotechnology research expect immediate tangible output in the first five years of their investment. There is a need to make investors understand that in biotechnology and with the current case of advances in science, research takes a long time before products are developed, and way before these products can be adopted by farmers for their benefits. A better understanding and clear communication on the long-term benefits of research investment must be in place to attract researchers and investors alike. Partnership in genomics research is very important to deliver fruits of high-end science. Thus, it is essential to create and nurture partnerships by having symbiotic relationships, engaging partners from conceptualization, and open communication to enable accessibility, flexibility, and accountability, as well as credit, resource, and knowledge sharing. Highlighting the success stories of products and their impact on society and the country would definitely attract more investments and open up new ideas for researchers.

Technical Session 1A: SUMMARY & KEY RECOMMENDATIONS

- Agriculture is a significant contributor to the GDP of countries in the Asia-Pacific and it supports the prioritization of investment initiatives towards research and development in the agricultural sector.
- Investing in R&D on agricultural biotechnology addresses the high demand for agricultural products, as well as global concerns including climate change, food security, nutrition. However, establishing partnerships within the private and public sectors, and ensuring long-term investment in biotechnology remains a challenge.

Key Recommendations

- Develop long-term policies that synergize R&D, regulation, and investment.
- Facilitate knowledge-sharing to engage partners and communicate the long-term benefits of biotechnology to encourage investments.
- Create an enabling policy and research environment to empower the research community and encourage country-level and regional-level collaborations.

TECHNICAL SESSION 1B

CASE STUDIES: INVESTMENT AND IMPACT

Chair : **Mohd Syaifudin Abdul Rahman,** MARDI, Malaysia

Rapporteur : **Ryan Lawrence Polinag,** DOST-PCAARRD, Philippines

The second part of the first session consisted of six presentations of different case studies on the investment and impact of agricultural biotechnology. The proceedings of the Technical Session 1B are presented below:

Dr M.A. Yousuf Akhond (BARI, Bangladesh) shared the success story of *"Bt Brinjal in Bangladesh."* Brinjal is the most popular vegetable in Bangladesh, yet it has low productivity of only 10.13 t/ha as compared to its yield potential of 40-50 t/ha. In 2020, the total production of brinjal is 0.5 million MT covering 52,396 ha of agricultural land. The country's eggplant production was severely damaged by the fruit and shoot borer (*Leucinodes orbitalis* Guenee) causing about 30-60% yield loss. This poses a serious problem because of the high reproductive potential of the pests. Likewise, farmers tend to frequently spray chemical insecticides every other day to control the said pest.

To address the damage being caused by the brinjal fruit and shoot borer (BFSB), the Bt brinjal was developed through a transgenic technology made possible by the United States Agency for International Development (USAID)-funded Agriculture Biotechnology Support Project (ABSP II) in 2004. The Cry1Ac gene from *Bacillus thuringiensis* (Bt), which has the potential to render eggplants resistant to BFSB, was used at Maharashtra Hybrid Seeds Company (Mahyco), India, to generate the EE-1 transgenic event. This was backcrossed into nine local varieties of eggplant at BARI which have varying colors, shapes, and sizes. Several years were devoted to generation advancement and various contained and confined trials.

By October 2013, four varieties of BARI Bt brinjal (BARI Bt Begun 1, BARI Bt Begun 2, BARI Bt Begun 3, and BARI Bt Begun 4) were approved for limited scale release production. Seedlings were distributed among 20 farmers in four regions of Bangladesh in 2014. Four deregulated Bt brinjal varieties exhibited reduced insecticide applications saving at least 61% on pesticide cost and improved yield ranging from 35-55 t/ha. It resulted into a 6-fold increase in farmers' net returns of about USD 2,151/ha, and a 21% increase in gross revenue of farmers.

By 2015, another project was funded by USAID entitled as Feed the Future Biotechnology Partnership (FtFBP)–South Asia Eggplant Improvement Program (SAEIP) to take over and continued with further extension and implementation of stewardship measures. Specifically, it aimed to improve insect resistance management and environmental safety, post commercial communication support, and seed commercialization plan for Bt eggplant in Bangladesh.

The Bt eggplant supply chain has already been established from seed production, quality assessment, seed processing, packaging, and up to distribution including capacity building, with involvement of government organizations such as Bangladesh Agricultural Research Institute (BARI), Bangladesh Agricultural Development Corporation (BADC), and the Department of Agricultural Extension (DAE). Adoption of Bt eggplant has been steadily increasing since 2016 with the multi-pronged approach in reaching out to farmers including training, demonstration, field days, farmer videos, and various national promotional activities. As of 2020, at least 27,600 (18%) farmers were already cultivating Bt eggplant across 64 districts in Bangladesh (82,206 acres). Almost 15-20% of farmers saved Bt eggplant seeds for the next season. This number is expected to increase in the coming years as more farmers adopt the planting of Bt eggplant.

The public sector extends its efforts in connecting and interacting with brinjal growing farmers by developing a mobile App called 'BtBegun'. This contains information on Bt brinjal technology, cultivation practices, stewardship practices, seed source, videos, and other related information.

To date, Bangladesh is still considering the development of agronomically superior varieties of eggplant incorporating better wilt tolerance for adoption to wider agro-ecological zones. It is also planned to implement laboratory and field practices to sustain the technology and develop second-generation products. Likewise, they hope to create an enabling environment with policy-level intervention to promote event-based approval and explore the possibility of private sector participation in GM technology development and dissemination.

Dr Charudatta Digambarrao Mayee (SABC, India) presented an overview of the status of *"Bt Cotton in Asia."* In 2018, India has 7.5 M farmers growing Bt cotton in around 11.4 M ha of their agricultural land which is equivalent to at least 97% adoption rate as far as cotton is concerned. This is equivalent to the adoption rates of China (95%), Pakistan (96%), and Australia (100%), who have already realized the advantages of Bt genes in transgenics.

The Bt technology is already made available, farmers will just sow the seeds without the need for special equipment. The Bt is expressed within every part of the plants and expressed almost throughout the plant life. The various commercial Bt cotton uses rDNA technology to express traits such as insect resistance (single or multiple genes), herbicide tolerance (CP4EPSPS/Bar gene (HT)), and stacked IR/HT traits (single gene/HT or multiple genes/HT). Thus, in the case of cotton, the entire plant is protected from bollworms. The pest larvae are killed in the early stage thereby preventing potential serious crop damage. There are also reduced chemical sprays against bollworms.

Prior to Bt cotton in 2002, yield losses due to bollworms in India were more than 60% despite 15-20 insecticide sprays, equivalent to at least 50% of the total insecticides used in the country. Still there was no proper control of the pests, thus, resulting in heavy losses in yield and income, and worst situation was that farmers tended to give up the cultivation of cotton.

In March 2002, the government of India approved Mahyco's Bt cotton which is incorporated with Bollgard Bt gene, Cry 1Ac licensed from Monsanto for control of cotton bollworms. The Bt cotton has undergone more than 500 field trials and many biosafety tests for 7-8 years to prove its safety. It has been the first GM crop of India.

Based on the analyses of the South Asia Biotechnology Centre (SABC) in 2020, there has been an incredible increase in the production of cotton upon the adoption of Bt cotton in 2002. The average production of cotton before was around 300kg/ha to 500kg/ha. With this increase, India has become the third largest producer of cotton after the US and China. The transformation brought by the adoption of Bt cotton also increased the exportation of cotton and decrease the importation of foreign cotton. Simultaneously, an improvement in the growth of long-staple cotton was also observed. This was brought by uniformity in the growth of the Bt cotton.

Cotton is a multi-purpose crop not only grown for its lint (fiber) but for cotton seeds also. In fact, lint only contributes to 33% of the cotton produced. About 67% are cotton seeds used for industrial uses, feed, and kernel (*e.g.,* oil for food and meal for feed). The use of Bt cotton has brought advantages to the farmers providing enough supply of new raw materials to meet the various demand of cotton by-products, thereby, increasing income and rural employment. It has also provided new avenues for rural industry and has relatively conserved natural resources.

The adoption of Bt cotton in India has revived and revolutionized cotton cultivation in the country along with the other advances made in plant breeding and agronomy. With its high yield potential that offers an increase of 31-67%, India has turned from importer to exporter of cotton providing the country an economic gain of USD 21.1B (2002-2016). It has substantially benefited farmers through increased net profit (INR 7,800-30,000/ha) and reduced insecticide use of about 25-55%. It has also improved the socio-economic status of 6-7M farmers and their families as it provides more jobs in seed and other sectors. It has also offered environmental and health benefits, as well as created an intense interest in biotechnology.

Overall, there is an effective adoption and economic benefit of Bt cotton in Asia, specifically in India, Pakistan, China, Australia, Myanmar. In Pakistan, unofficial cultivation started in 2006, that is five years before its actual approval. Now at 97% adoption, Bt cotton is planted on 3.0M ha by 725,000 farmers. There was also about 55% increased demand for female farm workers in Bt cotton. In China, the government is committed to being a strong biotech country, thus, it has already been cultivating Bt cotton for 23 years since its approval in 1997. China has made big investment in biotechnology as indicated by the acquisition of Syngenta. Now at 95% adoption, 6M farmers have already planted Bt cotton on about 3.18M ha. In Myanmar, they have cultivated a superior homegrown variety of Bt cotton for 13 years on 320,000 ha by 455,000 smallholder farmers. And lastly, Australia, being one of the pioneer countries to start biotech, has planted Bt cotton on around 405,000 ha.

The next-generation biotechnology cotton offers more promising advantages and benefits to both industrial and developing countries. The development, deployment, and adoption of a high-density planting system of biotech cotton hybrid varieties will further maximize yield potential. Thus, stewardship is necessary for the supply chain of quality Bt cotton seeds, refuge management, insect resistance management, and post-approval monitoring. The new generation of Bt cotton is expected to manage the emerging pests such as whitefly and pink bollworms, as well as diversify the different Bt cotton events. Strengthening the PPP to harness crop innovations (rDNA/gene-editing) will definitely fast-track cotton improvement.

India may have difficulty in the implementation and adoption of newly developed varieties of Bt cotton, but this does not hinder farmers in planting herbicide-tolerant Bt cotton. Evidence proves its effective management of the pink bollworm and the undeniable increase in yield and ease in cultivation. Thus, despite limitations set by the government, farmers resort to illegal cultivation to reap its benefits. Nevertheless, the SABC pursued its effort in campaigning to increase awareness and achieve the public sector's acceptance of Bt cotton. Likewise, SABC continues its wide-scale studies using the new mitigation and disruption technology management to assure that the new emerging pests can be managed.

Dr Leonardo A. Gonzales (STRIVE, Philippines), presented the investment and impact of *"GM Maize in the Philippines."* An impact assessment was conducted covering 13 major corn-producing provinces across eight regions in the country to analyze four criteria such as the socio-economic (micro), environmental, food and nutrition security, and the inter-sectoral impacts of GM maize adoption. It is believed that the adoption of GM corn enhanced directly the microeconomics and macroeconomics of corn farming and indirectly the food and nutrition security of households as well as the environmental sustainability of their farms through resource use efficiency.

The comparative socio-economic and microeconomic analyses showed that an increase in yield of at least 71.33% more for GM maize was recorded, resulting in a 37.83% increase in net farm income. It is equivalent to a 59.33% return on investment (ROI) for farmers which can be realized after two cropping seasons.

The use of GM maize was also proven environmentally efficient as 39% more land use and 37.50% less pesticide use was recorded. In terms of the food and nutritional impacts observed, there was more incidence of underweight, stunted, and wasted individuals for households not practicing GM production. Moreover, the use of GM maize as a feed ingredient affected animal production positively as an increase in the value of hog (29%), broiler (20%), and layer (12%) was recorded.

As on 2018, GM maize investment in the Philippines was PhP 127 M for the development of GM corn equivalent to a total of 1.27 M ha planted. For 2003-2013, there is a recorded total gain of PhP 32,517 ha/year in the farm level or a total of 13.591 B hectarage planting.

Private investment in GM corn technology in the Philippines indicated a robust impact in enhancing farmers' livelihood and income. It showed that GM corn is a great contributor to the country's economy and future. Thus, it is a good policy decision to continue the country's investment in modern agricultural biotechnology in terms of product development and production. There is a need to pursue investment for a holistic agri-biotechnology development policy framework focusing on both soft infrastructures (*i.e.*, technical extension services, sustainable credit schemes, climate change mitigation) and hard infrastructures (*i.e.*, farm-to-market roads, irrigation systems, post-harvest processing, and trading facilities), as well as on the enhancement of public research expenditure on agri-biotechnology and strategic homegrown GM products. Likewise, there is a need to push investment in the harmonization of biosafety guidelines and research protocols on biosafety in the Asia-Pacific.

Dr Graham Brookes (PG Economics Ltd., United Kingdom), presented the *"Impact of Using Biotech Corn in Vietnam: Results of the First Farm-Level Study"* among corn growers in all corn-growing regions in 2018-2019. The study was conducted by the Crop Protection Department (CPD) of the Ministry of Agriculture and Rural Development (MARD) in collaboration with the Vietnam Seed Trade Association (VSTA), Vietnam.

Biotech corn in Vietnam is tolerant to the herbicide glyphosate and resistant to some of the main lepidopteran pests such as Asian corn borer, fall armyworm, corn earworm, and common cutworm. Its commercialization started in 2015 and a total of 92,000 ha was already planted by 2019.

Based on the survey, the average yield performance of Bt corn is 8.72 t/ha which is higher than that of the average yield of all conventional corn varieties which is at 6.69 t/ha only. About 60% of the farmers reported improvements to the quality of the corn grains with reduced levels of wastage and rejection by purchasers.

Biotech corn has a superior yield compared to conventional varieties and their equivalents (+298.45 and +169.20). Preference for biotech corn is driven by its high yield and pest resistance and weed control. Biotech corn seeds cost 28-34% more than the conventional varieties and their equivalents. Savings in weed control from the use of Bt corn is largely attributable to the reduced cost from herbicides, hand weeding, and other mechanical control measures from USD 93.42/ha to USD 40.73/ha. Moreover, savings in pest control from the use of biotech corn is largely attributable to the reduced cost from both crop walking and insecticide use from USD 56.38/ha to USD 18.72/ha. There is also a small net reduction in labor usage which farmers viewed positively as they could have more free time for other productive activities. Overall, a total change in farm income resulting in a USD 195.67-USD 329.75 increase in revenue compared to conventional varieties was recorded, equivalent to 6.84-12.55% average ROI. Moreover, the use of biotech corn is more environment-friendly as indicated by its lower environmental impact quotient (EIQ) indicator in terms of herbicide use (-36%) and insecticide use (-77%).

The superior yield, effective pest resistance especially against the recent fall armyworm pest, and a significant decrease in insecticide usage from the cultivation of biotech corn offer high economic gains that are at par with the performance of biotech corn in other countries. However, national-level gains in terms of higher farm income, additional production of corn, and wider societal environmental benefits, have so far been limited due to the relatively low levels of adoption of the technology. Likewise, an additional factor that is likely to impact future adoption levels of the technology is the introduction of the ban on the use of herbicide glyphosate starting from mid-2021, which might discourage further adoption of GM corn. The evidence on economic gains presented here may contribute to increased adoption if effectively communicated to more corn farmers in Vietnam. Furthermore, a significant increase in national-level benefits is likely if levels of adoption can be increased especially if the biotech corn technology is available in the leading varieties of corn.

Dr Osman Mewett (ASF, Australia), shared the *"Impacts and Prospects of GM Canola in Australia."* Australia has one of the world's most stringent regulatory systems for identifying and managing risks to human health and safety and the environment associated with gene technology considering that agriculture is a key driver of the country's economy. Australia already had a long experience in the cultivation of GM crops like cotton since 1996. It was only in 2003 when the Gene Technology Regulator of Australia issued licenses for the commercial release of two types of GM canola. However, nearly all states and territory governments subsequently enacted moratoria on the commercial cultivation of GM canola through the establishment of GM-free zones to delay the release of GM canola until trade and marketing considerations could be addressed. Since 2008, several states such as Victoria, New South Wales, Western Australia, and South Australia have lifted their moratoria and permitted commercial cultivation of GM canola. About 25 years from the adoption of the GM technology, Australia is now free to cultivate GM canola in most of its canola-growing states.

Since 2008, farmers voluntarily cultivated GM canola which led to a swift increase in adoption. The strongest growth was recorded in Western Australia which comprised nearly 30% of the total canola crop planted. The GM canola was planted on nearly 500,000 ha, equivalent to an average farm income gain of USD 27.14/ha, and a total farm income gain of USD 13.5 M. Cumulatively, since cultivation was approved, the total farm income gain from GM canola has reached USD 117.4 M which delivered significant benefits to Australian farmers.

Most of the users of GM canola have also derived higher yields from better weed control with the 11% increase in the average yield gain. By 2015, Australian farmers had produced an additional 226,000 t of canola that would otherwise not have been produced if conventional technology had been used. Moreover, the total herbicide active ingredient savings arising from the use of GM canola has decreased by 4.7% with the EIQ load falling by 4.2%.

The European Union (EU) traditionally drives the demand for non-GM canola, and as the EU becomes more accepting of GM varieties, the landscape of the canola market will continue to change. Currently, the canola market in Australia is still geared to non-GM canola driven by the consumer oil market. However, the landscape is expected to change as the EU biodiesel market tends to accept GM canola. Nevertheless, the price differential between GM canola and non-GM has recently dramatically narrowed down, suggesting that when the demand is tight — canola is still canola.

Dr Martin Lema (NUQ, Argentina), presented the *"Regulatory Policy and Impact to Investment: Case Study of Argentina."* The Argentine regulatory framework for modern biotechnology came into existence in 1991, and the first commercial biotechnology product was approved in 1996. The Biosafety Commission was recognized by FAO as a Center of Reference. This shows that Argentina has vast experience in regulating biotech products. Commercial approvals take approximately 1-2 years, where over 60 GMO events have already been approved for use in agriculture. This accounts for about USD 127 B economic surpluses over the past 20 years.

The fact remains that it is plausible to develop local GM products and take them to the market which has encouraged many researchers, scientists, and entrepreneurs to develop more beneficial products of modern agricultural biotechnology despite the long period of laboratory testing, field trials, and commercial approval. In 2001, several local investors, including the Bioceres company, decided to put their money into biotechnology projects. This resulted in a boost on locally-developed GM products. The first molecular pharming in GM cattle was established in Argentina in 2003. This was followed by several commercial approvals of GM crops including virus-protected potato and drought-tolerant soybean (2015), molecular farming in safflower (2017), and drought-tolerant wheat (2020).

The regulatory criteria for gene editing in Argentina were issued in 2015 wherein the first assessments and decisions were officially made in 2016. The regulation has a case-by-case GMO/non-GMO sorting mechanism based on the definition of the Cartagena Protocol on Biosafety (CPB) of a living modified organism (LMO) wherein the decision process is predictable and fast (60 days). Several countries followed this lead including Chile. To date, over 25 cases of different genome-edited products have been assessed and found non-GMO in eight Latin American countries.

There is also a rising trend in GM crops approval, as well as the applications and products of NBT. Gene-edited products dominate the approvals (86%) compared to other NBT products. The approval accounts for the diversity in traits, as well as species or type of subject organisms. Due to the new regulation, most applications are now from local companies or public research compared to foreign SMEs and multinational companies. Clearly, there is a need to have adequate regulation that would foster more public and private investment in R&D.

Technical Session 1B: SUMMARY & KEY RECOMMENDATIONS

Case studies were presented on the following that provides evidence that the GM technologies led to positive and significant effects on-farm productivity and environment, which benefited farmers and the economies of countries:

- Bt Brinjal (Eggplant) in Bangladesh
- Bt Cotton in Asia, including India, Pakistan, China, Australia, Myanmar
- GM Maize in the Philippines and Bt Corn in Vietnam
- GM Canola in Australia
- Policy developments in Argentina.

Key Recommendations

- Apply the GM technology to new and agronomically superior varieties to achieve higher levels of adoption
- Explore partnerships among stakeholders to develop national policies that promote long-term investment in biotechnology
- Push for the harmonization of biosafety guidelines and research protocols on biosafety in the Asia-Pacific region
- An adequate regulation in place resulted in more public and private investments in R&D, as in the case of Argentina and to some extent the other countries.

TECHNICAL SESSION 2

IMPACTS OF ENABLING POLICIES FOR ENHANCED INVESTMENT

Chair : **Reynaldo V. Ebora,** DOST-PCAARRD, Philippines

Rapporteur : **Jean Claudine Guelos,** DOST-PCAARRD, Philippines

The second session consisted of three presentations that discussed several impacts of enabling policies for enhanced investment in modern agricultural biotechnology. The proceedings of Technical Session 2 are discussed as below:

Dr Saturnina Halos (BCP, Philippines), presented the *"Policy Changes for Enhancement of Funding in Modern Agricultural Biotechnology"* in the Philippines. A clear national policy to promote the responsible and safe use of modern biotechnology as a means to achieve agricultural and national development was in place through the Agriculture and Fisheries Modernization Act (AFMA) of 1997 and supported by several issuances through the Office of the President during the Estrada (1998) and Arroyo (2001) administrations.

Despite this, there is still a constant clamor to get the government to increase its investment in research. However, the government will be convinced only when the research community can explain to policymakers the undeniable proof of benefits from modern biotechnology research. It is also important to invest in capacity building for modern agricultural biotechnology through degree and non-degree training programmes and research fellowships. This is already made part of the Biotech Program of the Department of Agriculture.

Equal emphasis should also be given to the promotion of collaboration among scientists within and outside the country. This would allow research complementation to deliver results faster. Thus, priority must be assigned to research funding and support through recognition and awards for collaborative research teams, aside from the usual incentives given to individual scientists. Likewise, a clear and transparent policy on research collaboration with foreign research teams must be in place, including a clear IPR policy on the sharing of research results.

A consistent policy on regulation would establish a science-based, functional, predictable, and transparent regulatory system with enough flexibility for new technology developments and less political influence. In the case of the Philippines, regulatory policies are better implemented through executive issuances rather than laws because this would allow flexibility with the rapid evolution of biotechnology techniques. This may be slightly vulnerable to political whims, but having a strong scientific community that speaks up its mind would be an advantage. A simplified regulatory process would also encourage many researchers and investors. Furthermore, since most of the GM products are traded internationally, it is better to have harmonized data requirements with trade partners. One useful example is the guidelines presented under the *Codex Alimentarius* for the safety assessment of GM plants. Currently, the new trend is to remove products of gene editing from GMO regulation to democratize technology and encourage investments specifically from the private sector and even smallholder businesses.

There is also a need to establish a strong Information, Education and Communication (IEC) programme with regular activities like social media campaigns to spread the news about modern biotechnology to repeal the active movement against GMOs. This IEC programme must also include a system of open communication lines among policymakers and scientists. It is incumbent on scientists to be more proactive in communicating modern biotechnology by learning how to effectively communicate science and getting involved in science-based policy making. Identifying articulate and respected biotechnology champions among policy influencers would also be very helpful in the communication campaigns.

Another thing that helps in improving public perception and acceptance of biotechnology is having a science policy advisor at the agriculture department/ministry of the country. One who understands the science and its benefits, can also provide direction on how to promote and strengthen biotechnology in the country. It is also useful if that advisor can contribute to drafting science-based policies and monitor their implementation.

Providing incentives for the private sector to invest in modern biotechnology would also be encouraging. This can be done through tax exemptions of payment for research equipment, tax rebates for R&D expenses, provision of experts from the public sector to assist in technology development, promotion of industry and public research partnership, and establishment of a strong IPR protection. It would also be beneficial to establish science parks and business incubators, innovation hubs through PPP, and up-to-date and efficient service laboratories that can be initially funded by the government. And lastly, the establishment of a biotechnology guarantee fund would assure the venture capital invested in biotechnology companies.

Dr Szabolcs Ruthner (ISF, Switzerland), made a presentation on the *"Enabling Policies and their Impact on Genome Editing Related Innovations."* The ISF is the voice of the global seed industry having representatives from over 75 countries around the world including the 58 National Seed Associations that serve as the backbone of the organization.

Policies impact the fields that are to be regulated. The regulatory policy will determine the utilization methods across companies and crops. An overly high regulatory burden will lead to limited utilization of technologies to the largest companies. Thus, resulting in limited utilization to the highest value crops (*e.g.*, corn, soybeans) and a limited number of traits (*e.g.*, herbicide tolerance). To avoid this, it is important to have science-based, consistent policies across countries.

The goals of the global seed sector in the regulatory area around plant breeding innovation are to have a clear, science-based government policy that is consistent across countries or regions that will encourage and facilitate innovation and collaboration.

Genome editing research is diverse and global. There is a wide variety of public and private organizations of all sizes across the globe that are involved. In fact, the first commercialized gene-edited plants such as the high oleic acid soybeans in the US and the high GABA tomato in Japan were developed by two smaller companies. Evidently, genome editing methods are broadly accessible as manifested in the current number and diversity of genome-edited crops under development. These efforts are accelerating global research and crop development which benefits farmers, consumers, and the world.

Based on the Euroseeds Survey on plant breeding innovation, there is a very restrictive policy on targeted mutagenesis on GMOs in Europe. Most of the companies, be it large or small, shifted their product focus to non-EU markets or were moved out of the EU. The top identified factors seen that significantly limit the potential of the use of new breeding methods are the high regulatory costs, legal uncertainty, and future regulations and timelines, as well as the public acceptance under GM regulation. According to the respondents, they would invest if products are not regulated as GMOs but as conventional products.

The regulatory landscape dictates the behavior of developers in investing and conducting R&D activities. This emphasizes the need for a clear, science-based, and consistent policy across countries to maximize the utilization of crops and breeding methods. The latest breeding methods provide opportunities to target global challenges as well as the local needs, and can help in achieving sustainable agricultural production and food security.

Dr Laurie Goodwin (CLI, USA), made a presentation on *"Regulatory Harmonization Approaches to Reduce Cost of Products and Facilitate Trade."* CropLife International champions the role of plant science technology and the part that it can play in delivering sustainable food systems for the future. With its 25 years of experience, the association has demonstrated the benefits of several GM products including safe commercialization, safe use, and safe cultivation and trade. Some benefits are yet to be realized since there are still challenges in bringing these beneficial products to the market. Nonetheless, once these GM products have proven their benefits, they can help to deliver sustainable goals such as food security, improvements in biodiversity, and drought-tolerant crops that can help mitigate the challenges of climate change.

With the unpredictable regulatory systems, there will always be delays in the advancements of innovations which can decrease the amount of innovation and R&D that goes into a particular technology. Technology developers are developing innovations that can contribute to food security without compromising biodiversity. Predictable, science-based regulatory systems are critical to delivering these innovations to the market.

In terms of the product development timeline, it takes an average USD 130 M investment in over 13 years to get a GM crop to market. Technology developers have improved and become more efficient in the R&D and testing phases prior to product approval and commercialization. Over the last decade, regulatory requirements and registration time, and costs have significantly increased (at least 50%).

There is a tremendous opportunity in terms of the redundancy of the regulatory cooperation in the way safety assessment is being done by different regulatory agencies. One example is the average number of times a product gets food safety approvals like in corn (9x) and soybean (12x). The lack of safety assessment sharing leads to the same product being approved by multiple regulatory agencies. Popular events often with the same data package undergo food safety assessments by multiple regulatory authorities and eventually reach the same safety conclusion, as evident with GM corn and soybean which was evaluated and approved by 24 and 22 countries, respectively. Moreover, numerous products have the same inserted gene and express the same specific protein. This means that individual genes, and the proteins they produce, are often reviewed for safety hundreds of times (*i.e.*, CP4 EPSPS gene was used in 26 events and was approved 247x in different countries).

Given that there is a strong record of the safety and benefits of GM crops, there is a need to harmonize the benefits across stakeholders to promote innovation and appropriate resource allocation leveraging in the current global momentum. CropLife International has embarked on the Harmonization Project which promotes collaboration across industry experts in many scientific disciplines to provide aligned recommendations for safety assessments and encourages regulatory cooperation. The initiative includes consistent criteria from governments; data transportability; regulatory cooperation through trade agreements; safety assessment sharing; streamlined approval process based on approvals in trusted countries; mutual recognition; and alignment on data requirements that the industry must submit.

After more than 25 years of safe use and numerous benefits to farmers, consumers, and the environment, there is a need to review the safety assessment process for GM crops and apply a modernized approach. The industry recommends the inclusion of core studies (*i.e.*, molecular characterization, protein expression, characterization, and safety) and the use of a problem-formulation approach to identify hypothesis-driven supplementary case-by-case studies.

Technical Session 2: SUMMARY & KEY RECOMMENDATIONS

- New breeding methods help to achieve sustainable agricultural production and food security and address national and global concerns.
- However, developments may be delayed due to lengthy and costly regulations. There is also a lack of consistency, sharing, and mutual recognition of assessment criteria that leads to redundancies in the regulatory process.

Key Recommendations:

- Prioritize investment in R&D
- Promote collaboration among local and international scientists
- Establish/enhance Information, IEC and capacity-building programmes to raise awareness about modern biotechnology
- Revisit and refine the risk assessment procedures and criteria
- Develop clear and science-based policies, streamline the regulatory process, advocate for the sharing and mutual recognition of safety assessments, and promote regulatory harmonization across the region to maximize the utilization of crops and harnessing the benefits of new breeding methods.

TECHNICAL SESSION 3

PANEL DISCUSSION ON SCOPING INVESTMENTS IN MODERN AGRICULTURAL BIOTECHNOLOGY

Chair	:	**AK Singh,** IARI, India
Co-Chair	:	**Ram Kaundinya,** FSII, India
Rapporteur	:	**Farah Sevilla,** DOST-PCAARRD, Philippines

The third session consists of six presentations from a panel group to discuss the scoping investments in modern agricultural biotechnology highlighting several innovative funding mechanisms. The proceedings of Technical Session 3 are mentioned as below:

Dr Shivendra Bajaj (FSII, India), discussed the innovative funding mechanism of the *"National Public-Private Partnerships."* The FSII is an association that is committed to increased investment in seed research to bring better products to farmers for improving farm productivity and income. FSII also has joined the Alliance for Agri-Innovation which aims to bring greater investment into agricultural biotechnology by crafting a favorable environment and contributing towards food security and sustainability by increasing crop productivity and conserving biodiversity through efficient and effective utilization of agricultural resources.

Dr Bajaj shared his views on how the national PPP should be organized as its success relies on the certainty of the collaboration and commitment of each party especially in terms of the sharing of resources and revenues for the smooth completion of the project. As suggested, PPP should be a partnership of equals. It is also critical to have reliable regulatory policies. PPP in agricultural biotechnology is even more important to have regulatory certainty since product development is very time-consuming and extremely expensive. Biotechnology has more political and public perception challenges than scientific and technical challenges. Therefore, committed participation from the public sector is even more critical. For example, the public sector needs to contribute the availability of germplasm especially in the open-pollinated crops, an extensive network of educational facilities, research sites, infrastructure, and human resources. On the other hand, the private sector has elite germplasm lines, huge infrastructure, technical manpower, intellectual property rights, regulatory capabilities, technical and commercial launch experience, and more importantly, a focused vision of product development. Usually, the private sector identifies the need for the development of a product.

To ensure the success of PPP in agricultural biotechnology, it is proposed that the government or the appropriate public sector organization identify an agricultural problem of national importance that can be addressed by biotechnology interventions (*i.e.*, GM or gene editing). The public sector must commit to a fast-track, pre-defined, predictable, science-based process, which if scientifically conducted, will not be delayed due to policies (or lack of it) or so-called public perception issues. The public sector provides the genetic resources and access-benefit-sharing waivers that work with the state governments.

Meanwhile, the private sector should commit to provide the technology and waive off the IP specific to the crop or trait, to commit their research infrastructure and technical manpower, to provide capacity building of relevant public sector scientists, to prepare regulatory data and submit dossier, to provide market-related knowledge including any relevant global export, and import data to guide the R&D and its approval.

Both parties must commit to provide clarity in IP sharing, funding, exchange of infrastructure resources (public sector to provide field infrastructure, private sector to provide laboratory resources), ownership of the regulatory data, stewardship commitment, and freedom to use the technology in their programmes.

PPP can succeed if the trust deficit between the two parties is bridged. Commitments from both parties are of utmost importance beside from having well-defined regulatory policies. The benefits from the developed technology can be fully attained if both parties will work harmoniously together.

Dr Tomiko Yamaguchi (ICU, Japan) and **Dr Mai Tsuda** (UT, Japan), shared the experience of Japan in terms of its *"Consortium Approach for Public-Private Partnership for Commercializing Genome Editing Technologies."* The PPP has made it possible to achieve goals, mobilize resources, and identify required expertise and overcome challenges in developing promising modern biotechnology products. These collaborative networks would help to lay the ground necessary for innovation and bring efficacy to the government-regulated product development process.

The consortium approach has enabled the multi-disciplinary mobilization of knowledge by bringing in experts from different scientific and social disciplines. It has played an important role in addressing issues in the public domain such as social acceptability issues, public perception, and scientific literacy challenges that are beyond the capacity and resources of a single organization.

In Japan, there are several scientific consortia for gene-edited crops and animals including the OPERA Programme funded by Japan Science and Technology Agency and the SIP funded by the Cabinet Office. These programmes are mission-oriented wherein programmes have social-challenged-based priorities that steer activities towards goals as guided by the central government bodies. One of the important goals of the consortia is to address social acceptability issues by facilitating interactions among various stakeholders in the public domain. This includes a wide variety of activities such as the development of textbooks for school children, and websites like *Biostation* and *What is Gene Editing Technologies* which contain the glossary of gene editing technologies and message map. Likewise, the consortia conduct studies on consumer perceptions and contents of news reports. There are also dialogue programmes among stakeholders.

Some gene-edited agricultural products developed in Japan include GABA tomato, potato with reduced toxic and bitter contents, and red sea bream with increased skeletal muscle mass. Japan focussed on addressing negative public perception about gene editing technologies, through social media campaigns and engagements.

Japan's experience on the consortium approach on PPP suggested that such partnerships can play a vital role in interacting with members of the public who have some reservations about gene editing technologies and with those who are indifferent.

Dr Bharat R. Char (Mahyco, India), discussed the *"Regional Public-Private Partnership"* in the case of Bt brinjal. Since 2003, Mahyco has been working on Bt brinjal. It had donated its Bt brinjal technology (cry1Ac event EE-1) free-of-cost to use by the ABSP II project partners. The EE-1 was incorporated into partner germplasm by the ABSP II partners at Mahyco facilities and further developed by the ABSP II partners at their respective locations. The EE-1 event was also incorporated into ABSP II partners' self-pollinated varieties. The intention was to distribute the seeds at nominal cost by the public partners to resource-constrained farmers so that the farmers would be able to save and re-sow the seeds. No royalty of fees was to be paid to Mahyco for the technology by the public partners.

The Mahyco's EE-1 event entered into partner material from 2003 to 2006. There are several participating countries including India, Bangladesh, the Philippines, and the USA. In 2007, the large-scale trials of Bt brinjal started in India. By October 2009, Genetic Engineering Approval Committee (GEAC) declared Bt brinjal as biosafe, however, it left the decision of commercialization with the Minister of Environment, Government of India.

From the success of the implementation and adoption of Bt brinjal, it was evident that the synchronous work of the partners has paved the way for this success. There is a need of harmonization among the countries, as well as enabling policy environments. Using all available tools in the toolkit, and application of next-generation technologies is advantageous once utilized properly and efficiently. Overall, the stewardship of all partners has made it possible to successfully adopt the technology.

Dr Mahaletchumy Arujanan (MABIC, Malaysia), discussed the importance and impact of the *"Investment in Knowledge Management and Communication."* For over three decades, International Service for the Acquisition of Agri-biotech Applications (ISAAA) has collaborated with numerous partners across the globe on several initiatives on knowledge sharing and communication in agricultural biotechnology. This leads to the increased development and adoption of home-grown agricultural biotechnology, intensified food security and sustainable development, established science-based policies and regulations, reduced disruption of trade, raised public understanding and acceptance, and boosted women and youth participation.

There are several hurdles in communicating agricultural biotechnology and its safety that have made adoption very difficult. One of the constraints is the lack of funding for knowledge transfer and product knowledge dissemination. While there is funding support on the R&D, there is little or none at all that is allotted for knowledge management. This must be addressed as scaremongering activists composed of more than 500 formal and informal non-profit organizations have a collective annual expenditure of USD 2.5B which they use to advocate against GM. Thus, there is also a need to train more science communicators that would help promote agricultural biotechnology and rebut the seeds of doubt against it. Moreover, donors must look at the bigger picture and not always demand immediate return. They need to understand that creating a strong foundation is necessary to get more support from the public and private sector on the development and implementation of science-based regulations.

ISAAA recommends forming alliances among like-minded organizations not just to feed the world with food, but also with knowledge on agricultural biotechnology. Also, there is a need to change the public perception of private collaborations. ISAAA's efforts in managing knowledge and communicating agricultural biotechnology can be found on their websites, newsletters, webinars, and other downloadable materials that they have produced.

Dr Sanjay Saxena (BIRAC, India), shared activities of Biotechnology Industry Research Assistance Council (BIRAC) and how it is affected by the *"Stakeholder-Driven Funding Mechanism."* BIRAC is a non-profit company under the Department of Biotechnology (DBT), Ministry of Science and Technology in India which supports start-ups, entrepreneurs, and SMEs to develop innovative affordable biotechnology products and technologies to address the needs of the country.

Since 1986, the DBT has supported various researches to empower, enable, and accelerate the biotechnology innovation ecosystem in India. However, much of the support was directed towards the academic institutions or other public sector institutions, and not much was provided to the private industry. Thus, BIRAC was established in 2012 to address this gap and objectively guide innovators and investors from ideation (TRL 1) through commercialization (TRL 9). There are varying funding schemes available that students, researchers, entrepreneurs, and start-ups can avail to provide support from ideation to laboratory activities and on to the market release.

The Small Business Innovation Research Initiative (SBIRI) was India's first biotechnology funding scheme to promote PPP. It was launched by the DBT in 2005. SBIRI aims to facilitate early-stage research, support high-risk innovative research, strengthen R&D capabilities and capacities, create opportunities, and bring together the private industry, public institutions, and the government to promote research and innovation in the biotechnology sector. The funds are provided in the form of grants for research and capacity building, and the IPR remains with the industry partner.

Then in 2009, another PPP scheme called Biotechnology Industry Partnership Programme (BIPP) was launched to support research up to validation, scale-up, demonstration, and pre-commercialization of products and technology. This includes product evaluation and validation, as well as the setting up of required facilities. The endpoint of the research study is TRL 7 or higher. Unlike the previous scheme, the support grant was equally divided by BIRAC and the partner company.

To further stimulate ideas up to the proof-of-concept stage, the Biotechnology Ignition Grant (BIG) was eventually launched to foster the generation of ideas with commercialization potential. The scheme is currently managed through BIG partners who work with the grantees to provide mentoring, monitoring, networking, and other business development-related activities.

Another programme is the Social Innovation Programme for Products: Affordable & Relevant to Societal Health (SPARSH) Centres for Social Innovation Immersion wherein a pool of social innovators or fellows identify and address the social problems through biotechnological interventions. The Agri-Innovation Immersion Programme (AIIP) is another scheme in the pipeline that aims to create a pool of agri-biotech fellows and innovators who can identify the needs and gaps that exist in the agricultural sector in various agro-climatic regions and then help bridge those gaps through biotechnological and related interventions.

Another scheme is the Empowering Youth for Understanding Value-Added Innovative Translational Research (E-YUVA) which aims to promote a culture of applied research and need-oriented entrepreneurial innovation among students and researchers. There is also the programme on Promoting Academic Research Conversion to Enterprise (PACE) that has two components, namely, Academic Innovation Research (AIR) which promotes the development of proof-of-concept by academia with or without the industry involvement, and Contract Research Scheme (CRS) which aims at validating the processor prototype of the academia by the industry partner.

Other schemes were developed depending on the foreseen requirements of the stakeholders. This also includes the Product Commercialization Program Fund (PCP-Fund), Sustainable Entrepreneurship Enterprise Development (SEED) Fund, Launching Entrepreneurial Driven Affordable Products (LEAP) Fund, and Accelerating Entrepreneurs (AcE) Fund.

BIRAC also supports the provision of incubation space, equipment, mentorship, and networking through its programme Agri-BioNEST Bioincubators, and also provides advisory and financial support to safeguard the IP and various technical management services through a programme called BIRAC-PATH (Patenting and Technology Transfer for Harnessing Innovations). Likewise, BIRAC has a facilitation unit to address the queries of start-ups, entrepreneurs, and researchers among others through its Biotech FIRST HUB programme.

There are a lot of challenges faced by the industry including fewer start-ups or companies operating the field of agricultural biotechnology. This may be due to the long gestation period, lack of appropriate infrastructure, vagaries of the weather, and technical and IPR challenges. The general reluctance of investors also hinders the investment in companies at early-stage research. There is also a lack of a multi-disciplinary approach that results in delays in securing regulatory approvals and clarity on guidelines available. Affordability is also an issue because of the high cost of innovation. Likewise, farmers' acceptance adversely affects the commercial viability of the technology.

This can be dealt with long-term funding, clarity on regulatory requirements, and synergy among local and international partners. The process of the regulatory framework for new technology should start along with the initiation of research activities. The IPR associated with the commercial use of a particular foreign technology by a single nodal agency must also be resolved for the smooth development and transfer of technologies. Moreover, there is also an urgent need to change public perception towards agricultural biotechnology and a need to build an environment conducive to promoting entrepreneurship in agricultural biotechnology.

Dr Rhodora Romero-Aldemita (ISAAA, Philippines) shared briefly the efforts made by ISAAA on *"Investment in Capacity Building, Awareness and Policy Advocacy."* ISAAA is making an effort to ensure that the economic benefits of biotechnology crops are realized through effective communication. The benefits include an increase in crop productivity of about USD 225 B, a better environment, and poverty alleviation, among others.

There is a need to have to enable biotechnology policies and regulations. According to Andrew Roberts, there should be a "Gold Standard" regulation for agricultural biotechnology that is predictable, transparent, and efficient. The regulations must cater to the appropriate protection goals and define requirements and criteria before applications are received. This espouses clarity on the purpose of risk assessments and why such requirements must be complied with.

ISAAA has conducted several capacity-building activities, specifically training workshops on biotechnology policies and regulations across its partner agencies and institutions from various countries. In 2019, they have assisted the biotechnology policy development in Myanmar wherein several workshops were conducted to discuss the policy objectives, decision process, and key roles of relevant agencies. This resulted in the completion of the final draft of the country's national biosafety framework. Currently, the next steps include the formal launch of the framework, setting up of biotechnology information portal, stakeholders forum, and risk assessment workshop. Moreover, a three-day virtual training workshop on biotechnology animals for Philippine regulators was conducted in 2020 to support the crafting of the country's regulation on animal biotechnology. Several resource speakers from Latin America, Australia, and the USA were invited.

The Organization also provided institutional support and capacity to young, dynamic, and science-trained researchers, policymakers and regulators, managers, and communicators. They invested in the Progressive Manpower Enhancement Programme focused on building core technical and leadership competencies in biotechnology R&D, policy and regulation, management, and communication. There are also Asian Short Courses on Agri Biotechnology and Biosafety (ASCA) conducted annually, and Science Communication Workshop for Scientists and Academics of Myanmar conducted in 2020.

Furthermore, ISAAA has a continuous public information and outreach programme that aims to build alliances and reinforce knowledge, understanding, and acceptance of crop biotechnology. It intends to raise awareness on biotechnology including the existing regulatory system, R&D, and commercialized biotech crops while targeting all stakeholders, farmers, media, and academe alike, in as many ways as possible. Their strategies include the conduct of symposia/workshops and exhibits, the development and distribution of IEC materials, and maximizing social media campaigns.

ISAAA will continue helping developing countries while ensuring continuous benefits of biotechnology are realized. Although, the political will is a strong force that can indicate the adoption and acceptance of biotechnology and its products, ISAAA intends to continue its investments and efforts to reach, inform and influence as many audiences as possible.

Technical Session 3: SUMMARY & KEY RECOMMENDATIONS

- Public-private partnerships (PPPs) are one way to ensure investments in modern agricultural biotechnology as in the case of India, Japan, Malaysia, and the Philippines.
- Through science communication, we can create and nurture effective public-private and private-private partnerships and/or scientific consortia at the national and regional level, and establish consolidated effort in fostering R&D activities.
- Enabling policy environments, supporting research institutions, and reaching out to the public are avenues where benefits of biotechnology can be communicated.

Key Recommendations

- An enabling policy environment is a key for building multi-stakeholder partnerships on agri-biotechnology
- Invest in knowledge management and communication, capacity building of scientists and prospective researchers, and supporting start-ups
- Work on changing public perception towards acceptance of crop biotechnology products and for policy advocacy
- To ensure continuous economic benefits from agri-biotechnology, policies should meet the "Gold Standard" — predictable, transparent, and efficient
- Maximize multi-stakeholder initiatives through the partnership of equals — the certainty of the collaboration and commitment of each party towards the completion of projects.

CONCLUDING SESSION

Chair : **Ravi Khetarpal,** APAARI, Thailand
Co-Chair : **Chih-hung Lin,** COA, Taiwan
Rapporteur : **Ian Bernard Ines,** DOST-PCAARRD, Philippines

Mr Ian Bernard Ines (DOST-PCAARRD, Philippines), formally presented the draft of overall summary and recommendations emerged out from the technical sessions. He highlighted that agriculture plays a significant role in the economy for the countries along the Asia Pacific region but there were challenges in attaining sustainable production of agricultural products such as climate change, increasing population, health, and environment-related issues, among others. Evidently, agricultural biotechnology is a modern solution that has been proven to: (a) improve farm productivity, (b) enhance capacities, (c) generate revenues and employment, and (d) promote food and nutrition security and environmental sustainability. However, to broaden the knowledge and strengthen the efforts toward agricultural biotechnology in the region, the following are necessary:

- Prioritization of public and private investments towards agricultural biotechnology;
- National and Regional (Asia-Pacific) R&D collaborations and/or partnerships;
- Capacity-building activities focusing on crop development and varietal improvement using new breeding techniques (NBTs);
- Investment in knowledge management and communication to promote biotechnology and address political and social concerns;
- Development of agricultural biotechnology-focused roadmaps for crop production; and,
- Harmonization of biotechnology regulations across the region.

One participant was keen to ask for APAARI's next step for the big picture after the workshop. To address this, Dr Ravi Khetarpal responded that APAARI intends to take gradual movements and actions. Upon consolidation of all the recommendations, APAARI will take the lead in identifying its next steps in carrying the recommendations forward. The big picture must be a joint, integrative effort which may probably take some time and will be challenging. Nonetheless, APAARI is committed to taking action and making a change.

Dr Chih-hung Lin (COA, Taiwan), delivered the concluding message for the two-day virtual regional workshop. He recognized the success of the workshop with the very fruitful recommendations that were raised. The activity provided a platform for all the participants to have an overview of investments in agricultural biotechnology R&Ds by public and private sectors and their impacts in the region. There was wonderful sharing of views on investments in modern agricultural biotechnology and case studies on different crops in different countries during the workshop. From these cases, some solutions could really make a difference for farmers and growers. After the two-day workshop, he hoped that all the participants have obtained some useful knowledge and information about investment in modern agricultural biotechnology and will be able to understand further the interesting foundation for enhancing the investment in agri-biotechnology. Bearing such ideas in mind, he hoped that the participants from various organizations and institutions can contribute more to assure many great developments in agricultural biotechnology. Finally, he extended his appreciation to all the speakers and participants for their active participation.

Dr Ravi Khetarpal (APAARI, Thailand), acknowledged the very rich, engaging, and educative sessions from the two-day virtual workshop. A lot of recommendations had come up that are useful to all the partners, global organizations, and institutions, as well as for APAARI. In delivering his concluding remarks, Dr Khetarpal shared some of his notable observations from the two-day workshop:

1. The investment in modern biotechnology is showing its impact. That is very clear in the first technical session. However, the investment from the public sector as presented by Dr Tyagi is something that must be highlighted to the global community so that it can be scaled up;

2. In the Bt impacts presented in the second technical session, be it brinjal, canola, maize, or cotton, some examples linked the impact on to the small farmers' socio-economic life and their livelihood. However, there were not many studies on the impact that provides much information on the livelihood and socioeconomics of the smallholder farmers. This is a very important and very active area that needs a lot of homework;

3. On policies, the challenges will only be dealt with and addressed with appropriate and proper communication and knowledge management on agricultural biotechnology. This was evident with the efforts of CLI and many private players. Most developing countries still have regulatory challenges on biotechnology. Unfortunately, there is a lot of investment in the negative propaganda of biotechnology rather than on its positive side. Thus, it is important to consider how this can be reversed. Based on the presentation of Dr Saxena, the 50-50 investment schemes of public sector and private companies are great for biotechnology investment and can be beneficial for the academician, entrepreneur, innovators, SMEs, and practically anyone. A closer look into the details of this model should be done and see if this model can be replicated in other countries, specifically in the Asia-Pacific who are still in the initial stage of biotechnology or who are just scaling up their biotechnology activities;

4. The importance of the capacity building was effectively highlighted by ISAAA. Definitely, it is an area that needs attention. It is necessary to be innovative even in capacity building. Building technical capacities must be blended with the functional capacity. This is something that is missing at the global level in most of the projects. In APAARI, it is intended to build technical capacity while ensuring to use the model of developing capacity from the functional angle (soft skills) so that people can effectively use this for more strategic processes, policy intervention to navigate complexities, reflection, learning, and collaboration. There is a need to ensure that there is a blend of technical and functional capacity which may have more impact. APAARI is open for discussion to support anyone and help some global projects in blending technical and functional capacities;

5. Looking at the global funding scenario from several funding and/or donor institutions and organizations, there is no donor as of today that wants to do some funding only on one given subject. However, people who are working in the field of biotechnology need to have an integrative project. There is a need to have a clear integrative project where biotechnology, its use, and issues of biosafety of GM crops are consolidated. A global level integrative project must cover scoping development, management, and implementation. When developing a biotechnology product, there should be technical research and testing process to ensure biosafety, and at the same time include plans for knowledge management and right communication. Regular and proper science communication which is understood by both policymakers and civil society must be anchored with the development of new biotechnology products. Never make a stand-alone biotechnology project because it must be linked with all the processes including all the approval up to

the impact on smallholder farmers and on the national economy. Researchers and investors need to be smart in making projects in one place to avoid problems later specifically on the adoption;

6. Thus, there is a need for a regional or global consortium of private sectors funding the public sector biotechnology research. A consortium with a more innovative funding system that can trigger regular investment in biotechnology research. This may help researchers who do not have enough funding.

Overall, there is a need to change the mindset on how individuals and organizations/institutions/agencies deal with biotechnology and biotechnology investment. Dr Khetarpal thanked all the speakers and participants who attended and deliberated during the workshop.

Mr Jack Lin (APAARI, Thailand), proposed a vote of thanks to all the organizers and collaborators, Chairs and Co-chairs of all sessions, speakers and panelists, participants, rapporteurs, and the APAARI Secretariat and technical team.

Major Recommendations

Over the years, the evolution of agri-biotechnology from selection breeding to precision breeding including genomic selections, GM technologies, and gene editing has paved the way to new and improved methods of agricultural crop production. Biotech crops contributed significantly towards achieving Sustainable Development Goals (SDGs), from alleviating poverty and hunger, mitigating climate change, protecting the environment, securing food, feed and fiber, up to conserving biodiversity. Despite the proven socio-economic benefits and efforts made in the Asia-Pacific region, it is evident that massive under-investment in agricultural biotechnology exists in most developing countries.

The deliberations held during the workshop brought forth many important issues that need immediate attention to enhance the investment to harness the maximum potential of agricultural biotechnologies for improving livelihoods of farmers in form of following recommendations:

Prioritization of Areas for Investment

1. **Research** areas should be prioritized/identified by developing an agricultural biotechnology-focused road map for crop production at national/regional level as per their needs, capacities and infrastructure to attract the donor for investment;
2. **Knowledge Management and Communication** is an important area where more investment is needed to promote agri-biotechnology by addressing political and social concerns, and long-term benefits through enhanced information, education and communication (IEC);
3. **Investment in public awareness** is equally important to demystify the pre-conceived myths and explain various concepts and advantages of the biotech products using all media platform and clarity to avoid any mis-trust or mis-information and negative public perception with scientific evidence-based information before any harm is done to either producers or consumers;
4. Revisit and refine the **risk assessment guidelines** at national level considering the biosafety research conducted at regional/global level to save resources by avoiding repetition to conduct the same biosafety trials (same crop/trait) in several countries to get same results;
5. Investment is required for **capacity building** (technical and functional capacities) of scientists, prospective researchers, policy-makers, and young biotech entrepreneurs to adopt more strategic processes and policy intervention to navigate complexities, learning and collaborations/partnerships;

Innovative Partnerships for Enhanced Investment

6. **Public-private partnership** (PPP) is one way to ensure investments in modern agricultural biotechnology. Through science communication, there is a need to create and nurture effective public-private and **private-private partnerships** to establish scientific consortia for fostering R&D activities at the national and regional level;
7. To develop synergies and **co-investment** by the organizations in modern agri-biotechnology, collaborations among local and international scientists and institutions (South-South and North-South)

need to be promoted by creating enabling policy and research environment and empower the research community;

8. **Multi-stakeholder** initiatives through the partnership of equals with the certainty of the collaboration and commitment for investment by each party (public and private both) towards the completion of projects and adoption of the products should be maximized;

9. Both parties must commit to provide **clarity in IP sharing, funding, exchange of infrastructure resources** (public sector to provide field infrastructure, private sector to provide laboratory resources), ownership of the regulatory data, stewardship commitment, and freedom to use the technology in their programmes;

10. There is a need to develop **Integrative Project** through collaborations where use of biotechnology and issues of biosafety including scoping development, knowledge management and communication, impact on smallholder farmers and national economy are consolidated to avoid problems later specifically for adoption of the biotech products;

11. **A Global/Regional Consortium** of private sectors with a more innovative funding system that can trigger regular investment in biotechnology research to fund the public sector biotechnology research in partnership mode is needed to help researchers.

Enabling Policy Development

12. To ensure continuous economic benefits from agri-biotechnology, policies should meet the "**Gold Standard**"— predictable, transparent, and efficient; and

13. It is important to: (i) develop clearly streamlined science-based and consistent **Regulatory Policies** for risk assessment and long-term investment in biotechnology at national/regional level; (ii) share and mutually recognizethe biosafety assessment data; (iii) promote regulatory harmonization across the region to avoid delay due to lengthy and costly trials, and; (iv) maximize the utilization of crops for harnessing the benefits of new breeding methods in order to enhance the trade between the countries in the region.

List of Resource Persons

TECHNICAL SESSION 1A

INVESTMENT STATUS AND IMPACTS IN MODERN AGRICULTURAL BIOTECHNOLOGY

Dr Krishna Ravi Srinivas

Senior Fellow & Consultant, Research & Information System for Developing Countries, New Delhi, India

Dr Krishna Ravi Srinivas is a Senior Fellow & Consultant with RIS, a policy research think tank based in New Delhi. He researches inter alia, Science, Technology and Innovation, and, Science Diplomacy. He was a Fulbright Fellow at the University of Pennsylvania, Visiting Scholar at Indiana University, Bloomington, and Post-Doctoral Research Fellow at South Center. He is coordinating research projects sponsored by UNESCO, FAO on biotechnology in Asia-Pacific. He has co-edited a book on Socio-Economic Considerations regarding GM crops. He is Editor of Asian Biotechnology & Development Review (ABDR) an international, peer-reviewed, open-access journal. Currently, his focus is on the governance of synthetic biology, genome editing, DSI, and gene drives.

Dr Rishi K. Tyagi

Coordinator, Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources, APAARI, Thailand

Dr Rishi K. Tyagi is working as Coordinator, Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB), APAARI, Bangkok, Thailand. Dr Tyagi holds a Ph.D. degree in Botany from the University of Delhi, Delhi, India, and a Post-Graduate Diploma in Intellectual Property Rights laws from the Indian Law Institute (Deemed University), New Delhi, India. Dr Tyagi worked as a Post-Doctoral Research Associate at the University of Illinois, USA, employing biotechnological methods for wide hybridization in soybean. He worked as Head of the National Genebank of India. Currently, he working for enhancing the use of biotechnologies for sustainable agricultural development in the Asia-Pacific region through greater stakeholder partnerships, an improved policy environment, enhanced capacity building, and greater public awareness.

Dr Rajeev K. Varshney

Research Program Director – Accelerated Crop Improvement & Director – Center of Excellence in Genomics & Systems Biology, ICRISAT, India

Dr Rajeev Varshney is an agricultural research scientist specializing in genomics and molecular breeding with 20+ years of service in developing countries in sub-Saharan Africa and Asia. He is a globally recognized leader for his work on genome sequencing, genomics-assisted breeding, and translational genomics in legume and cereal crops, and capacity building in developing countries in Africa and India. He has initiated and led major international programmes that are creating and delivering superior crop varieties to some of the world's poorest farmers.

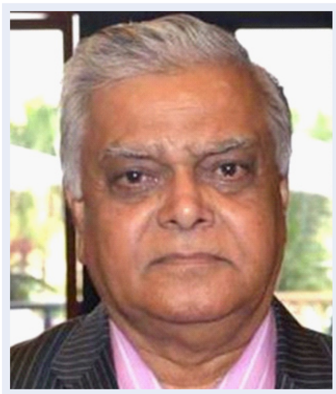
TECHNICAL SESSION 1B

CASE STUDIES: INVESTMENT AND IMPACT

Dr M.A. Yousuf Akhond

Chief Scientific Officer (Head of Biotechnology Division), Biotechnology Division, Bangladesh Agricultural Research Institute (BARI), Bangladesh

Dr M.A. Yousuf Akhond is Chief Scientific Officer and the Head of Biotechnology Division at BARI. Dr Yousuf has more than 28 years of research experience at BARI. He obtained his PhD degree from University of Dundee, UK for his research at the Scottish Crop Research Institute and he later acquired post doctoral research experience from Science and Advice for Scottish Agriculture. Dr Akhond was instrumental in establishing a modern biotechnology research facility at BARI and has been involved with the introduction of Bt eggplants and late-blight resistant potato in Bangladesh. He has wide experience in crop improvement research beginning with plant breeding through diferent areas of biotechnology.



Dr C.D. Mayee, SABC, India

President, South Asia Biotechnology Centre, India

Dr C.D. Mayee is well-known cotton scientist and currently serving as President, SABC and Chairman AFC Ltd., Mumbai. Dr Mayee worked in various capacities including Director, Cotton, Vice Chancellor, Agriculture Commissioner and Chairman, ASRB, New Delhi. He was instrumental in release of the first biotech crop; Bt cotton in India. A firm believer of new technologies, Dr Mayee served various committees of Government of India and was also Vice President of National Academy of Agricultural Sciences. After superannuation, he is closely working with farmers to improve their income from farming. Recently his work of Fall Army Worm of maize creating pan-India awareness has been internationally acclaimed.

Dr Leonardo A. Gonzales

Founder President and Chairman, Society Towards Reinforcing Inherent Viability for Environment (STRIVE), Inc., Philippines

Dr Leonardo A. Gonzales obtained his PhD in Agricultural Economics from the University of Tennessee under a Fulbright-Hays Scholarship. He was a former Liaison Scientist for Asia cum Research Fellow of the International Food Policy Research Institute, USA, and Agricultural Economist of the International Rice Research Institute. he has a vast experience in the field of biosafety, having served as the Community Representative of the National Committee on Biosafety of the Philippines (NCBP) from 2000 to 2008 and of the DOST-Biosafety Committee from 2009 to the present.

Dr Graham Brookes

Agricultural Economist, PG Economics Ltd, UK

Dr Graham Brookes is an agricultural economist and consultant with more than 30 years' experience of examining economic issues relating to the impact of technology, policy changes and regulatory impact. He has, since the late 1990s, undertaken a number of research projects relating to the impact of agricultural biotechnology and its regulation and written widely on this subject in peer reviewed journals. He has also undertaken a number of recent country-specific analyses of the possible impact of no longer using glyphosate in agriculture.

Mr **Osman Mewett**

Chief Executive Officer, Australian Seed Federation, Australia

Mr Osman Mewett leads the overall management and operations of the Australian Seed Federation (ASF). Prior to joining the ASF, for seven years Osman effectively led CropLife Australia's policy, advocacy and regulatory reform activities relevant to the Crop Biotechnology sector in Australia. Osman holds a Bachelor of Science with first class Honours in plant molecular biology and a Bachelor of Laws, both from the Australian National University. He is a Graduate Member of the Australian Institute of Company Directors and Chairs the Board of the Pasture Trials Network. He is a non-Executive Director of the Boards of the Australian Crop Accreditation System, and the Grains Industry Market Access Forum.

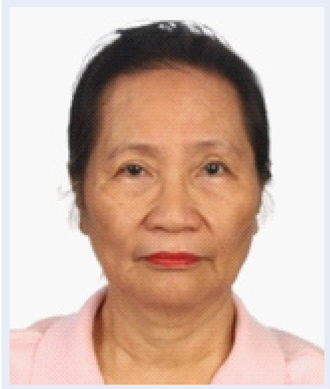
Dr Martin Lema

Adjunct Professor, National University of Quilmes, Argentina

Dr Martin Lema is Adjunct Professor in the Biotechnology School of the National University of Quilmes, Argentina, with 20 years of academic experience in teaching, research, technology transfer, and entrepreneurship. Besides, he counts with 15 years of experience as a policymaker in agricultural biotechnology, being appointed as former Director of Biotechnology and Chair of the National Advisory Commission for Agricultural Biotechnology. He accounts for more than 30 technical and scientific publications in different aspects of biotechnology.

TECHNICAL SESSION 2

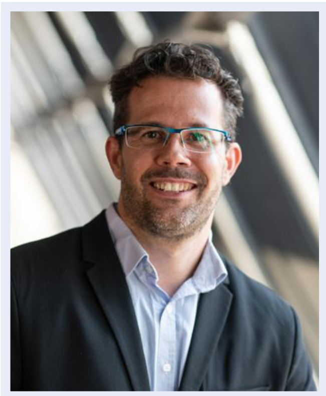
IMPACTS OF ENABLING POLICIES FOR ENHANCED INVESTMENT



Dr Saturnina Halos

Senior Technical Advisor, Department of Agriculture, Philippines

Dr Saturnina Halos helped craft the biotechnology policies and programmes of the Department of Agriculture and monitor their implementation since 1999. She currently serves the Department as Chair, Technical Advisory Group for Modern Biotechnology and Innovations; Chair, Technical Committee on Applied Biotechnology Research and senior technical adviser to the Climate Resilient Agriculture Office. Dr Halos is a former professor in molecular biology and biotechnology at the University of the Philippines, Diliman. She established the first functional forensic DNA analysis laboratory that led to the acceptance of DNA evidence by the Philippine Supreme Court. She holds a Ph.D. in Genetics from, University of California, Berkeley, and a BS in Agriculture from the University of the Philippines.

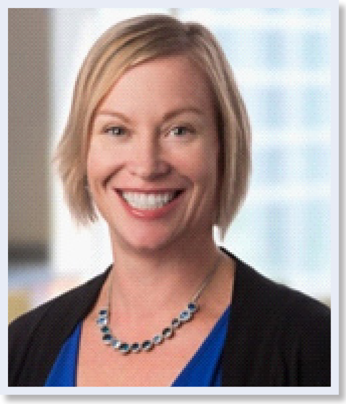


Dr Szabolcs Ruthner (Szabi)

Regulatory Affairs Manager at International Seed Federation, Switzerland

Dr Szabolcs Ruthner, a Hungarian national, graduated from Corvinus University in Budapest where he completed a Ph.D. degree in molecular plant breeding. In 2004 Szabi joined the Hungarian Seed Association (HSA) as a professional assistant and in 2006 he was appointed to the position of Secretary-General.

He started working at the International Seed Federation as Regulatory Affairs Manager in February 2015. He works on various seed-related regulatory and policy issues with a major focus on the policy developments around the latest breeding methods such as genome editing.



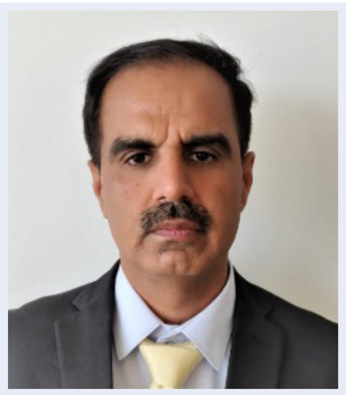
Dr Laurie Goodwin

Vice-President, Public Affairs and Communications, CropLife International, USA

Dr Laurie Goodwin is Vice President, Public Affairs and Communications for CropLife International. She leads a team responsible for the association's public affairs and communications agenda on a range of global priorities. In her previous role as Director of Regulatory Affairs for Plant Biotechnology, she was responsible for facilitating the CropLife International global regulatory strategy by working with and synchronizing efforts of regional networks and regulatory teams. Before joining CropLife International Laurie spent almost 15 years with Syngenta where she held roles in both research and development and stakeholder relations and government affairs. Laurie is currently based in Washington, D.C.

TECHNICAL SESSION 3

PANEL DISCUSSION ON SCOPING INVESTMENTS IN MODERN AGRICULTURAL BIOTECHNOLOGY



Dr Shivendra Bajaj

Executive Director, Federation of Seed Industry of India (FSII) and Alliance for Agri Innovation (AAI)

Dr Shivendra Bajaj holds the office of the Federation of Seed Industry of India (FSII) &the Alliance for Agri Innovation (AAI) as the Executive Director. He drives public policies, advocates for the adoption of seed and biotechnology policy, innovation, new technologies, and breeding applications in the agriculture sector. He works with stakeholders such as center and state governments, regulators, media to inform and educate them about the role and benefits of biotechnology for farmers and agriculture. Dr Bajaj has over 20 years of experience in the industry and has worked in several multinational organizations as a regulatory expert in biotechnology.

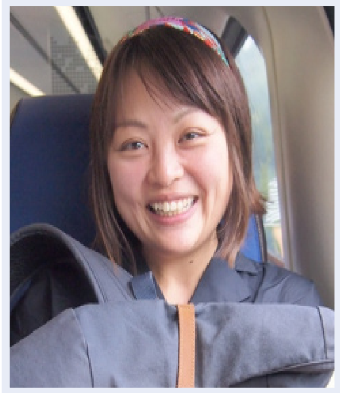
Dr Tomiko Yamaguchi

Professor of Sociology, College of Liberal Arts, International Christian University, Japan

Dr Tomiko Yamaguchi's research interests are in the areas of the social dimensions of agricultural biotechnologies, the governance of food technologies, and social studies of science and technology. She has researched in India, the United States, and Japan. Her current research concerns the governance issues related to plant gene-editing technologies.She has held numerous government advisory positions including Biotechnology Strategy Working Group, Council of Science, Technology, and Innovation and ELSI Programs, Research Institute of Science and Technology for Society, Japan Science and Technology Agency.

Dr Mai Tsuda

Professor, University of Tsukuba, Japan



Dr Mai Tsuda's main research theme is on the regulatory science of biotechnology crops in the field of plant breeding, and she is also involved in activities related to promoting the demand for biotechnology crops in society.

Dr Bharat R. Char

Chief Science Officer, Mahyco Private Limited, India

Dr Bharat R. Char is Chief Science Officer at Mahyco. He obtained his Ph.D. in Biochemistry and Molecular Biology at the University of Southern California Medical School, Los Angeles, and undertook postdoctoral work at the University of California, Berkeley, in plant molecular genetics. His responsibilities include oversight of the R&D and Regulatory programmes at the company. He has served on national and international committees in the seed industry.

Dr Mahaletchumy Arujanan (Maha)

Global Coordinator, International Service for the Acquisition of Agribiotech Applications (ISAAA), Malaysia

Dr Mahaletchumy Arujanan is the Global Coordinator of the International Service for the Acquisition of Agribiotech Applications (ISAAA) and the Executive Director of the Malaysian Biotechnology Information Centre (MABIC). She has a Ph.D. in science communication and a Master of Biotechnology from the University of Malaya and a degree in Microbiology from Universiti Putra Malaysia. She is the founder and Editor-in-Chief of The Petri Dish – the first science newspaper in Malaysia and the Asian Short Course on Agribiotechnology, Biosafety Regulations and Communications (ASCA). She also co-founded Science Media Centre Malaysia. Maha is listed as the world's 100 most influential people in biotechnology by Scientific American Worldview 2015. She is also on the honorific list of Women in Biotechnology Law and Regulation in Biotechnology Law Report 2015.

Dr Sanjay Saxena

General Manager & Head – Investment, Biotechnology Industry Research Assistance Council (BIRAC), India

Dr Sanjay Saxena works as a General Manager & Head (Investment) at BIRAC, a Public Sector Enterprise set-up by the Department of Biotechnology (DBT), Govt. of India as an Interface Agency to stimulate, foster, and enhance the strategic research and innovation capabilities of the Indian Biotech industry, particularly start-ups and SMEs, for creation of affordable products. His prime responsibility is to complete Grant Management of research projects supported under various funding schemes of BIRAC.

Dr Rhodora Romero-Aldemita (Olah)

Director, International Service for the Acquisition of Agri-biotech Applications (ISAAA); SEAsiaCenter, Philippines

Dr Rhodora Romero-Aldemita leads the development and publication of ISAAA's Annual Global Status of Commercialized Biotech/GM Crops, coordinates capacity building and biotechnology and biosafety activities in ISAAA's 15 countries Biotechnology Information Centers, and the technical backstop for ISAAA publications. She is a member of DA-Biotech Program Office's Technical Advisory Team, board member of Biotechnology Coalition of the Philippines, editor-in-chief of the Philippine Journal of Crop Science. She holds a Ph.D. (Botany) from Purdue University, the USA, and Post-Doctoral Fellowship at Albert-Ludwigs University, Germany on Golden Rice. She is one of the leading scientist-lecturers on Agricultural Biotechnology in the Philippines and the region and received various international and national awards.

Technical Programme

Virtual Regional Workshop on

Investment in Modern Agricultural Biotechnology and its Socio-economic Impact on Livelihoods of Farmers in Asia Pacific

Date : August 2-3, 2021
Time : 11:00 – 14:15 ICT (Bangkok Time)
Digital Platform : Zoom

Moderator: Rishi K. Tyagi, APAARI, Thailand

Day 1: August 2, 2021 (Monday)

OPENING SESSION		
11:00 – 11:05	Setting the Ground Rules (Housekeeping)	**Rishi K. Tyagi** APAARI, Thailand
11:05 – 11:30	Opening Remarks	**Ravi Khetarpal** Executive Secretary APAARI, Thailand
		Reynaldo V. Ebora Executive Director DOST-PCAARRD, Philippines
		Vincent Lin Director General COA, Taiwan

Technical Session 1A

Investment Status and Impacts in Modern Agricultural Biotechnology

Chair : **Julianne Biddle,** ACIAR, Australia
Rapporteur : **Gil Markov Alcantara,** DOST-PCAARRD, Philippines

11:30 – 11:45	Long-Term Investment in Agricultural Biotechnology for Feeding the Future Generation	**Krishna Ravi Srinivas** RIS, India
11:45 – 12:00	Investment by Public Sector in Agricultural Biotechnology in Asia-Pacific	**Rishi K. Tyagi** APAARI, Thailand
12:00 -12:15	Investment *vis-à-vis* Impact of Genomics on Livelihoods of Smallholders through Enhanced Crop Productivity	**Rajeev Varshney** ICRISAT, India
12:15 – 12:25	***Open Discussion***	**All Participants**
12:25 – 12:30	*Comfort Break*	

Technical Session 1B

Case Studies: Investment and Impact

Chair : **Mohd Syaifudin Abdul Rahman,** MARDI, Malaysia
Rapporteur : **Ryan Lawrence Polinag,** DOST-PCAARRD, Philippines

12:30 – 12:45	Bt Brinjal in Bangladesh	**M.A. Yousuf Akhond** BARI, Bangladesh
12:45 – 13:00	Bt Cotton in Asia	**C.D. Mayee** SABC, India
13:00 -13:15	GM Maize in the Philippines	**Leonardo A. Gonzales** STRIVE, Philippines
13:15 – 13:30	Impact of Using Biotech Corn in Vietnam: Results of the First Farm-level Study	**Graham Brookes** PG Economics Ltd., UK
13:30 – 13:45	Impact and Prospects of GM Canola in Australia	**Osman Mewett** ASF, Australia
13:45 – 14:00	Regulatory Policy and Impact to Investment: Case of Argentina	**Martin Lema** NUQ, Argentina
14:00 – 14:15	Open Discussion	All Participants

Day 2: August 3, 2021 (Tuesday)

Technical Session 2

Impacts of Enabling Policies for Enhanced Investment

Chair : **Reynaldo V. Ebora,** DOST-PCAARRD, Philippines
Rapporteur : **Jean Claudine Guelos,** DOST-PCAARRD, Philippines

11:00 – 11:10	Policy Changes for Enhancement of Funding in Modern Agricultural Biotechnology	**Saturnina Halos** BCP, Philippines
11:10 – 11:20	Enabling Policies and their Impact on Genome Editing Related Innovations	**Szabolcs Ruthner** ISF, Switzerland
11:20 -11:30	Regulatory Harmonization Approaches to Reduce Cost of Products and Facilitate Trade	**Laurie Goodwin** CropLife International, USA
11:30 – 11:40	***Open Discussion***	**All Participants**

Technical Session 3

Panel Discussion on Scoping Investment in Modern Agricultural Biotechnology

Chair : **A.K. Singh,** IARI, India
Co-Chair : **Ram Kaundinya,** FSII, India
Rapporteur : **Farah Sevilla,** DOST-PCAARRD, Philippines

INNOVATIVE FUNDING MECHANISM		
11:40 – 11:50	National Public-Private Partnership	**Shivendra Bajaj** FSII, India
11:50 – 12:00	Consortium Approach for Public-Private Partnership and Perception of Gene Editing in Japan	**Mai Tsuda** UT, Japan **Tomiko Yamaguchi** ICU, Japan
12:00 -12:10	Regional Public-Private Partnership	**Bharat R. Char** Mahyco, India
12:10 – 12:20	Investment in Knowledge Management and Communication	**Mahaletchumy Arujanan** MABIC, Malaysia
12:20 – 12:25	Comfort Break	
12:25 – 12:35	Stakeholder-driven Funding Mechanism	**Sanjay Saxena** BIRAC, India
12:35 – 12:45	Investment in Capacity Building, Awareness and Policy Advocacy	**Rhodora Romero-Aldemita** ISAAA, Philippines
12:45 – 13:55	***Open Discussion***	**All Participants**

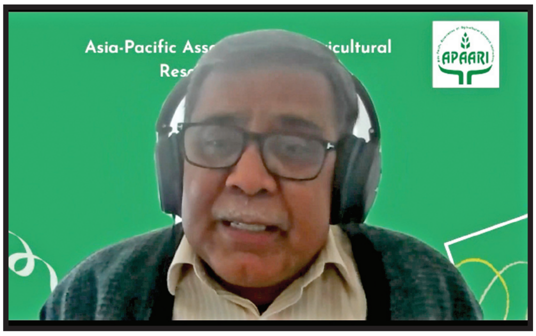
Concluding Session

Co-Chair : **Ravi Khetarpal,** APAARI, Thailand
Chih-hung Lin, COA, Taiwan
Rapporteur : **Ian Bernard Ines,** DOST-PCAARRD, Philippines

13:55 – 14:05	Key Recommendations from Technical Sessions	**Rapporteurs**
14:05 – 14:15	Impressions from Participants	***2-3 Participants***
14:15 -14:25	Concluding Remarks	**Chih-hung Lin** COA, Taiwan
		Ravi Khetarpal APAARI, Thailand
14:25 – 14:30	Vote of Thanks	**Jack Lin** APAARI, Thailand

Photo Gallery

Opening Session



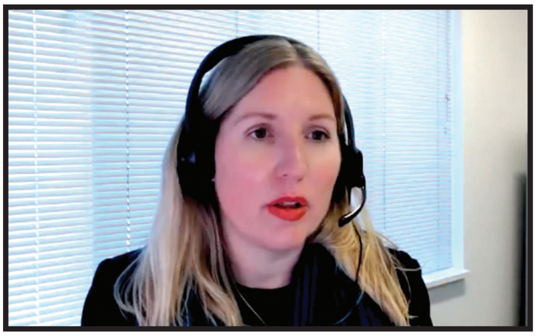
Dr Ravi Khetarpal
Executive Secretary, APAARI, Thailand

Dr Reynaldo V. Ebora
Executive Director, DOST-PCAARRD, Philippines

Mr Vincent Lin
Director General, Department of International
Affairs, Council of Agriculture, Taiwan

Dr Rishi K. Tyagi
Coordinator, APCoAB, APAARI
Thailand

Session Chairs and Co-Chairs



Dr Julianne Biddle
ACIAR, Australia
CHAIR: Technical Session 1A

Dr Mohd Syaifudin Abdul Rahman
MARDI, Malaysia
CHAIR: Technical Session 1B

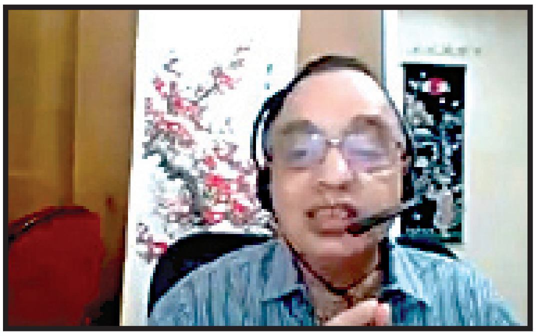
Dr Reynaldo V. Ebora
DOST-PCAARRD, Philippines
CHAIR: Technical Session 2

Dr A.K. Singh
IARI, India
CO-CHAIR: Technical Session 3

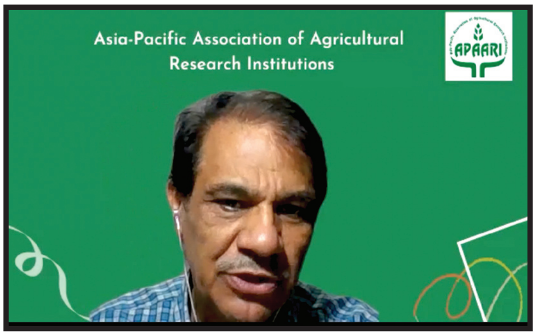
Dr Ram Kaundinya
FSII, India
CO-CHAIR: Technical Session 3

Speakers for Technical Session 1A

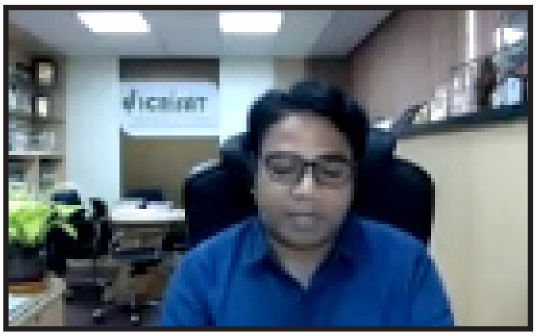
INVESTMENT STATUS AND IMPACTS IN MODERN AGRICULTURAL BIOTECHNOLOGY



Dr Krishna Ravi Srinivas
RIS, India



Dr Rishi K. Tyagi
APAARI, Thailand



Dr Rajeev K. Varshney
ICRISAT, India

Resource Speakers for Technical Session 1B

CASE STUDIES: INVESTMENT AND IMPACT

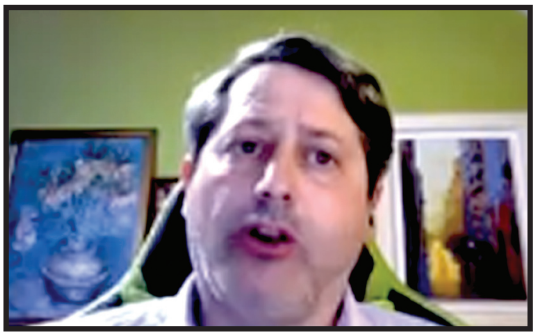
Dr M.A. Yousuf Akhond
BARI, Bangladesh

Dr C.D. Mayee
SABC, India

Dr Leonardo A. Gonzales
STRIVE, Philippines

Dr Graham Brookes
PG Economics Ltd, UK

Dr Osman Mewett
ASF, Australia



Dr Martin Lema
NUQ, Argentina

Resource Speakers for Technical Session 2

IMPACTS OF ENABLING POLICIES FOR ENHANCED INVESTMENT

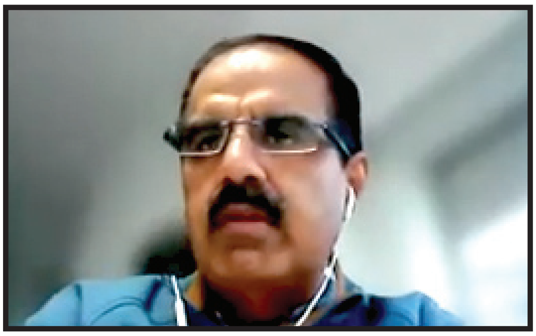
Dr Saturnina Halos
BCP, Philippines

Dr Szabolcs Ruthner
ISF, Switzerland

Dr Laurie Goodwin
CLI, USA

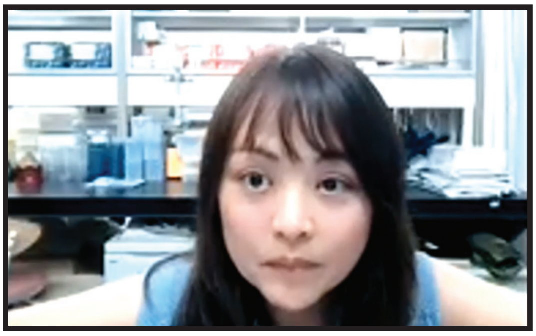
Panelists for Technical Session 3

PANEL DISCUSSION ON SCOPING INVESTMENTS IN MODERN AGRICULTURAL BIOTECHNOLOGY



Dr Shivendra Bajaj
FSII, India

Dr Bharat R. Char
Mahyco, India



Dr Mai Tsuda
UT, Japan

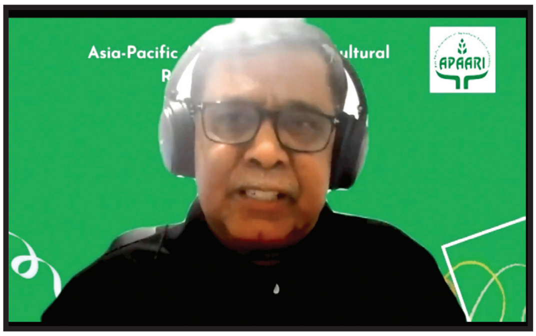
Dr Tomiko Yamaguchi
ICU, Japan

Dr Mahaletchumy Arujanan
MABIC, Malaysia

Dr Sanjay Saxena
BIRAC, India

Dr Rhodora R. Aldemita
ISAAA, Philippines

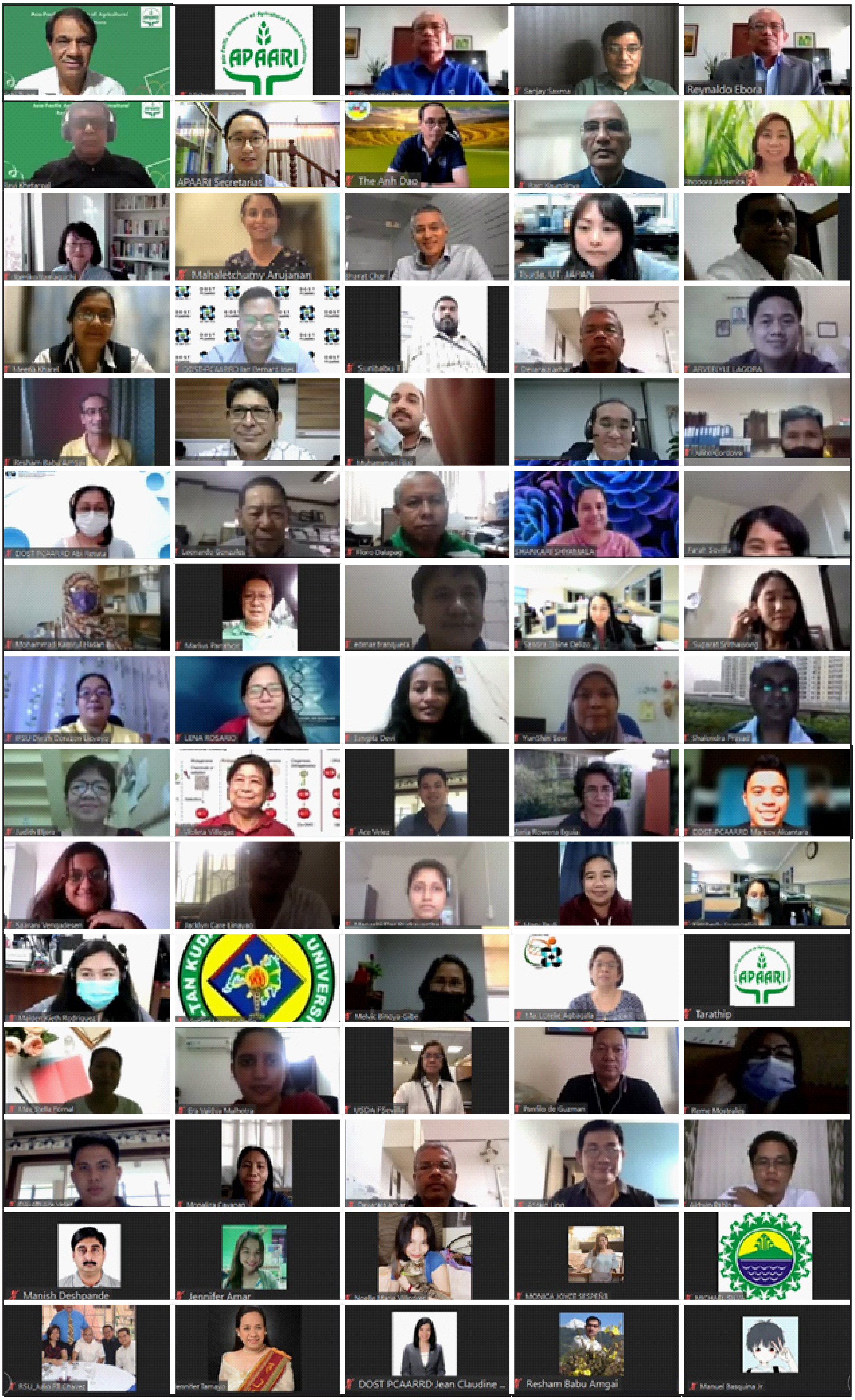
Concluding Session



Dr Ravi Khetarpal
APAARI, Thailand
CHAIR: Concluding Session and delivered the closing remarks

Mr Ian Bernard Ines
DOST-PCAARRD, Philippines
Presented the Key Recommendations

Mr Jack Lin
APAARI, Thailand
Proposed a Vote of Thanks



Experts and some Participants of Regional Workshop on Investment in Modern Agricultural Biotechnology and its Socio-economic Impact on Livelihoods of Farmers in Asia-Pacific

ASIA-PACIFIC ASSOCIATION OF AGRICULTURAL RESEARCH INSTITUTIONS