1ST INTERNATIONAL AGROBIODIVERSITY CONGRESS

Science, Technology and Partnership

6-9 November, 2016; New Delhi, India

Proceedings and Recommendations

Organized by

Indian Society of Plant Genetic Resources, New Delhi, India &
Bioversity International, New Delhi, India

Co-Organizers

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PPV FRA

राष्ट्रीय जैव विविधता प्राधिकरण National Biodiversity Authority, India 2003

taas Progress Through Science

National Academy of Agricultural Sciences New Delhi

MSSRF Science for Sustainable Development

Asia-Pacific Association of Agricultural Research Institutions APAARI

CIMMYT MR International Maize and Wheat Improvement Center

BISA Borlaug Institute for South Asia

german cooperation DEUTSCHE ZUSAMMENARBEIT

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FAO FIAT PANIS Food and Agriculture Organization of the United Nations

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1st International Agrobiodiversity Congress

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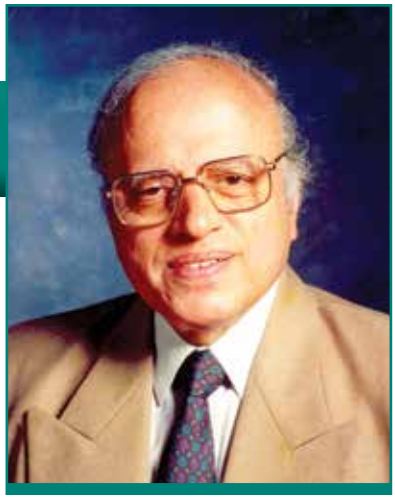


M.S. SWAMINATHAN
M.S. Swaminathan Research Foundation
Chennai, India

Towards an Era of Biohappiness

Both biodiversity and human society have co-existed over many millennia, resulting in rich agrobiodiversity across varying ecosystems, especially where it has been managed well and used effectively for overall human welfare. Therefore, agrobiodiversity has been the main foundation of our civilization across the globe and offers both food and nutritional security and improved livelihood opportunities to global population. However, unprecedented growth in human population during the past century and shrinking per capita land under agriculture have resulted in over-exploitation and abuse of available natural resources, including agrobiodiversity. Considerable loss of genetic diversity has thus occurred demanding an urgent action to research and conserve available genetic resources for posterity. Though National Agricultural Research Systems, International Research Systems under the CGIAR and the Food and Agriculture Organization of the United Nations have made significant efforts towards agrobiodiversity conservation, yet it continues to remain a major challenge. Currently, about 800 million people suffer from insecure food supplies and malnutrition globally. Pattern and determinates of inadequate nutrition or hidden hunger are changing, where women and children are the most vulnerable segments.

To overcome these, agrobiodiversity-centric issues, in-depth deliberations involving researchers, intellectuals, regulators, policymakers, executives, farmers, NGOs, donors, philanthropists, and other stakeholders on a common platform are essential. This could possibly help in defining a clear roadmap as well as implementation strategy for various agrobiodiversity policies, programs and capacity building. In this context, I am happy that the *1st International Agrobiodiversity Congress* focusing on *Science, Technology, Policy and Partnership* was organized jointly by the Indian Society of Plant Genetic Resources and Bioversity International, from 6-9 November 2016 with support from many national and international organizations who are directly or indirectly engaged in the conservation and use of agrobiodiversity.

The Congress brought together over 1000 experts from over 60 countries covering almost all aspects related to conservation of agrobiodiversity and its enhanced use. These includes: genetic resources, genetic and breeding, biotechnology, human nutrition, ecology and environmental science, information management, bioinformatics, genomics, agronomy, forestry, integrated pest management, conservation biology, law and policy analysis, economics and other social sciences.

I am pleased that the specific recommendations under each of the Congress themes and overall recommendations as *"Delhi Declaration on Agrobiodiversity Management"* have emerged as an outcome of this Congress. Hence, their systematic implementation will help both national and international organizations/agencies for effective conservation and use of agrobiodiversity for ensuring food and nutritional security and also to address the emerging challenges associated with climate change. Agrobiodiversity is the feedstock for biotechnology and genetic modification. It provides the basis for food and climate security. The loss of every gene and species limits our options for the future. The Delhi Declaration therefore is an important pathway to a more food and environment secure world characterized by biohappiness.

I would like to congratulate all the partners and organizers of this important Congress, especially to **Dr R.S. Paroda** and the core team: **Drs P.N. Mathur, R.K. Tyagi, R.C. Agrawal, Sunil Archak** and **Anuradha Agrawal** for having organized 1st IAC and for bringing out these proceedings, which I am sure will help the national, regional and global players involved in the conservation and use of agrobiodiversity for prosperity.

M.S. Swaminathan

Chairman, International Organizing Committee, 1st IAC and
Emeritus Chairman and Chief Mentor
M S Swaminathan Research Foundation
Chennai, India

PREFACE

Organizing the **1st International Agrobiodiversity Congress (IAC 2016)**, a first-of-its-kind event, was very exhilarating and satisfying. This publication encapsulates succinctly the diverse events, scientific deliberations and recommendations that emanated from the IAC 2016.

We are deeply indebted to Hon'ble Prime Minister of India **Shri Narendra Modi** for inaugurating the IAC 2016 and delivering an unequivocal message to all stakeholders regarding the importance of agrobiodiversity in human life. We are immensely grateful to **Shri Radha Mohan Singh**, Hon'ble Minister for Agriculture and Farmers Welfare, for gracing the inaugural function and administrative support from all the Indian government departments, especially the Ministries of Agriculture and Farmers Welfare, External Affairs and Home Affairs.

The **Indian Society for Plant Genetic Resources** (ISPGR) and **Bioversity International** conceived and organized the IAC 2016, with enormous support from several international (13), national agencies (13) and individuals (125) who were part of **International Advisory Committee, National Steering Committee, Core Organizing Committee, Technical Program Committee** and **Local Organizing Committee**. We place on record our gratitude to all who were directly or indirectly involved in successful organization of the IAC 2016.

This event has become a reality due to the personal interest and excellent guidance provided by **Prof. M.S. Swaminathan**, Chair of the International Advisory Committee of IAC 2016. The Core Committee members (Drs. P.N. Mathur, R.K. Tyagi, Anuradha Agrawal, R.C. Agrawal and Sunil Arachak) for the organization of this Congress are equally grateful to **Dr R.S. Paroda**, Co-Chair of the International Advisory Committee and Chair of the National Steering Committee of IAC 2016, for his continuous guidance and untiring efforts in organizing this event. The organizers are very grateful to **Dr T. Mohapatra**, Secretary, Department of Agriculture Research and Education (DARE) & DG, Indian Council of Agricultural Research (ICAR) and **Dr S. Ayyappan**, his predecessor, for extending steadfast institutional support.

The event received **financial support** from several **organizations** (21) and was ably supported by **knowledge/institutional partners** (7). We take this opportunity to thank each one, as enumerated herewith - Bioversity International, ISPGR, ICAR, Protection of Plant Varieties and Farmers Right Authority (PPV&FRA), National Biodiversity Authority (NBA), Trust for Advancement of Agricultural Sciences (TAAS), National Academy of Agricultural Sciences (NAAS), M.S. Swaminathan Research Foundation (MSSRF), Indian Society of Genetics and Plant Breeding (ISGPB), International Maize and Wheat Improvement Centre (CIMMYT), Borlaug Institute for South Asia (BISA), International Centre for Research in Semi-arid Tropics (ICRISAT), German Corporation for International Cooperation (GIZ), Asia-Pacific Association of Agricultural Research

Institutes (APAARI), Global Crop Diversity Trust (GCDT), Japan International Research Centre for Agricultural Sciences (JIRCAS), Australian Centre for International Agricultural Research (ACIAR), International Centre for Research in Dryland Areas (ICARDA), Centre for Agriculture and Biosciences International (CABI), Kirkhouse Trust, Madhya Pradesh State Biodiversity Board (MPSBB), Maharashtra Hybrid Seeds Company Private Limited (MAHYCO), Association of Biotechnology-Led Enterprise-Agriculture Group (ABLE-AG), Rasi Seeds, Controlled Environment Limited (CONVIRON), Food and Agriculture Organization of United Nations (FAO), National Innovation Foundation (NIF), Anand and Anand and EcoAfrica.

The IAC 2016 provided an excellent opportunity for exchange of views among the **1,000 participants** hailing from **60 countries**. The goal was to formulate a road map for management of genetic resources in tune with the Sustainable Development Goals (SDGs). Accordingly, recommendations emerging on major issues have been synthesized in these *Proceedings*. It is hoped that this document would be useful across the globe for shaping the policy, guidelines and procedures related to agrobiodiversity management and use.

An event of this magnitude is only possible with the help from dedicated persons, organizations and service providers. As the list is very long, we are refraining from taking names of individuals. However, it is our pleasure to place on record, the excellent technical support provided by the **staff** of **ISPGR, Bioversity International, TAAS, BISA, NAAS, MSSRF** and **NBPGR** in technical, logistic and administrative matters. We acknowledge **Team ICE** (M/S Integrated Conference and Event Management) for excellent management of the event. We are also very thankful to M/S **Professional Group, Aryan Facility Services, Venus Conferences & Exhibition Pvt Ltd, Malhotra Publishers, Angkor Publishers, Infinite Ingenious Solutions** in providing services towards catering, logistics, exhibition, printing and video production.

Finally, we thank all the **dignitaries** and **delegates** who participated in the IAC 2016, and have given an overwhelmingly positive feedback about the program, arrangements and overall ambiance. It is our expectation that International Agrobiodiversity Congress would be a **rolling event** to provide a platform to address all the emerging issues related to agrobiodiversity.

Editors

Acronyms and Abbreviations

ABLE-AG	Association of Biotechnology Led Enterprise-Agriculture Group
ABS	Access and Benefit Sharing
ACIAR	Australian Centre for International Agricultural Research
AICRP	All India Coordinated Research Project
AnGR	Animal Genetic Resources
APAARI	Asia Pacific Association of Agricultural Research Institutes
APSIM	Agricultural Production Systems Simulator
ASRB	Agricultural Scientists' Recruitments Board
ATARI	Agricultural Technology Application Research Institute
BAIF	Bharatiya Agro Industries Foundation
BBSRC	Biotechnology and Biological Sciences Research Council
BCIL	Biotech Consortium India Limited
BCP	Biocultural Community Protocols
BGRI	Borlaug Global Rust Initiative
BISA	Borlaug Institute for South Asia
BKS	Bharat Krishak Samaj
BLUP	Best Linear Unbiased Prediction
BMGF	Bill & Melinda Gates Foundation
BRC	BioResource Center
CABI	Centre for Agriculture and Biosciences International
CAUs	Central Agricultural Universities
CBD	Convention on Biological Diversity
CBM	Community-based Biodiversity Management
CCARI	Central Coastal Agricultural Research Institute
CGIAR	Consultative Group of International Agricultural Research
CGRFA	Commission on Genetic Resources for Food and Agriculture
CIAT	International Center for Tropical Agriculture
CIB	Central Insecticides Board
CIFT	Central Institute of Fisheries Technology
CIMMYT	International Maize and Wheat Improvement Centre
CIRG	Central Institute for Research on Goats
CISH	Central Institute for Subtropical Horticulture
CLR	Crop Land Races

CMFRI	Central Marine Fisheries Research Institute
Conviron	Controlled Environment Limited
CRP	Consortium Research Platform
CRPS	Central Potato Research Institute
CSKHPKV	Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya
CWR	Crop Wild Relatives
DBT	Department of Biotechnology
DGR	Directorate of Groundnut Research
DIHAR	Defence Institute of High Altitude Research
DivSeek	Diversity Seek
DMR	Directorate of Mushroom Research
DNA	Deoxyribonucleic Acid
DRRW	Durable Rust Resistance in Wheat
DUS	Distinctness, Uniformity and Stability
ELC	Ecogeographic Land Characterization
FAANG	Functional Annotation of Animal Genomes
FAO	Food and Agriculture Organization of the United Nations
FRI	Forest Research Institute
FSN	Farming System for Nutrition
GBLUP	Genomic Best Linear Unbiased Prediction
GBS	Genotyping by Sequencing
GCDT	Global Crop Diversity Trust
GIS	Geographic Information System
GIZ	German Corporation for International Cooperation
GM	Genetically Modified
GMO	Genetically Modified Organism
GPA	Government Procurement Agreement
GRIN	Germplasm Resources Information Network
GRSV	Global Research-for-development Support Ventures
HCIs	Higher-order Composite Indices
IAC	International Agrobiodiversity Congress
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICMR	Indian Council of Medical Research
ICRAF	International Centre for Research in Agroforestry (World Agroforestry Centre)
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT KU	Information & Communication Technology, Kenyatta University
IDDC	International Dryland Development Commission
IGFRI	Indian Grassland and Fodder Research Institute
IIHR	Indian Institute of Horticultural Research
IIMR	Indian Institute of Millets Research

IIOR	Indian Institute of Oilseeds Research
IITA	International Institute of Tropical Agriculture
IIWBR	Indian Institute of Wheat and Barley Research
ILRI	International Livestock Research Institute
IMIN	International Mungbean Improvement Program Open Network
IPES Food	International Panel of Experts on Sustainable Food Systems
IPK	Leibniz Institute of Plant Genetics and Crop Plant Research
IPRs	Intellectual Property Rights
IRRI	International Rice Research Institute
ISGPB	Indian Society of Genetics and Plant Breeding
ISPGR	Indian Society of Plant Genetic Resources
ISSD	Integrated Seed Sector Development
ITK	Indigenous Technical Knowledge
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IUCN	International Union for Conservation of Nature
JIRCAS	Japan International Research Centre for Agricultural Sciences
KIT	Royal Tropical Institute
KSU	Kansas State University
KVKs	Krishi Vigyan Kendras
LD	Linkage Disequilibrium
LMOs	Living Modified Organisms
LTFE	Long-Term Fertilizer Experiments
M&AP	Medicinal and Aromatic Plants
Mahyco	Maharashtra Hybrid Seeds Company Private Limited
MPKV	Mahatma Phule Krishi Vidyapeeth
MSSRF	M.S. Swaminathan Research Foundation
MTA	Material Transfer Agreement
NAAS	National Academy of Agricultural Sciences
NACA	Network of Aquaculture Centres in Asia-Pacific
NaCRRI	National Crops Resources Research Institute
NARC	National Agricultural Research Center
NARS	National Agricultural Research Systems
NBA	National Biodiversity Authority
NBAGR	National Bureau of Animal Genetic Resources
NBAIM	National Bureau of Agriculturally Important Microorganisms
NBAIR	National Bureau of Agricultural Insect Resources
NBFGR	National Bureau of Fish Genetic Resources
NBPGR	National Bureau of Plant Genetic Resources
NCVTC	National Centre for Veterinary Type Cultures
NDRI	National Dairy Research Institute
NEHU	North Eastern Hill University
NGOs	Non-Governmental Organizations

NIF	National Innovation Foundation
NIN	National Institute of Nutrition
NISCAIR	National Institute of Science Communication and Information Resources
NIVEDI	National Institute of Veterinary Epidemiology and Disease Informatics
NP-ABS	Nagoya Protocol on Access and Benefit Sharing
NRCB	National Research Centre for Banana
NRCPB	National Research Centre on Plant Biotechnology
PAU	Punjab Agricultural University
PGR	Plant Genetics Resources
PGRFA	Plant Genetic Resources for Food and Agriculture
PPV&FRA	Protection of Plant Varieties and Farmers' Right Authority
PVS	Participatory Variety Selection
QAAFI	Queensland Alliance for Agriculture and Food Innovation
QTL	Quantitative Trait Loci
RHoMIS	Rural House Multi-Indicator Survey
RSM	Resource Seed Mexicana
SADC	Southern African Development Community
SAUs	State Agricultural Universities
SDGs	Sustainable Development Goals
SeeD	Seeds of Discovery
SMTA	Standard Material Transfer Agreements
SNP	Single Nucleotide Polymorphism
SoWAqGR	State of the World's Aquatic Genetic Resources
SR	Stem Rot
SRISTI	Society for Research and Initiatives for Sustainable Technologies and Institutions
SSR	Simple Sequence Repeat
STDF	Standards and Trade Development Facility
TAAS	Trust for Advancement of Agricultural Sciences
TRIPRs	Trade Related Intellectual Property Rights
UAS-B	University of Agricultural Sciences, Bengaluru
UC	University of California
UNFCCC	United Nations Framework Convention on Climate Change
USAID	United States Agency for International Development
VCRI	Veterinary College and Research Institute
VIR	N.I. Vavilov Research Institute of Plant Industry
VNMKV	Vasantrao Naik Marathwada Krishi Vidyapeeth
WIEWS	World Information and Early Warning System
WTO	World Trade Organization
YAAS	Yunnan Academy of Agricultural Sciences

1st International Agrobiodiversity Congress: Science, Technology and Partnership

Context and Rationale

Agrobiodiversity includes all components of biological diversity, relevant to food and agriculture. It encompasses varieties, breeds and populations of useful plants, animals, and fish species along with the diversity of insects, microbes and other species which are part of the production systems. Human-mediated co-existence around the world in diverse agro-ecosystems has shaped and sustained unique structures, processes, functions and their economic value. With the advancement of societies and nations, available food and nutrition basket has expanded globally due to exchange and effective use of available agrobiodiversity.

In the past century, we have witnessed an unprecedented growth of human population along with shrinking of per capita land under agriculture. This has resulted in the over-exploitation and abuse of available natural resources, including agrobiodiversity. Considerable losses of genetic diversity have, thus, occurred over the last few decades. This demands urgent focus for research to conserve available genetic resources for posterity. In this context, National Agricultural Research Systems (NARS), International Research Centres under the Consultative Group of International Agricultural Research (CGIAR) and the Food and Agriculture Organization of the United Nations (FAO) have made significant strides for conservation of genetic resources, but it still remains a major challenge.

At present, about 800 million people suffer from insecure food supplies and malnutrition. Although, Green Revolution resulted in considerable reduction of poor and undernourished people, yet hidden hunger persists and affects over two billion people worldwide. Lately, the United Nations has renewed commitment to push sustainable development agenda, in which food, nutrition and environmental security figures as the key sustainable development goals (SDGs).

Capacity building, trained human resource and partnerships, research and adoption of new technologies are imminently required for meeting future demands of new varieties and breeds in agriculture through fast-track germplasm use. Increased and targeted use of genetic resources is needed to cope with changed production environments and climate change scenarios. Increased diversity in agricultural production systems, including their sustainable intensification, would buffer the capacity to cope with increased volatility on the the environment.

Efficient and sustainable agrobiodiversity management would require functional convergence of global policy and regulatory frameworks, such as United Nations Convention on Biological Diversity

(CBD), International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), Food and Agriculture Organization of the United Nations (FAO), Commission on Genetic Resources for Food and Agriculture (CGRFA), Nagoya Protocol on Access and Benefit Sharing (NP-ABS), Aichi Targets 2011-2020, Framework Convention on Climate Change (UNFCCC), World Trade Organization (WTO), in shaping biodiversity, food and agriculture, climate change and trade-related mechanisms.

The above agrobiodiversity-centric issues need to be addressed through in-depth deliberations involving researchers, intellectuals, regulators, policy-makers, farmers, non governmental organizations (NGOs), donors, philanthropists, and other stakeholders on a common platform. Countries need to have interface for sharing knowledge, information and technology associated with *in situ* and *ex situ* conservation, use and sustainability of agrobiodiversity, including plants (field crops, horticultural crops, and agroforestry), animals, fish, and agriculturally important insects and microbes.

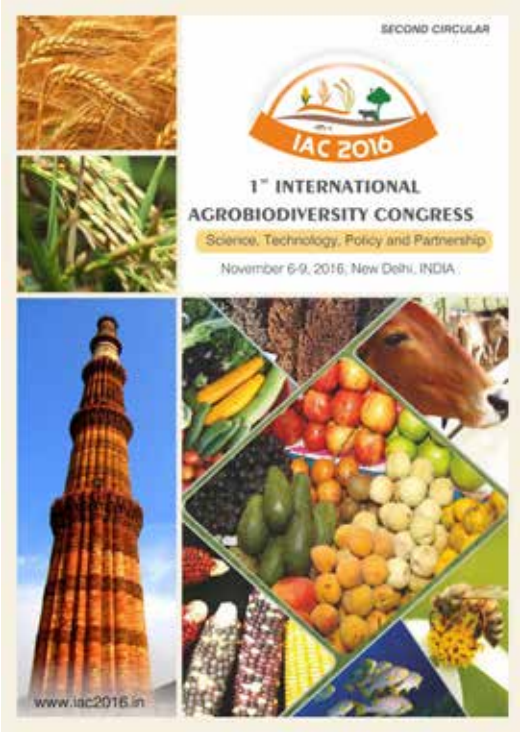
The above issues led to organization of the 1st International Agrobiodiversity Congress 2016 (IAC 2016) from 6-9 November 2016 at New Delhi, India.

Objectives

- To provide a common platform to share experience and knowledge on the sustainable conservation and use of agrobiodiversity.
- To critically evaluate the current research and systems of management and use of agrobiodiversity and to assess preparedness for meeting short- and long-term requirements of humanity.
- To identify and prioritize research areas requiring greater inputs and thrusts for better management of agrobiodiversity.
- To strengthen capacity and build new partnerships to help management of agrobiodiversity worldwide.

Expected Outputs

- New thinking on sustainable management and use of agrobiodiversity through interdisciplinary exchange of ideas and opinions among various stakeholders.
- Mainstreaming agrobiodiversity-related issues into global discussion to ensure fair access, benefit sharing and sustainable use.
- Developing a network of partnerships to strengthen agrobiodiversity management systems at the national, regional and global levels.
- Preparation of a road map to enhance food, nutrition and health security by optimal utilization of agrobiodiversity while protecting agro-ecosystems and landscapes.
- 'Delhi Declaration' on Agrobiodiversity Management and Use.



Venue and Program Outline

The inaugural session and all the technical sessions of the Congress on November 6, 2017 were held at Vigyan Bhawan and all other sessions were organzied at the National Agricultural Science Center, New Delhi, India. About 1,000 delegates from 60 countries participated in the Congress. The Congress acted as a platform for the delegates to share their knowledge and experiences on several aspects of agrobiodiversity management for preparing a road map to accelerate conservation and sustainable use of genetic resources (plants, animals, fish, agriculturally important insects and microbes) to ensure food and nutritional security at the global level.

The Congress was structured into 4 Plenary Sessions, 7 Technical Sessions, 4 Satellite Sessions, 1 session each on Round Table Discussion on Genebank Management, Farmers' Forum on Farmers' Role in Conservation of Genetic Resources and Public Forum on Role of Stakeholders in Agrobiodiversity Management. Besides, two evening lectures, entitled "Agrobiodiversity and Achieving the Zero Hunger Challenge" by Prof. M.S. Swaminathan and "Biodivesity, Food, and the Future" by Prof. Peter Raven were highlights of IAC 2016.

Keeping in view the specialization of speakers and interest of delegates, concurrent sessions were also organized under some of the technical sessions. To showcase Indian agrobiodiversity, an exhibition, displaying live samples of genetic diversity of plant, animal, fish, insects and microbes, was also organized. Keynote lectures were delivered by the leading experts in agrobiodiversity management during each technical session, to have in-depth discussion with delegates. Young scientists were given an opportunity to share their research findings through 'Rapid Presentations' in each technical session. Poster Sessions were also organized to display the research results of many of the delegates. During the technical sessions, in depth discussions were held and outcomes of these discussions, deliberations and recommendations were presented in the concluding session. On basis of the recommendations, the text of 'Delhi Declaration on Agrobiodiversity Management' was also presented, which was unanimously adopted by the delegates.

Themes

1. Agrobiodiversity for Food, Nutrition and Ecosystem Services
2. Agrobiodiversity for Adaptation and Mitigation of Climate Change
3. Intellectual Property Rights (IPRs), Access and Benefit Sharing (ABS) and Farmers' Rights
4. Quarantine, Biosafety and Biosecurity Issues
5. Conservation Strategies and Methodologies
6. Science-led Innovation for Agrobiodiversity Management and Sustainable Use

7. Capacity Building and Strengthening Partnerships

Plenary Sessions

1. Agrobiodiversity for Sustainable Development Goals (SDGs)
2. Conservation through Use
3. Agrobiodiversity for Livelihood Security and Ecosystem Services
4. ABS in Context of Regulatory Systems

Satellite Sessions

1. Harnessing Biodiversity for Food Security and Sustainable Development
2. Agrobiodiversity for Nutrition and Health
3. Climate Change - an Opportunity
4. Crop Wild Relative: Back to the Wild to Save the Future

Other Activities

1. Round Table Dialogue on Genebank Management - among National Genebanks and International Research Centers
2. Farmers and Public Forum - to extend scope of participation beyond scientists and researchers
3. Poster sessions for individual interactions among participants
4. An exhibition to display indigenous agrobiodiversity and traditional knowledge of Indian farming systems

About the Organizers

The IAC 2016 was jointly organized by the Indian Society of Plant Genetic Resources (ISPGR) and Bioversity International, in collaboration with the Indian Council of Agricultural Research (ICAR), Protection of Plant Varieties and Farmers' Right Authority (PPV&FRA), National Biodiversity Authority (NBA), Trust for Advancement of Agricultural Sciences (TAAS), National Academy of Agricultural Sciences (NAAS), M.S. Swaminathan Research Foundation (MSSRF), Indian Society of Genetics and Plant Breeding (ISGPB), International Maize and Wheat Improvement Centre (CIMMYT), Borlaug Institute for South Asia (BISA), International Centre for Research in Semi-arid Tropics (ICRISAT), German Corporation for International Cooperation (GIZ) and Asia-Pacific Association of Agricultural Research Institutes (APAARI). Co-sponsors of the Congress included many partners such as Global Crop Diversity Trust (GCDT), Japan International Research Centre for Agricultural Sciences (JIRCAS), Australian Centre for International Agricultural Research (ACIAR), International Centre for Agricultural Research in the Dry Areas (ICARDA), Centre for Agriculture and Biosciences International (CABI), Kirkhouse Trust, Madhya Pradesh State Biodiversity Board (MPSBB), Maharashtra Hybrid Seeds Company Private Limited (MAHYCO), Association of Biotechnology-Led Enterprise – Agriculture Group (ABLE-AG), Rasi Seeds and Controlled Environment Limited (CONVIRON). Knowledge partners for the event were FAO, National Innovation Foundation (NIF), Anand and Anand, and EcoAfrica.

Indian Society of Plant Genetic Resources (ISPGR): The Society was founded in 1987 as a multidisciplinary scientific body involved in various issues of plant genetic resources (PGR) and related fields. The genesis of the Society was from the initiative taken by the scientists at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, under the leadership of Dr R.S. Paroda, the then Director of NBPGR and presently President, ISPGR and Chairman, TAAS. The primary objective of the Society is to provide a forum to those interested in the field of PGR for expressing their views, publishing their findings and interacting with different stakeholders. Membership of the ISPGR is open to all persons interested in PGR in India and abroad.

Bioversity International: Bioversity International is a global research-for-development organization. Its vision is that agricultural biodiversity nourishes people and sustains the planet. It delivers scientific evidence, management practices and policy options to use and safeguard agricultural and tree biodiversity to attain sustainable global food and nutrition security. Bioversity International works with partners in low-income countries in different regions where agricultural and tree biodiversity can contribute in improving nutrition, resilience, productivity and climate change adaption. Bioversity International is a CGIAR research centre. CGIAR is a global research partnership for a food-secure future.

Inaugural Session

Lighting of the lamp by the Chief Guest and Dignitaries on the Dais

The Congress was inaugurated on November 6, 2016 by the Chief Guest, **Shri Narendra Modi**, Hon'ble Prime Minister of India. Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India, was the Guest of Honour. The Inaugural Session was chaired by Prof. M.S. Swaminathan, Chair, International Advisory Committee of the IAC 2016. The other dignitaries on the dais were Dr R.S. Paroda, Co-Chair, International Advisory Committee and Chair, National Advisory Committee of the IAC 2016; Dr T. Mohapatra,

Floral welcome to Hon'ble Prime Minister of India, Sh. Narendra Modi by Prof. M.S. Swaminathan (left) and to Hon'ble Union Minister of Agriculture and Farmers Welfare, Sh. Radha Mohan Singh, by Dr R.S. Paroda (right)

A view of the delegates and guests at Inaugural Function

Secretary, Department of Agricultural Research and Education (DARE) and Director General, Indian Council of Agricultural Research (ICAR); Ms Ann Tutwiler, Director General, Bioversity International; and Dr P.N. Mathur, Organizing Secretary of the IAC 2016 and Honorary Research Fellow, Bioversity International. The inaugural function was attended by more than 1,200 invited guests from different Ministries of the Government of India, scientific institutes located in Delhi, including ICAR Headquarters and its institutions, CGIAR Centers and various other institutions and State Agricultural Universities from different parts of the country, press and media personnel, including 1,000 delegates registered for the Congress.

Dr R.S. Paroda, President, Indian Society of Plant Genetic Resources and Co-Chair, International Advisory Committee of the Congress, welcomed the dignitaries, distinguished invitees, participants, farmers, and press and media personnels. He expressed his gratitude to Hon'ble Prime Minister of India as Chief Guest and to Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India, as Guest of Honour for gracing the occasion. During his welcome address, he emphasized the role of agrobiodiversity for sustainable agriculture in the context of growing population, rapid degradation of resources for agricultural production and threat due to climate change, at national and global levels. He said that the organization of this Congress was very timely to discuss some imminent threats for sustainable and productive agriculture and to chart a road map in the form of '*Delhi Declaration*' for sustainable management and use of agrobiodiversity.

Dr R.S. Paroda giving the welcome speech on behalf of ISPGR

Ms Ann Tutwiler, Director General, Bioversity International, welcomed dignitaries and participants on behalf of Bioversity International.

Ms Ann Tutwiler giving the welcome speech on behalf of Bioversity International

While speaking about the importance of agrobiodiversity, she briefed about the role of Bioversity International in partnership with the national partners in management of agrobiodiversity at the national, regional and global levels and expressed her happiness that Bioversity International was a coorganizer. She reinforced the need to hold this Congress in the context of the present scenario of agriculture for food and nutrition security. She expressed

her hope that doable recommendations would emerge during the deliberations, and a road map would be chalked out for implementing the program with national and international organizations engaged in the conservation and use of agricultural biodiversity for sustainable agricultural production and for achieving the Sustainable Development Goals (SDGs). Finally, she assured that Bioversity International is fully committed to be an active partner for conservation of genetic resources through use.

Prof. M.S. Swaminathan, Chair, International Advisory Committee of the IAC 2016, welcomed the dignitaries and expressed his pleasure that a large congregation of global experts from different parts of the world had joined 1st International Agrobiodiversity Congress. He said that such deliberations are very useful

Prof. M.S. Swaminathan addressing the gathering

to share scientific knowledge at one platform to develop future strategies for research and outreach programmes for conservation and sustainable use of agrobiodiversity. He quoted the example of developing Biodiversity Garden in Kandahar University, Afghanistan with the expertise available in India. Referring to the smog problem which pollutes environment and seriously affects human health, he mentioned that left-out whole biomass of plants should be utilized for many other purposes, including animal feed; and there is no reason that rice straw should be burnt, which pollutes the environment. Stating the importance of agrobiodiversity in securing food and nutritional security, he emphasized that new food crops such as millets should be introduced and need to be cultivated. Prof. Swaminathan enumerated the recent initiatives taken by the Government of India *e.g.* neem-coated urea which releases nitrogen very slowly and checks pollution substantially. To draw the global attention about the importance of agrobiodiversity, he urged Hon'ble Prime Minister to take up the matter to the United Nations for declaring one of the coming years as 'International Year of Agrobiodiversity'.

Shri Radha Mohan Singh, Hon'ble Union Minister of Agriculture and Farmers Welfare, Government of India, expressed his happiness that such a meet, focusing on conservation and use of agrobiodiversity, was organized for the first time in India. He mentioned that India is not only agriculture-based country but also very rich in all components of agrobiodiversity. Expressing concern on the burgeoning population of the world, he urged all the countries to jointly cooperate in solving food security challenges. Shri Singh voiced his confidence that India has a strong national agricultural research system to face challenges in managing all kinds of genetic resources, be it plants, animals, fish, and agriculturally important microbes and insects. He said that five bureaux under the ICAR are actively involved in managing and effectively conserving different types of genetic

Sh. Radha Mohan Singh sharing his vision with the IAC 2016 participants

resources. He also referred to the national genebank located at the ICAR-National Bureau of Plant Genetic Resources, which conserves about 0.43 million accessions of PGR, that are available for use in development of new varieties to increase the production and productivity. He expressed his gratefulness to Hon'ble Prime Minister of India for his vision and guidance for developing and implementing policies for the welfare of the farmers, and his august presence for encouraging participants of the IAC 2016. Finally, he congratulated the organizers for holding this event in India.

Shri Narendra Modi, Hon'ble Prime Minister of India, delivered the inaugural speech. He welcomed all the delegates gathered from different countries and expressed his happiness at the organization of such an event for the first time, that too in India. He said that the challenges of food, nutritional, health and environmental security are a consequence of exploitation of natural resources in past years, mostly by human beings and are increasing day by day. Therefore, critical discussions and research on agrobiodiversity are very important and the organization of the IAC 2016 was very timely. He expressed his satisfaction that India is very rich in agrobiodiversity and all other natural resources and mentioned many unique and promising genetic resources of India - landraces of rice from Tamil Nadu (*Konamani*), Assam (*Agni bora*), and Kerala (*Pokkali*); wheat (*Bhalia*) and grass (*Banni*) for cow feed from Gujarat; mushroom (*Guchhi*) from Himachal Pradesh; and buffalo (*Murrah* and *Jafarabadi*) from Haryana and Gujarat.

Referring to the Millennium Development Goals (MDGs), he voiced that the role of nature is very well accepted for appropriately resolving different challenges. He reminded that even after the acceptance of Convention on Biological Diversity, about 50-150 species are getting extinct every day. He also mentioned that millions of people are presently struggling with hunger, poverty and malnutrition. Science and technology has an important role in mitigating these challenges. He reiterated that though science and technology has a role to play but we need to ensure that while finding solutions, we should not ignore other aspects like sustainable development and conservation of agrobiodiversity. Modern agriculture focuses on only a limited number of crops. He cited the example of the decreased population of honey bees by increased use of pesticides, which resulted in low pollination, and thus affected productivity. He called upon for new

Hon'ble Prime Minister of India, Sh. Narendra Modi, delivering the inaugural address of the IAC 2016

dimensions of thinking to conduct the research on agrobiodiversity for sustainable development and conservation of agrobiodiversity.

He expressed his concern on how the germplasm conserved in genebank should be made accessible to farmers. He suggested that characterization, evaluation and value addition of genetic resources should be done with the involvement of the farmers and farming community. He emphasized that a pool of resources be developed and a vision in harmony with the national and international laws be developed so that laws do not hinder the process of helping farmers and ensuring food security. He reiterated India's commitment towards conservation of nature and informed that India had signed the Paris Agreement on October 2, 2016, the birthday of Mahatma

Gandhi. He showed confidence that a collective vision would be developed through discussions during the IAC 2016 so as to handover the agrobiodiversity *in toto* to the next generation, as was bestowed by our ancestors. He thanked all the delegates for their large presence and conveyed his best wishes for the success of the IAC 2016.

(*The video of the speech is available at: https://www.youtube.com/watch?v=S4-zxMxpxyQ)*

The Inaugural Session was concluded by a formal vote of thanks by **Dr P.N. Mathur**, Organizing Secretary, IAC 2016, to the Chief Guest, Guest of Honour, other dignitaries on the

Dr P.N. Mathur delivering vote of thanks

dais, and to all the invited guests, delegates, farmers, print and electronic press and media.

As part of the Inaugural Function and in recognition of the excellent work done by

Felicitation of World Food Prize Laureates by Hon'ble PM, Sh Narendra Modi - Drs M.S. Swaminathan, G.S. Khush, B.R. Barwale, M. Vijay Gupta, S. Rajaram and Howarth Bouis (from top left to right)

the World Food Laureates of Indian origin, Hon'ble Prime Minister felicitated **Dr M.S. Swaminathan** (1987) for his contribution in achieving Green Revolution in India through the introduction of high yielding varieties of wheat and rice; **Dr. G.S. Khush** (1986) for co-developing several rice varieties, which doubled rice yields in Asia; **Dr B.R. Barwale** (1998) for building and strengthening seed production and supply system in India through the establishment of first seed company in India; **Dr M. Vijay Gupta** (2005) for developing low-cost technique for fresh water fish farmers for the rural-poor and as being founder of blue revolution in Asia; and **Dr S. Rajaram** (2014) for developing over 80 resistant varieties for many pests and diseases, which are under use all over the wheat-growing areas of the world. **Dr Howarth Bouis** (2016) was also felicitated for his significant contribution in addressing the problem of hidden hunger through biofortification. **Dr S.K. Vasal** (2000) was felicitated in absentia, for developing quality protein maize.

Hon'ble Prime Minister also digitally released the following publications: (i) Souvenir, IAC 2016, (ii) Abstract Book IAC 2016, (iii) Global Consultation on Use and Management of Agrobiodiversity for Sustainable Food Security, (iv) Guidelines of Management of Plant Genetic Resources in India, (v) Guidelines of Management of Animal Genetic Resources in India, (vi) Guidelines of Management of Fish Genetic Resources in India, (vii) Guidelines of Management of Microbial Genetic Resources in India, and (viii) Guidelines of Management of Insect Genetic Resources in India.

Hon'ble PM, Sh Narendra Modi releasing the publications of IAC 2016 in digital format

Token of appreciation being presented to the Chief Guest, Hon'ble PM, Sh. Narendra Modi by Dr M.S. Swaminathan (left) and to the Guest of Honour, Sh. Radha Mohan Singh by Dr R.S. Paroda (right)

Technical Sessions

Different aspects relating to conservation and use of agrobiodiversity were discussed across following seven Technical Sessions: (i) Food, nutrition and environmental security; (ii) Conservation strategies and methodologies; (iii) Adaptation and mitigation of climate change; (iv) Science-led innovation; (v) Quarantine, biosafety and biosecurity issues; (vi) Intellectual Property Rights (IPRs), ABS and Farmers' Rights; and (vii) Partnership, networks and capacity building. Also organized were, two evening lectures, seven plenary lectures, a round-table discussion on genebank management related issues, a farmers forum, a public forum and posters presentations. In addition, four theme-based satellite sessions were organized to focus discussion on: (i) agrobiodiversity for nutrition and health; (ii) use of agrobiodiversity as an opportunity for climate change; (iii) role of crop wild relatives for sustainable food production in the future; and (iv) harnessing biodiversity for food and security and sustainable development. There were 115 invited speakers from 35 countries, who delivered lectures on topics across the seven congress themes. The details of various sessions and fora are presented below.

Plenary Session 1: Agrobiodiversity for Sustainable Development Goals (SDGs)

This session was co-chaired by **Dr M.S. Swaminathan**, MSSRF, India and **Dr Martin Kropff**, CIMMYT, Mexico. **Dr R.K. Tyagi**, ICAR-NBPGR, India, was the Convener and **Drs Anjula Pandey**

Chairs and Speakers of the Plenary Session 1

and **B. Sarath Babu,** ICAR-NBPGR, India, were rapporteurs for the session. **Ms M. Ann Tutwiler** and **Dr R.S. Paroda,** delivered the two plenary lectures.

The first lecture '*We Manage What We Measure: An Agrobiodiversity Index to Help Deliver the Sustainable Development Goals*' was delivered by **Ms M. Ann Tutwiler**, Director General, Bioversity International, Rome, Italy. In her presentation, she referred to the inaugural speech by Hon'ble Prime Minister of India and agreed with his vision that agrobiodiversity was very critical for sustainable growth not just for India but for the whole globe. She appreciated how

Ms M. Ann Tutwiler, Director General, Bioversity International

during the green revolution, new varieties and production methods were developed. While mentioning the issues of global malnutrition and food related diseases, she emphasized on the identification of traits in the germplasm and utilizing them effectively through biofortification. Among the commonly grown crops like wheat, rice, maize, barley, rye, oats, millets, sorghum, rye and oats, iron can be added to enhance nutritional quality. She referred to the flawed old model of agriculture in terms of quality seed production and emphasized that seed replacement rates should be replaced with new improved models for better access of quality and diverse seeds to farmers, which would require lower inputs while yielding nutrition-rich produce.

While mentioning about the linkages between the nutrition and the production system-year-round production of fresh foods, she emphasized that supportive government policies would go a long way in playing an important role. She cited an example of the reintroduction of traditional diets of small millets in school mid-day meals by the MSSRF in India, which would promote conservation and use of millets in India. She stressed on linking better resilient production farms and biodiversity towards enhancing nutritional value of crops. To ensure continuous availability of local varieties/landraces for sustainable food systems, she emphasized promotion of community seed banks in diversity-rich areas for *in situ*/on-farm conservation. She shared that use of traditional crops varieties resulted in reduced pest and diseases pressure in Uganda and farmers were able to manage pests and food losses through cultivation of diverse bean varieties. She expressed how seed systems contributed to diversity in innovation, seed production and distribution, seed access support and conservation of crop diversity across eco-systems.

With reference to agrobiodiversity index and long-term monitoring systems for agrobiodiversity conservation, she defined some important steps: mainstreaming conservation activities, working with public and private sector institutions in diversity-rich countries, taking up pilot projects and development of infrastructure.

The second plenary lecture was delivered by **Dr R.S. Paroda,** President, ISPGR and Chairman, TAAS, on '*Managing Agrobiodiversity through Use: Changing Paradigms'*, wherein he discussed about global and domestic experiences in agrobiodiversity use,

Dr R.S. Paroda, President ISPGR and Chairman TAAS

conservation and exchange, and paradigm changes during the past few decades. Mentioning that if N.I. Vavilov had not moved all over the globe, we would not have known the significance and extent of diversity available in the nature, he emphasized that for further diversification, use of agrobiodiversity needs to be more effective. He also mentioned the significant role of women, local farmers and tribal communities for conservation and use of agrobiodiversity to check on genetic erosion and for enrichment of the food basket with vast diversity under the present changing scenario of climate and cropping systems.

He narrated the paradigm shift for free exchange of germplasm, starting from 1992 to the present day's regulatory regime. He talked about the CBD where conservation, sustainable use and sharing of benefits with the utilization of diversity was emphasized to multilateral PGR exchange mechanism of the ITPGRFA. The difficulties being faced owing to domestic legislations of different countries, including India's Biological Diversity Act, 2002, were highlighted. Another shift was relating to *ex situ versus in situ* conservation systems of agrobiodiversity and the significance attached to these mechanisms. Due to his consistent efforts, *ex situ* conservation facilities in India and in many of the Central Asian countries were developed.

Dr Paroda described India's Protection of Plant Varieties and Farmers' Rights Act 2001, as another paradigm shift in protecting the farmers' varieties through registration and recognition of farmers as the primary conservationists and breeders, providing them unique rights. At the same time, he expressed concerns over the slow pace of registration of extant varieties by the PPV&FRA. He voiced concerns over the loss of PGR due to a variety of reasons, including climate change, urbanization and cultivation of modern varieties. He discussed about the FAO initiatives at length in plant breeding and PGR utilization. He enumerated some of the reasons for decline in PGR utilization - access to PGR is becoming difficult, funding is elusive, breeders decline to use germplasm especially wild relatives, and there has been a paradigm shift from traditional to molecular breeding. He advocated judicious applications of new technologies like DNA fingerprinting, nanotechnology and bioinformatics for better conservation and utilization of agrobiodiversity. He reiterated the necessity for documenting of traditional knowledge and its validation for effective conservation and use of agrobiodiversity.

Certain outstanding and significant issues to be addressed were also discussed, for example, expansion of FAO list of Annex 1 crops, designation of PGR under ITPGRFA and proper adoption mechanisms for SMTA and MTA for material exchange, enhancing ABS looking at the tribal conservationists, capacity building, incentives and compensation for ecosystem services. He expressed an urgent need for expansion /creation of national gene funds in diversity rich countries. Dr Paroda expected a road map to unlock the hidden treasure of agrobiodiversity for food and nutritional security at global level.

A view of the audience during the plenary session

Recommendations - Plenary Session 1

- *Agrobiodiversity Index* should be developed and implemented to help monitor on-going genetic resource conservation and management efforts and to deliver Sustainable Development Goals, with particular emphasis across agrobiodiversity hot spots globally.
- *Landraces and traditional farmers' varieties* should be "conserved through use, both *ex situ* and *in situ* on-farm, by ensuring continuous availability of their quality seed materials; strengthening local seed systems and promoting community seed banks across diversity-rich agroecosystems.
- *Government policies* should be supportive to promote crops contributing to malnutrition and food related diseases, especially in women and children.
- *List of crops of Annex 1* of the ITPGRFA should be expanded to include more agriculture crops of national, regional and global significance.
- *National system on protecting farmers' varieties* should be established/strengthened and National Gene Funds should be created/ expanded in diversity-rich countries for supporting conservation and sustainable use of agrobiodiversity at farm and community levels.
- *Technological advances* in genomics, nanotechnology, space and bioinformatics should be employed judiciously and appropriately for better conservation and utilization of agrobiodiversity.
- *Traditional knowledge*, available with rural and tribal communities, especially with women farmers, should be documented on priority for effective use of agrobiodiversity.

Technical Session 1: Food, Nutrition, and Environmental Security

In this session, discussions were held on the role of agrobiodiversity in addressing nutrition security and hidden hunger in addition to food and environment security. There were two concurrent sessions: Technical Session 1A on Plant Genetic Resources and Technical Session 1B on Animal, Aquatic, Insect and Microbial Genetic Resources.

Dignitaries on the dais during concurrent session 1A on PGR

Concurrent Session 1A: Plant Genetic Resources

This session was co-chaired by **Dr David Bergvinson**, Director General, ICRISAT, India and **Dr Nikolay Dzyubenko**, Director General, VIR, Russia. **Dr P.N. Mathur**, Honorary Research Fellow, Bioversity International, India, was the Convener and **Drs Kalyani Srinivasan** and **Kamala Venkateswaran,** ICAR-NBPGR, India, were the Rapporteurs for the session. Dr David Bergvinson introduced the session, which was followed by four lead presentations by **Drs Martin Kropff**, **T. Mohapatra**, **Howarth Bouis** and **Emile Frison.** Four rapid presentations were made by **Drs I.S. Bisht**, **Masatoshi Funabashi**, **W.L.G. Samarasinghe**, and **Mani Vetriventhan**.

Dr Martin Kropff, Director General, CIMMYT

Dr Martin Kropff, Director General, CIMMYT, Mexico, delivered a lecture on '*Why we need Effective Partnerships and Agrobiodiversity to feed 9 billion people?*' He emphasized that to feed the projected population of 9 billion by 2050, two times greater production from two times lesser resources are needed to yield two times better nutrition and diversity. To achieve it, effective partnerships required to facilitate easy access to valuable genetic resources which is the key to food security in the future. Dr Kropff advocated that food security can be achieved through creation of a platform for sharing knowledge generated through integrated research programmes. To address upcoming challenges of food and nutritional security, he emphasized accelerated pace of using conserved genetic resources in crop improvement.

Dr T. Mohapatra, Director General, ICAR, India**,** made presentation on '*Indian Agrobiodiversity Management System*'. He highlighted the details of national strength for management of genetic resources of plants, animals, fish, agriculturally important microbes and insects. Dr Mohapatra emphasized on exploration of protected areas, followed by collection and systematic characterization/ evaluation for economic traits for better valuation and value addition. Conservation of trait-specific germplasm and rationalization of conserved germplasm to demarcate unique genotypes was mentioned as another priority, besides emphasising on allele-mining, pre-

Dr T. Mohapatra, Director General, ICAR

breeding and resolving biosecurity issues. He advocated strong on-farm conservation program and developing mechanisms of incentives to recognize value of ITK, and ecological goods and services provided by the farmers. He felt that towards this end, facilitation of registration of farmer's varieties was imperative. He emphasized on developing and strengthening mechanisms for fair and equitable sharing of benefits accruing from utilisation of genetic resources.

Dr Howarth Bouis, HarvestPlus, USA, gave a presentation on '*Reducing Mineral and Vitamin Deficiencies through Biofortification: Progress under HarvestPlus*'. He emphasized on biofortification of staple food crops without compromising on yield or farmer-desired traits through conventional breeding/safe interventions. Promoting partnerships between key stakeholders to mitigate nutritional deficiencies through supply of biofortified products was another important activity. He reinforced that biofortification should be integrated as a core activity within global institutions.

Dr Howarth Bouis, HarvestPlus, USA

Dr Emile Frison, IPES-Food, Italy, gave a lecture entitled '*From Industrial Agriculture to Diversified Agroecological Systems*'. He mentioned the paradigm shift from industrial agriculture to diversified agro-ecological systems. He laid emphasis on development of new indicators for sustainable food systems and for a shift of public support towards agro-ecological production systems. Also, short supply chains and alternative retail infra-structures should be supported.

Dr Emile Frison, IPES-Food, Italy

Informal markets and policy measures must be put in place linking farmers to consumers. Local agro-ecological produce can be supported through use of public procurement system. Dr Frison stressed on the following: (i) strengthen movements that unify diverse constituencies around agro-ecology, (ii) mainstream agro-ecology and holistic food systems approaches into education and research agendas, and (iii) develop food planning processes and joined-up food policies.

Dr I.S. Bisht, ICAR-NBPGR, India, gave a presentation on '*Traditional Land and Food Systems: A Case Study of Uttarakhand State in North-western Indian Himalayas*', emphasizing on revival of local food systems and landscapes within the broader framework of food sovereignty.

Dr Masatoshi Funabashi, Sony Computer Science Laboratories Inc., Japan, made a presentation on '*Synecological Farming for Mainstreaming Biodiversity in Small Holding Farms and Foods: Experiments in Japan and Burkina Faso*'. Based on his experiences, he informed that **s**ynecological farming systems are capable of supporting sustainable food production to alleviate poverty and malnutrition to a great extent in small holding farms. The cost-effective system would be feasible for adoption in different agro-ecological zones.

Dr W.L.G. Samarasinghe, Plant Genetic Resources Centre, Sri Lanka, presented a talk on '*Strategies for Conservation and Sustainable Use of Biodiversity for Food and Nutrition in Sri Lanka*'. Through baseline surveys of biodiversity conservation and sustainable use for improved human nutrition in Sri Lanka, it was revealed that a high level of utilization of rich biodiversity by the households showed consumption pattern not of a balanced diet. Thus, more awareness programmes for nutritional values of biodiversity are needed.

Dr Mani Vetriventhan, ICRISAT, India, presented results of the experiments on '*Little Millet, Panicum sumatrense, an Under-utilised Multipurpose Crop*'. He mentioned that out of 200 accessions of little millet (*Panicum sumatrense*), evaluated at ICRISAT, Patancheru, three accessions gave high grain yield and high biomass with limited water supply, and have been identified for utilization as a bioenergy crop for food and fodder.

Recommendations - Concurrent Session 1A: Plant Genetic Resources

- *Effective partnerships* should be established and sustained for easy access to valuable genetic resources, and indicators for a successful partnership be developed.
- *Systematic characterization/evaluation* should be undertaken for economic traits identification and value addition and their conservation through enhance use.
- *Legislations* should be enacted by countries necessary for enhanced access to PGR and associated benefit sharing.
- *Enabling environment* for access to PGR should be created by harmonizing various domestic Acts and Regulations and a single *window system* be developed for enhancing the accessibility and use of PGR.
- *Biofortification be integrated as a core activity* within global institutions to mitigate nutrition deficiencies.
- *Policy measures and informal markets* should be put in place linking farmers to consumers.
- *New indicators* for sustainable food systems be developed for public support, including towards agroecological production systems.

Concurrent Session 1B: Animal, Aquatic, Insect and Microbial Genetic Resources

This session was co-chaired by **Dr J.K. Jena** from ICAR, India and **Dr Purvi Mehta** from BMGF, India. **Dr A.K. Saxena** from ICAR-NBAIM, India was the Convenor. **Dr Monica Sodhi** from ICAR-NBAGR and **Dr S. Renu** from ICAR-NBAIM, India, were the Rapporteurs.

Drs A.K. Saxena, Purvi Mehta and J.K. Jena

Dr A.K. Saxena welcomed all the participants to the session and introduced the Co-chairs. **Dr Purvi Mehta** spoke on the relevance of IAC 2016 and referred to the Hon'ble Prime Minister's address on agrobiodiversity. **Dr J.K. Jena** informed that the session would encompass various sectors, from underground to sky *i.e.* from fish to animals, insects and microbes. There were four lead presentations by **Drs Olivier Hanotte**, **N.K. Krishna Kumar**, **J.K. Jena** and **Anil Saxena**; and four rapid presentations by **Drs C. Lavina**, **Sijun Zheng**, **K. Vinod** and **R.K. Vaid**.

Dr Olivier Hanotte, ILRI, UK, made a presentation on '*Animal Genetic Resources for Food Security*'. He focussed on global context of diversity and challenges faced for animal production; documentation of animal genetic resources, and the way forward. He emphasized on the need to characterize animal germplasm for its documentation, conservation and future use, more so, many of these are nondescript, but might carry unique and functional diversity, useful to meet future challenges. In the present scenario of increasing human population and global

Dr Olivier Hanotte, ILRI, UK

warming, higher production of meat as well as milk is required, while simultaneously livestock resources exposed to new diseases and higher global temperature need to be managed well. There is a need to characterize animal germplasm using precision-based technologies for its documentation, conservation and future utilization.

Dr N.K. Krishna Kumar, Bioversity International, India, talked on '*Insect Biodiversity, Ecosystem Services and Sustainable Agriculture*'. His focus was on the diversity of insects, who are the largest occupants of earth, most resilient survivors and exhibit diversity in number, size and other traits. The role of insects for reduction of agricultural pests, pollination and savour of wild species was described. He suggested that synergistic interaction of humans, agriculture, animals and insects with biodiversity was the backbone of a sustainable ecosystem.

Dr N.K. Krishna Kumar, Bioversity International, India

Dr J.K. Jena, ICAR, India, made a presentation on '*Conservation and Management Approaches of Fish Genetic Resources in India: Present Status and Future Outlook*'. He gave insight into fish genetic resources contribution in global as well Indian context. Various components of fish genetic resources including its variation at three levels - species, sub-population and individual, were detailed out. His talk focused on the need of conservation and related management practices. He emphasized on the need for *in situ* conservation requiring collaborative endeavours; *ex situ* conservation; stock enhancement and culture diversification; establishment of live genebanks. He suggested specific diversification as one of the approaches

Drs Anil Saxena ICAR-NBAIM and J.K. Jena, ICAR, India

for characterization of fish genetic resources. He urged the need to decipher the genome architecture using next generation sequencing technologies to establish complementary taxonomy and evolutionary linkages. He informed about many such programs being undertaken like network program on fish biodiversity in transboundary rivers, biodiversity assessment, establishment of region wise genebanks, etc. He also gave the concept of designating breeds as "state breeds" and giving the responsibility of conserving them to respective states.

Dr Anil Saxena, ICAR-NBAIM, India, spoke on '*Microbial Biodiversity of Microbial Diversity of Extreme Regions: An Unseen Heritage and Wealth*'. He highlighted the need for exploring microbes from extreme environments, to identify activated/ expressed genes/pathways that make the microbes tolerant to such environments.

A view of the audience of Concurrent Session 1B

The information could be mimicked to other biosystems like animals and plants. He pointed out that although, India is one of the 12 mega biodiversity countries and has 25 hot-spots of the richest and highly endangered ecoregions of the world, but still not much information is available on the microbial diversity, in particular, from extreme regions. He shared that under defined projects, many habitats were surveyed and organisms belonging to many different genera isolated, and baseline information generated. These organisms are being explored for their utilization for alleviation of salt stress, for sustenance of growth under salt and salinity, low/high temperature stress, frost protection, potassium and zinc solubilization. He opined that with the availability of whole genome sequences, it would be possible to manipulate microbes, using recent molecular technologies. Currently, draft genome sequencing of a few bacteria from halophillic zones is available. He also discussed about the utility of microbes to obtain biomolecules important for industry, agriculture and waste management.

Dr C. Lavina Vincent, ICAR-CMFRI, India, presented studies on '*Partial Gene Characterization of Candidate Functional Gene MSTN encoding Growth and Muscle Development in Trachinotus mookalee and Trachinotus blochii*'.

Dr Sijun Zheng, Bioversity International, China, presented his work on '*Innovative Integrated Systems for Intensification of Banana, Pig and Cattle Production in Yunnan Province of Southwest China'*.

Dr K. Vinod, ICAR-CMFRI, India, made a presentation on '*Conservation and Sustainable Management of Seahorses in the Gulf of Mannar and Palk Bay, South-East Coast of India*'.

Dr R.K. Vaid, NCVTCC, India, presented his studies on '*Role of Veterinary Type Culture Collection in Capturing Equine Microbial Diversity*'.

Recommendations - Concurrent Session 1B: Animal, Aquatic, Insect and Microbial Genetic Resources

- *Regional collaborations* should be established and promoted for conservation and use of microbe, insect, fish and animal genetic resources of transboundary nature.
- *Genetic characterization* be carried out on priority by using both genome wide markers and phenotypic data for documentation of diversity and for trait discovery.
- *Agrobiodiversity Index* should be developed for making rational decisions on conservation of diversity.
- *Cataloguing of indicators* should be developed to understand agrobiodiversity holistically.
- *Value addition of bio-products* and conservation of habitat should be initiated/ intensified, at local level, to enhance the sustainability.

Plenary Session 2: Conservation through Use

The session was co-chaired by **Dr R.S. Paroda,** TAAS, India and **Mr Cristian Samper,** Bioversity International, Italy. **Dr Kuldeep Singh**, ICAR-NBPGR, India was the Convener and **Drs J. Radhamani** and **Rakesh Bhardwaj** ICAR-NBPGR, India, were Rapporteurs. In this session, two plenary lectures were given by **Dr Gurdev Singh Khush,** University of California, Davis, USA and **Dr Toby Hodgkin,** Bioversity International, Italy.

Dr R.S. Paroda and Cristian Samper, Co-Chairs of the Plenary Session 2

Dr Gurdev Singh Khush who has been working on the genetic resources of rice since last three decades, spoke on '*Agrobiodiversity Use for Food Security*',

Dr Gurdev Singh Khush

wherein he presented his work done on rice breeding at the International Rice Research Institute (IRRI), Philippines. He emphasized on the importance of traditional cultivars and crop wild relatives of cereals mainly rice, wheat and maize which contribute to more than 50% of the calories consumed by world population. His presentation mainly focused on the rice genetic diversity and its use in rice improvement, as a case study. Rice is one of the most important crops and a staple food the world over contributing 23% of the calories supplied to world population. Traditional cultivars and crop wild relatives of rice are the main reservoir for potential genes which can be exploited for various traits like biotic and abiotic stress tolerance, nutritional and agronomical traits using both conventional breeding and biotechnological tools for crop

improvement in climate change scenario. He emphasized on the importance of short duration varieties to accommodate two crops per season for benefitting farmers. Dr Khush reinforced enhanced use of genes from wild species and landraces to combat biotic and abiotic stresses and for increasing yield potential, as was evident in the case of rice. Based on his past experiences, he suggested need for developing systematic breeding programmes in a network mode, where both national and international centers could work together.

Dr Toby Hodgkin, in his presentation on '*Exploring the Benefits of a System Based Approach to PGR Conservation*', mentioned that available genetic diversity needs to be adequately conserved, by strengthening linkages between *ex situ* and *in situ* conservation programs. He suggested the development of a system approach by creating an integrated and dynamic system. The sets of inter-connected elements and processes would result in a particular set of functions to achieve objectives of holistic conservation.

Dr Toby Hodgkin receiving a memento from Dr R.S. Paroda

Plenary lectures were followed by panel discussion and the panellist were: (i) **Dr S. Rajaram,** RSM, Mexico; (ii) **Ms Marie Haga,** GCDT, Germany; (iii) **Dr Calvin Qualset,** University of California Davis, USA and (iv) **Dr Usha Zehr**, MAHYCO, India.

A view of panelists

Dr S. Rajaram, who has led collaboration on wheat germplasm between CIMMYT and national partners including India, highlighted the issues of increasing wheat production in the wake of climate change. *Puccinia* sp. is still a threat to increase wheat production and *Aegilops squarrosa* may be used in wheat

Dr S. Rajaram

breeding to combat this. He said that utilization of genetic resources depended on the breeding system of crop and crop improvement program. Wheat germplasm available with CIMMYT and ICARDA genebanks have valuable traits so there are possibilities of utilizing these potential germplasm by wheat research community at the global level. He cautioned about quarantine importance during exchange of germplasm, for example, wheat blast is prevalent in tropical areas.

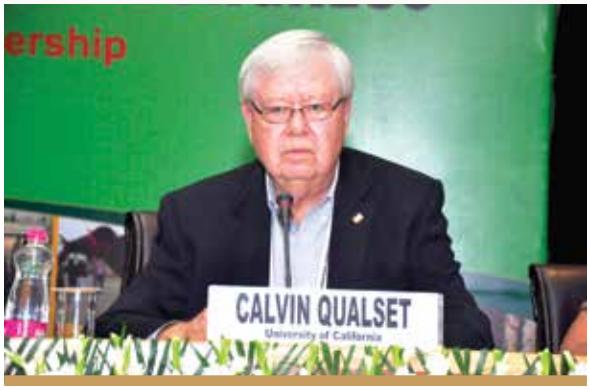
Ms Marie Haga stressed upon the importance of crop diversity which would provide

vital options for the survival of mankind. Conservation in either way *i.e. in situ* or *ex situ* is important and it is important even for species, which are considered less useful today. According to her, half of the increase in food production can be attributed to improvements through natural breeding. Although, undoubtedly great achievements were made in the last decade but still enormous challenges lie ahead, like further advances in crop science, building efficient markets for the produce and reducing food wastage. There are about 1,700 genebanks around the world holding more than 7 million accessions, but this germplasm needs to be systematically characterized to enhance its use by researchers and breeders. Genotyping

Ms Marie Haga

and phenotyping of germplasm can aid in identification of valuable traits and thereby its proper utilization. Crop wild relatives can be a game changer, therefore, pre-breeding programs need to be strengthened. She underlined that agrobiodiversity is mainly being threatened on three fronts - in wild, in farmers' field and even in genebanks.

Dr Calvin Qualset discussed about the importance of crop landraces (CLR) which are at high risk, being replaced by improved varieties. These shifts have brought along some environmentally distressing changes in soil, as pesticide and fertilizer contamination of ground water and decline in crop quality.



Dr Calvin Qualset

These landraces may be screened by growing them in nurseries for various potential valuable traits, and farmers should be given incentives for *in situ* conservation of these landraces. The most important target for CLR improvement is disease, pest resistance and improvement in nutritional quality of edible crops. He also emphasized using crop wild relatives, landraces and germplasm in crop improvement programs. Under all such conditions, care is a must to retain the traditional end-use traits of the CLRs.

Dr Usha Zehr emphasized application of new technologies and tools for improving quality and productivity of seeds and agriculture. Conservation and diversity creation is the key for future crop improvements. Private sector's primary customers are small farmers with small land holding of less than one hectare. In respect to access and importance of germplasm, she emphasized that private sector needs potential trait-specific germplasm of commercial value.

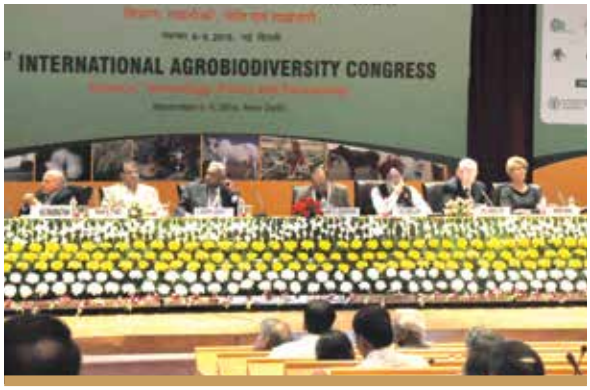
Dr Usha Zehr

Recommendations - Plenary Session 2: Conservation through Use

- *Wild species germplasm and landraces* of cultivated food and agriculture crops should be evaluated using conventional and modern techniques to identify and exchange trait-specific germplasm.
- *Trait-specific germplasm* should be intensively used to develop high yielding varieties tolerant to biotic and abiotic stresses.
- *Sustainable system-based approach* should be developed to strengthen on-going conservation activities and *effective linkages* need to be established between *ex situ* and *in situ* conservation activities.
- *Quarantine regulations* need to be followed for safe movement of germplasm.
- *Genotyping and phenotyping* of conserved germplasm be undertaken for valuable trait identification and their utilization.
- Pre-breeding programmes need to be strengthen at national and global level for enhancing use of crop wild relatives, especially for biotic and abiotic stresses.

Technical Session 2: Conservation Strategies and Methodologies

This Technical Session had three Concurrent Sessions on: (i) plant, (ii) animal and aquatic and (iii) microbe and insect genetic resources. The Concurrent Session on PGR had three Sub-Concurrent sessions comprising: (i) seed genebank, (ii) *in situ*, on-farm genebank and (iii) *in vitro*, cryo and DNA bank. Presentations made and recommendations emerging from each session are presented hereunder.



A view of the dignitaries on the dais during Concurrent session on Seed Genebanks

Concurrent Session 2A: Seed Genebanks

The session was co-chaired by **Dr B.S. Dhillon,** PAU, India and **Dr R.S. Hamilton,** IRRI, Philippines. **Dr H.D. Upadhyaya** from ICRISAT, India was the Convenor, **Drs Sherry R. Jacob** and **Veena Gupta**, ICAR-NBPGR, India, were the Rapporteurs. Dr B.S. Dhillon briefed about the importance of seed conservation and relevance of genebanks in the present agricultural scenario. During this session five lead lectures by **Ms Marie Haga**, **Drs H.D. Upadhyaya**, **Mariana Yazbek**, **N. Murthy Anishetty** and **R.K. Tyagi** were delivered. In addition, three rapid presentations were also given by **Drs Arnab Gupta**, **Manisha Thapliyal** and **Teswang Rinchen**.

Ms Marie Haga, GCDT, Germany, presented a lecture on '*Building a Global System for the* Ex situ *Conservation of Crop Diversity*'. She emphasized on how, even with loss of 90% field diversity in rice varieties in India and China, fruits and vegetables in USA and 80% of corn diversity in Mexico, their genetic resources are available still for utilization because of their *ex situ* conservation in genebanks. These genetic resources can be used for increasing food production, for fighting pests

Ms Marie Haga

and diseases, for increasing nutritional value, and for adaptation to climate change and also for reducing agriculture foot print. An excellent example is the 'Scuba' rice developed by IRRI that can withstand climate change. The world's food supply cannot be secured if the genetic basis is lost. This has also been endorsed by United Nations Sustainable Development Goals. The ITPGFRA is the legal umbrella for linking countries for germplasm exchange. The GCDT holds the key funding mechanism for implementation of ITPGFRA. However, government and policy makers across the globe need to realize the importance of investing in conservation and management of PGR including it in their priority list.

Dr H.D. Upadhyaya, ICRISAT, India, made a presentation on '*Germplasm Management for Enhanced Genetic Gains*'. He stressed on the relevance of actual genetic gain, which is the annual increase in genetic gain realized through crop breeding. It is <1% in most of the crops. To achieve food and nutritional security targets, it needs to be doubled. For this, the PGR conserved in genebanks needs to be utilised. Statistics revealed the utilization of germplasm in crop improvement is extremely low, 50% of wheat varieties, 75% of maize and 50% of soybean cultivars in the USA were derived from just 10 germplasm accessions. The major reasons for the low utilization by plant breeders are the lack of reliable characterization data and trait-specific information. ICRISAT has accorded due priority to this requirement, and has developed mini-core collections in almost all its mandated crops, each having approximately 200 accessions. This includes multiple trait genotypes, with desirable agronomic background and few with even higher yielding ability as compared to the best checks. Development of these mini-core collections has led to enhanced utilization of germplasm in crop improvement programs.

Dr H.D. Upadhyaya

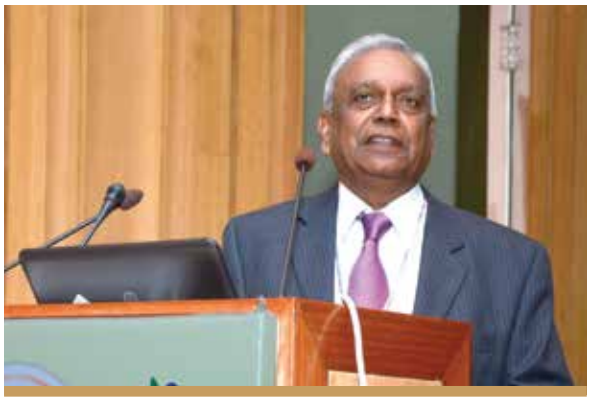
Dr Mariana Yazbek, ICARDA, Lebanon, gave a comprehensive presentation on

Dr Mariana Yazbek

'*ICARDA's Efforts to Promote* In Situ/*On-farm Conservation of Dryland Agrobiodiversity*'. A brief outline on ICARDA's work among marginal farmers of the dryland tracts was presented. The majority of the dryland farmers still rely on landraces and ICARDA is promoting *in situ* conservation by providing inputs for value addition of these agricultural products. *Ex situ*

conservation efforts at ICARDA presently focus on re-establishing their genebank partly in Lebanon (for crop wild relatives) and partly in Morocco (for other breeding lines). For this, ICARDA repatriated its collection from Svalbard Seed Vault, Norway and regenerated all the accessions in the field. ICARDA's current repatriation is the best illustrated example of the importance of having safety duplicates of the *ex situ* germplasm collections.

Dr N. Murthy Anishetty, Ex-FAO, Italy, delivered a lecture on '*Genebanks: Management of Genetic Erosion in* Ex Situ *Collections*', along with his co-author, **Dr K.S. Varaprasad**, Ex IIOR, Hyderabad. Discussing progressive development in establishment of genebanks, he mentioned that in early 1960s there were only 6 genebanks with facilities for managing large *ex situ* collections. Today there are around 1,750 genebanks accounting for 7.4 million germplasm collections globally. It is very important to have a scientific strategy for preventing/minimizing genetic erosion in these collections. The specific parameters for assessing the extent of genetic erosion and the precautionary measures to avoid allele loss were also elaborated. The need to accommodate maximum diversity within a variety and encourage value addition of targeted landraces through appropriate policies and government support, was emphasized.



Dr N. Murthy Anishetty (above) and Dr K.S. Varaprasad

Dr R.K. Tyagi, ICAR-NBPGR, India, made a presentation on '*Conservation of PGR for Effective Utilization: New Initiatives at NBPGR*'. Under the National Initiatives on

Dr R.K. Tyagi

Climate Resilient Agriculture (NICRA) project, characterization of all wheat and chickpea accessions conserved in the National Genebank of NBPGR was undertaken, to develop a core set in each crop. About 20,000 accessions of wheat were evaluated for rusts, spot blotch and Karnal bunt diseases to identify multiple disease resistant germplasm. Similar characterization efforts are being continued in major food crops germplasm conserved in National Genebank under the Consortium Research Platform (CRP) on Agrobiodiversity. By the year 2017, it is anticipated that around 40% of the germplasm collection in National Genebank would be characterized and documented. He emphasized on making trait-specific information available to the breeders and in this regard, PGR Portal at the NBPGR has helped in ensuring better access to information. He

stressed that other countries should also take up characterization of germplasm available in their national genebanks for unlocking potential of genebank collections and effective utilization of germplasm.

Dr Arnab Gupta, Bioversity International, India, presented his work on '*Low Carbon Footprint Seed Conservation technique: The Desiccated-ambient Storage System Using Zeolite Beads*'. He apprised about the use of zeolite beads as potential desiccant, for use by farmers for enhancing seed longevity at ambient conditions.

Dr Manisha Thapliyal, FRI, India, discussed '*Conservation of Forest Genetic Resources: Need and Challenges*'. She emphasized on the inventorization and subsequent conservation of wild forest genetic resources, especially of Uttarakhand region, using various techniques.

Dr Teswang Rinchen, DIHAR, India, made presentations on '*Phytodiversity and its Conservation Strategies in Permafrost Conditions at Extreme Altitude of Trans-Himalaya in Leh-Ladakh*'. He presented findings on evaluation and characterization of potential vegetable germplasm conserved at permafrost conditions of Chang la (17,650 ft. amsl) at Leh-Ladakh.

Recommendations - Concurrent Session 2A: Plant Genetic Resources

- *Regional and international cooperation* should be established/strengthened to facilitate accessibility of genebank collections for ensuring food and nutritional security and climate resilient agriculture production.
- *National governments* should enhance/sustain investment in *ex situ* conservation of PGR.
- *Core and mini-core collections* should be developed in targeted crops and *PGR Informatics* should be strengthened to enhance effective utilization of germplasm conserved in the national, regional and global genebanks.
- *Safety duplicates* should be maintained for repatriation of lost germplasm owing to any emergent situations.
- *Traditional seed conservation methods* by farmers and communities be improved/strengthen with scientific backstopping.

Concurrent Session 2B: *In Situ* and On-farm Conservation

This Technical Session was Co-chaired by **Dr Stephan Weise**, Bioversity International, Italy, and **Dr H.S. Gupta**, Ex-BISA, India. **Dr Shailendra Rajan,** CISH, India, was Convener and **Drs K. Joseph John** and **A.K. Mishra,** ICAR-NBPGR, India, were Rapporteurs. Dr Shailendra Rajan introduced the Co-chairs and introductory remarks about the session were made by the Co-chairs. In this session, five invited presentations were made by **Drs Calvin Qualset**, **Coosje Hoogendoorn**, **Nigel**

Drs H.S. Gupta, Stephan Weise and S. Rajan (from left to right)

Maxted, **V. Ramanatha Rao** and **Stefan De Haan**. The five rapid presentations were also made by **Drs N. Hovhannisyan**, **S. Rajan**, **S.R. Maneeesha**, **S.D. Kumbhar** and **Y.Y. Wang**.

Dr Calvin Qualset, University of California, USA, made a presentation on *'Agro-biodiversity: Prospects for a Genetic Approach to In situ Conservation of Crop Landraces*'. He said that on-farm (*in situ*) conservation is generally not a planned program, but is based on the farmers' preferences. Therefore, incentives for *in situ* conservation need to be worked out. He opined that the genetic approach, such as mass selection and single plant selection, are highly effective in improving yield and sustainable cultivation of landraces for an out-crossing crop such as maize.

Dr Calvin Qualset receiving a momento from Dr Stephan Weise

Dr Coosje Hoogendoorn, Royal Tropical Institute, Netherlands, spoke on *'Integrated Seed Sector Development (ISSD) – How Informal and Formal Seed Systems Can Work Together for the Conservation and Use of Agricultural Biodiversity*'. She mentioned that a dynamic agricultural biodiversity conservation program and its availability for use by the breeders would be central to food security, poverty eradication and resilience to climate change. She advocated synergy between formal and informal seed sectors for better and efficient management of agrobiodiversity. Integrated Seed Sector Development (ISSD) approach would be equally important for a better and balanced *in situ* and *ex situ* PGR conservation, effective in conserving minor and neglected crops.

Dr C. Hoogendoorn

Dr Nigel Maxted, University of Birmingham, UK, presented an account on '*Impacts of a Changing Climate on Conservation Priorities for Crop Wild Relatives*'. He emphasized that crop wild relatives (CWR) hold a key for human survival in the event of food insecurity and malnutrition driven by climate change. Therefore, modelling of species distribution is useful to predict effect of climate change on survival of CWR. He informed about an increased severity of threat to CWR with more and more species coming under the IUCN red list categories. For effective conservation and utilization, preparation of regional and national CWR strategic action plan is urgently required.

Dr N. Maxted receiving a memento from Dr Stephan Weise

Dr V. Ramanatha Rao, GRSV, India, presented strategies for *'On-farm/In situ Conservation of Tropical Fruit Tree Diversity: Emerging Concepts and Practices*'. He opined that on-farm conservation efforts are sustainable only when they contribute to enhanced livelihood options and need adoption of community driven approaches such as Community-based Biodiversity Management (CBM) model. Role of farmers, especially custodian farmers, as user, conserver, innovator and promoter, is important for on-farm management of tropical fruit tree diversity. He emphasized that on-farm conservation works well in diversity hotspots, and farmers need to lead and scientists should play only a supportive role. As far as tropical fruit trees are concerned, elite tree selection from farmers' orchards would be the best approach for on-farm conservation.

Dr V. Ramanatha Rao

Dr Stefan De Haan, CIAT, Vietnam, made a presentation on *'Conservation Dynamics of Roots and Tuber Crops under On-Farm Management*'. He mentioned that on-farm conservation of landrace populations in centres of crop genetic diversity would require intelligent interventions like systematic monitoring, measuring transitions and documenting drivers. He was of the opinion that farmer managed diversity changes actively and continues to produce novel and unique diversity.

Dr Stephan De Haan receiving a memento from Dr Stephan Weise

Dr N. Hovhannisyan from Yerevan State University, Armenia, presented his work on '*The Role of Monastic Gardens in Sustainable Conservation of Grape* (*Vitis vinifera* L.) *Genetic Diversity in Armenia*'. He informed that Monasteries played a key role for effective *in situ* conservation of the grape genetic resources in Armenia.

Dr S. Rajan, ICAR-CISH, India, made presentation on '*On-farm Conservation of Mango Diversity through Community Based Organization: A Case Study*'. He concluded that innovative community efforts such as selling assorted fruit baskets, organizing diversity fair and promoting community nurseries helped achieve dual goals of supporting livelihood of mango growers of non-commercial varieties and on-farm conservation of mango diversity sustainably in India.

Dr S.R. Maneeesha, ICAR-CCARI, India, talked on '*Kulagar – A Potential System to Conserve the Crop Diversity*'. In Goa and Konkan region, farmers have a conventional homestead system called '*Kulagar*' which has been found very effective for conservation of species diversity and some landraces.

Dr S.D. Kumbhar, MPKV, India, presented his work on '*Farmers' Participatory Conservation of Rice landraces*'. Farmers Participatory Variety Selection (PVS) using the wisdom of elderly farmers was found to be a useful technique for varietal purification as well as conservation of the scented rice landrace, '*Champakali*', in Konkan, Maharashtra.

Dr Y.Y. Wang, Yunnan Agricultural University, China, discussed '*Innovative Biodiversity Management and Community Development: Yunnan Hani Rice Terraces Case*'. She reported that the high heterogeneity of traditional rice varieties, which was maintained by Hani community in Yunnan province of China under terrace farming, helped provide a strong buffer effect to combat biotic and abiotic stresses.

Recommendations - Concurrent Session 2B: In Situ and On-farm Conservation

- *Incentivize mechanism for* in situ*/on-farm conservation* and genetic approaches should be developed and adopted for on-farm conservation of landraces diversity.
- In situ*/on-farm conservation* should be supported by providing scientific inputs, monitoring, measuring transitions and documentation.
- *Synergy between formal and informal seed sectors* should be brought in by adopting Integrated Seed Sector Development (ISSD) approach for conservation and use of agrobiodiversity.
- *Regional and national CWR strategic action plan* and species distribution modelling should be put in place on priority for their effective management and utilization.
- In situ*/on farm conservation approached* based on enhanced livelihood options for farmers and communities; *Custodian farmers* need to be identified for promoting crop and tree diversity on farm.

Concurrent Session 2C: *In Vitro* Conservation, Cryopreservation, and DNA Banking

This technical Session was co-chaired by **Dr P.L. Gautam**, Former Chairperson, PPV&FRA, India and **Dr Emile Frison**, IPES-Food, Italy. **Dr Neelam Sharma**, ICAR-NBPGR was the Convenor and **Dr P. Rajasekhran**, ICAR-IIHR, India and **Dr Sandhya Gupta**, ICAR-NBPGR, India, were the Rapporteurs. Five lead presentations were made by **Drs Hugh Pritchard**, **Hiroshi Abe**, **Bart Panis**, **Rekha Chaudhury** and **Badara Gueye**. In addition to these, three rapid presentations were made by **Drs R.P. Kaur**, **Neelam Sharma** and **S. Uma**.

Dr Hugh Pritchard, Royal Botanical Garden, Kew, made presentation on '*Priority Science for the Preservation of Priority Crops*'. He emphasized on gene pool conservation

Drs P.L. Gautam (left) and Emile Frison

Dr Hugh Pritchard receiving a memento from Dr P.L. Gautam

through cryopreservation of orthodox seeds of heterozygous crops listed in Annex 1 of the ITPGRFA. He described in detail the viability, longevity, storage behaviour and pattern of seeds of various species under different families.

Dr Hiroshi Abe, RIKEN, Japan, delivered lecture on '*Plant DNA Resources in RIKEN BRC to Bridge the Gap between Gene Function and Phenotype*'. The role and purpose of BRC was discussed. The presentation mainly focused on *Arobidopsis* genome, cDNA libraries, *etc*. Emphasis was given on the development of DNA resources to bridge the gap between gene function and phenotype.

Dr Hiroshe Abe

Dr Bart Panis, Bioversity International, Belgium, talked on '*Securing Plant Genetic Resources for Perpetuity through Cryopreservation*'. The importance and applicability of droplet vitrification method of cryopreservation was discussed. Safety back-up of cryopreserved collection was emphasized with the proposal of creating a 'Global Cryo Vault' for a range of vegetatively propagated crops.

Dr Bart Panis

Dr Rekha Chaudhury, ICAR-NBPGR, India, made a presentation on '*Expanding Applications of Cryobanking for Genetic Resources Conservation*'. She discussed the status and work done on cryopreservation at ICAR-NBPGR, including efforts on cryobanking of microbes.

Drs S. Uma, R.P. Kaur, Rekha Chaudhury (left to right)

Dr Badara Gueye from IITA, Nigeria, made presentation on '*In Vitro Propagation and Conservation of Tropical RTBs*'. *In vitro* propagation, slow growth conservation and cryopreservation practices being practised in IITA were presented and discussed.

Dr Badara Gueye

Dr R.P. Kaur, ICAR-CPRS, India, presented her work on '*Pollen Cryopreservation in Aid to Conservation of Potato Genetic Resources*'. She enumerated the benefits of pollen cryopreservation of potato germplasm as an alternative method of conservation. The protocol to cryopreserve pollen of various potato varieties like *Kufri Jyoti, Kufri Himalini*, *etc,* was detailed out.

Dr Neelam Sharma, ICAR-NBPGR, India, presented her studies on '*Application of In Vitro Techniques for Conservation of Indian Medicinal Plants – A Case Study*'. *In vitro* protocols for an important medicinal plant, *Bacopa monnieri* were described The species could be conserved for more than 14 months with no subculturing. Cryopreservation protocol developed using vitrification-beased technique in shoot tip explants, gave substantial regrowth after thawing.

Dr S. Uma, ICAR-NRCB, India, described the '*Success Story of Rejuvenation of Near Extinct Fragrant Banana,* cv. *Manoranjitham through Inter-Institutional and Public Private Partnership*'. She described substantiative efforts to rejuvenate a near-extinct fragrant banana, cv. *Manoranjitham*. Tribal farmers of the Kolli Hills, Tamil Nadu, benefitted immensely by growing pest-free (virus and bacteria) micropropagated banana plantlets.

Recommendations - Concurrent Session 2C: In Vitro Conservation, Cryopreservation, and DNA Banking

- *Global Cryovault-2*, similar to Svalbard Global Seed Vault, should be established for safety back-up of vegetatively propagated crops either at the ITC, KU Leuven, Belgium or at ICAR-NBPGR, India.
- *Cryopreservation of threatened plants* and CWR should be prioritized; pollen and DNA be cryopreserved as complimentary conservation strategy and to aid basic research.
- *Fundamental research and application*, *and capacity-building* in the field of cryopreservation be supported at national and global levels.

Concurrent Session 2D: Animal and Aquatic Genetic Resources

This Technical Session was co-chaired by **Dr M. Vijay Gupta**, Ex-World Fish, India and **Dr H. Rahman**, ICAR, India. **Dr Arjava Sharma**, ICAR-NBPAGR, India was the Convenor while **Dr R.S. Kataria**, ICAR-NBAGR, India and **Dr V.S. Bashir**, ICAR-NBFGR, India, were the Rapporteurs. In this session, three lead lectures on animal genetic resources were presented by **Drs S.J. Hiemstra**, **Arjava Sharma** and **S.B. Gokhale**, and two lead lectures on aquatic genetic resources by **Drs C.N. Ravishankar** and **K.K. Lal**. These were followed by rapid presentations by **Drs S.K. Singh**, **A.K. Thiruvenkadan** and **S.K. Majhi**.

Drs A. Rahman and M. Vijay Gupta, Co-chairs of Concurrent Session on Animal and Aquatic Genetic Resources

Dr S.J. Hiemstra, Centre for Genetic Resources, Netherlands, made a presentation on '*Complementary Strategies for AnGR*

Dr S.J. Hiemstra

Conservation and for Global Innovation Challenges'. He pointed out that globally nearly 15-20% livestock breeds are at risk. To overcome this, complementary strategies, including *in situ* and *ex situ* conservation methods are needed. These conservation measures should be made through active breeding programs maintaining farmers' interest to keep the breed profitable for future generations. He referred to the Dutch AnGR genebank which conserves DNA, semen, embryo, ova as well as tissues of various livestock species with short- and long-term goals. Globally, 64 countries have established gene banks for *ex situ* conservation of AnGR and 41 countries are planning to do so. He emphasized on the establishment of a network of national genebanks across the world, on lines similar to European project. He reiterated upon genomic and phenotypic characterization of gene bank accessions as the key challenge in conservation of AnGR. He was of the opinion that improved parent stock/ germplasm should be made available to the farmers and new breeding techniques based on genomic selection and reproductive methods like embryo transfer, *in vitro* fertilization, semen sexing as well as genome editing should be part of AnGR characterization as well as improvement.

Dr Arjava Sharma, ICAR-NBAGR, India, expressed his views on '*Farm Animal Genetic Resources: Evaluation and Conservation in India*'. He mentioned that out of 85% of the animal food production coming from 14 species, 11 species are part of Indian livestock systems, of which buffalo is very important livestock species. Loss of heterogeneity of Indian cattle breeds due to cross breeding is a major challenge in their conservation. He expressed his concern about decreasing trend of cattle, horse and camel populations in the country. He also presented detailed account on the diversity available in Indian livestock species having unique production and adaptation traits. Characterization and cataloguing of majority non-descript populations is required for their conservation. He pointed out challenges faced in AnGR management including large number of undefined populations, changing population

Dr Arjava Sharma

dynamics, insufficient breeding bulls/semen available, lack of identification of animals, depleting habitat and gazing areas, non-availability of sexed semen, identification of new biomolecules/genes for unique traits like heat adaptation and disease resistance.

Dr S.B. Gokhale, BAIF, India, delivered a lecture on '*Experiences on Conservation of Indian Dairy Animal Biodiversity*'. He opined that assigning societal relevance to animal biodiversity would help in their conservation. Giving the example of Krishna valley cattle, he pointed out uncontrolled breeding as well as lack of government initiative as major constraints in their conservation. Improvement by increasing productivity would boost

Dr S.B. Gokhale

economic value of livestock population/ breeds, and indirectly help in conservation. Major constraints in AnGR conservation, according to him, were lack of breed societies, inadequate capital resources, absence of animal breeders' and animal keepers' act. He suggested preparation of breed watch list, characterization and documentation of lesser known populations and value addition to the animal products. Dr Gokhale asserted that small holding and social requirements of animal products like, cow milk, *ghee*, urine, curd, *etc.* by the farmers should be considered as positive point for conservation of livestock species.

Dr C.N. Ravishankar, ICAR-CIFT, India, talked on '*Conservation and Responsible Fisheries and Fishery Technology*'. He presented glimpses of global scenario of fisheries and over capitalization followed in fish capturing. He informed that production

Dr C.N. Ravishankar

from capture fisheries is declining in India and CIFT is putting effort in designing new vessels for the conservation of fish genetic resources. He pointed out that energy efficient, solar powered vessels designed using safe material like rubber would help in conservation. He explained different gears designed by CIFT for excluding non-targeted fishes/shrimps/turtle. He concluded his presentation by emphasising restriction on the number of fishing fleets, taking initiatives for certification to responsible fishing for better returns and popularization of new fishing technologies among fisher-folks in different states.

Dr K.K. Lal, ICAR-NBFGR, India, presented a lecture on '*Aquatic Genetic Resources and Technologies for Food and Environmental Security*'. He apprised about the FAO

Dr K.K. Lal

information available on aquaculture as well as world scenario in AqGR. He described the process of making the status of country report on aquatic genetic resources (SoWAqGR). He emphasized increasing domestication of cultured aquatic species for their conservation, propagation of genetic technologies available for fish genetic resources, identification of wild relatives, popularizing health benefits of fish which would help in their conservation.

Dr S.K. Singh, ICAR-CIRG, India, presented his studies on '*Impact of Structured Breed Improvement Programmes on Genetic*

Dr S.K. Singh

Improvement and Conservation of Indian Goat'. He talked about Indian goat breeds and role of structured breeding programmes to be adopted in goat genetic resource conservation. He mentioned the achievements made under AICRP on Goat regarding genetic improvement and conservation through identification and production recording.

Dr A.K. Thiruvenkadan, VCRI, India, presented a paper on '*Options and Strategies for the Conservation of Sheep and Goat Genetic Resources in India*'. He opined that there should be better linkages among stakeholders making concerted efforts for their conservation.

Dr S.K. Majhi, ICAR-NBFGR, India, gave presentation on '*Germ Cell Transplantation into Adult Recipient Fish for Speedy Propagation of Endangered Germlines*'. He mentioned that the described technique could be used as an important tool for conservation of fish genetic resources.

Recommendations - Concurrent Session 2D: Animal and Aquatic Genetic Resources

- *Conservation strategy*, including *in situ* and *ex situ* conservation methods, be promoted through active breeding programmes through farmers' participation.
- *Regional genebanks and breeders' societies* should be established for the conservation of animal and aquatic genetic resources.
- *Genomic and phenotypic characterization* of genetic materials stored in genebanks as well as non-descript populations should be carried out on priority.
- *Improved reproductive technologies* for the faster multiplication of fish and animal genetic resources should be used for their conservation.
- *Enhancing economic value of animal and fish genetic resources* should be emphasized through identification of unique characters and subsequent certification.
- *Technologies and infrastructure* for excluding non-target species should be developed/ adopted.

Concurrent Session 2E: Microbial and Insect Genetic Resources

This Technical Session was co-chaired by **Dr N.K. Krishna Kumar**, Bioversity International, India and **Dr B. Venkateshwarlu,** VNMKV, India. **Dr S.K. Sharma** ICAR-NBAIM, India was the Convener, **Dr R.N. Singh,** ICAR-IARI, India and **Dr Ankita Gupta,** ICAR-NBAIR, India were Rapporteurs. In the session, four lead lectures were presented, on insect

Drs B. Venkateshwarlu (left) and N.K. Krishna Kumar

genetic resources by **Drs R.C. Upadhayay** and **Sushil K. Sharma**; and on microbial genetic resources by **Drs A. Verghese** and **V.V. Belvadi**. Besides, one rapid presentation was made by **Dr Pradeep Mehta**.

Dr R.C. Upadhayay, ICAR-DMR, India, gave a presentation on '*Biodiversity of Fleshy Fungi, their Conservation and Applications for Human Welfare*'. He enumerated the economic importance of mushrooms in terms of nutritional value (e.g. vitamin B_{12} and D), pharmaceutical prospects (anti-cancer, anti-malarial), waste management (bioremediation, biofertilization), animal feed and colour production. He informed that only 1,921 species of mushrooms have been catalogued and conserved at the DMR, Solan, out of 14,000 described mushrooms species from India; one reason may be lack of taxonomists. He informed that out of 100 species discovered from India, 40 are new to India and 10 are new even to world.

Dr R.C. Upadhayay

Dr Sushil K. Sharma, ICAR-NBAIM, India, talked on '*Microbial Conservation Strategies and Methodologies: Status and Challenges*'. He expressed concern for conserving ecosystem, mainly for exotic and niche-specific microorganisms. He recommended vitrification for storage microbes (mushroom fruiting bodies and fungal spores). He suggested that the development of new methods for *in situ* and *ex situ* conservation of microbes should be a priority.

Dr A. Verghese, GPSAIM, India, spoke on *'Birds and Insectivory: Agrobiodiversity Implications in Sustainable Agriculture*'. A case study was presented on tolerance and adaptive behaviour of birds to changing environments and impact on insect populations important for crops and trees. Sharing data of last 20 years, he concluded that diversity of birds has come down along with disappearance of scrub jungles, marshy lands, tress, and increment in agricultural area. He also suggested

Dr A. Verghese

conserving scrub jungle (including naturally existing trees), marshy lands for conserving biodiversity of insectivorous birds.

Dr V.V. Belvadi, UAS-Bengaluru, India, talked on *'Conservation of Pollinators Biodiversity in the Era of Neonicotinoids*'. He mentioned that India houses about 800 species of bees (including honey-bee). However, since 1990,

Dr V.V. Belvadi

bee population has declined. Excessive use of chemicals/pesticides in agriculture, monoculture cropping, deforestation, led to habitat destruction and loss of flora. India does not have any basic data about the use of neonicotinoids. He pointed out that neonicotinoids are extremely harmful to bees and there should be some regulation for its use, as USA has restricted its use in 2016 while European Union has banned its use. He also mentioned that identification of all bees may be done to catalogue their species.

Dr Pradeep Mehta, Earthwatch Institute, India, presented his study on '*Reviving Traditional Bee Keeping Practices and Restoration of Landscape for Sustainable Agriculture in Indian Himalaya*'. He concluded that adaptation of landscape farming, restoring and revival of traditional practices, inclusion of citizen science approach and use of ICT tools would help in assessment of biodiversity risk in agriculture and restoration of function of bees in pollination.

Recommendations - Concurrent Session 2E: Microbial and Insect Genetic Resources

- *National catalogue* on microbial communities should be prepared.
- *Natural extreme environments* should be identified for conservation of microbial and insect genetic resources; and trees that are the natural habitats of birds, need to be protected.
- *Unique niches* of non-culturable microbes should be explored through metagenomics approach.
- *Diversity dynamics* at the hotspots for microbial communities should be analysed; whereas *indicator species* need to be identified for indexing fauna change.
- New and innovative techniques for *ex situ* and *in situ* conservation of microbes need to be developed on priority.

Technical Session 3: Adaptation and Mitigation of Climate Change

This technical session was co-chaired by **Dr J.S. Sandhu,** ICAR, India and **Dr Ravinder Kaur,** ICAR-IARI, India. **Dr J.C. Rana**, ICAR-NBPGR, India was Convener and **Drs K. Pradheep** and **T.V. Prasad,** ICAR-NBPGR, India, were Rapporteurs. Lead presentations were made by **Drs Edwin M. Southern, Jacob van Etten, J.C. Rana** and **Devender Gauchan.** It was followed by seven rapid presentations by **Drs D.C. Putri Hendrawan, B.K. Joshi, B.N. Motagi, N.V.P.R. Ganga Rao, M.P. Paulton, F. Hamidou** and **E.O. Manyasa**.

Dr Edwin M. Southern, Kirkhouse Trust, UK, made presentation on '*Fighting Climate Stress with Orphan Crops*'. He expressed the need for alternative crops in Sahel region of Africa, where traditional crops, like cowpea and beans, suffer from heat and drought, besides loss of top soil. He presented the work plan involving multi-location trials with four alternative crops *e.g. Dolichos lablab*, moth bean, horse gram, and marama bean, which

Dr E.M. Southern

would help farmers in fighting climate stress through their multiple uses like production of grain to feed the family and provide income; fodder and forage to feed livestock; and ground cover for improving soil.

Dr Jacob van Etten, Bioversity International, Italy, presented a talk on '*Climate Change and Agricultural Biodiversity: Rethinking the Role of Science*'. He discussed the importance and use of citizen science and crowd sourcing in infusing adaptation of diverse varieties by farmers. Emphasizing climate change is real-time, one shot and multi-dimensional event posing big challenge to science, he stressed upon working with diversity, rather than working with averages and trends. He

Dr Jacob van Etten

explained the Rural House Multi-Indicator Survey (RHoMIS), a monitoring tool for rapid characterization of household diversity to inform climate smart agriculture interventions. He concluded that massive digital participation would accelerate human learning for action to climate change.

Dr J.C. Rana, ICAR-NBPGR, India, talked on '*Use of Agrobiodiversity in Adapting to Climate Change*'. He pointed both positive and negative impacts of climate change, through examples from work undertaken in Western Himalayas. He explained different strategies adopted by farmers in crop production practices – changes in varieties, crops and crop combinations,

Dr J.C. Rana

alterations in agronomic and seed storage practices, etc. Other measures suggested by him included agroforestry-based land use system, harnessing wild edibles, animal husbandry, soil and water conservation measures, *etc.* This demanded the need to develop new crop and livestock varieties, use of multiple varieties or continuing maintenance of traditional germplasm (crop and livestock varieties) adapted to changed (and changing) environments.

Dr Devendra Gauchan, Bioversity International, Nepal, spoke on '*Post-disaster Revival of Local Seed Systems for Climate Change*'. He described the post-earthquake rescue collection mission for local seeds carried out in Nepal, which led to collecting of 764 samples of 47 crop species from seven earth quake affected districts through participatory seed exchange (PSE) programs.

Dr D. Gauchan

Interestingly, 10% of the collected samples were endangered varieties, and over 90% of the collected and shared seeds in the earthquake affected local communities were not in the official national notified list of varieties in Nepal. This demonstrates the valuable complementary role PSE can play to strengthen local seed systems.

Dr D.C. Putri Hendrawan, ICRAF, Indonesia, presented his work on '*Increasing Resilience to Climate Change in Rural Livelihoods: to Diversify or Not*?' He presented a case study at Bantaeng, South Sulawesi, Indonesia, to determine whether farmers' decision over land allocations was to maximize their resilience to climate change. The land use management was grouped into: (i) complex agroforestry (AF); (ii) simple AF; and (iii) annual cropland through nested plot method for vegetation analysis. Although farmers' decisions over land allocations varied, most of them were found to practise the system which maximized resilience to climate change.

Dr B.K. Joshi, National Genebank, Nepal, talked on '*Policy Framework for Adaptation to Climate Change*'. He discussed the current degree of crop interdependency in Nepal based on the origin and pedigree analysis of modern varieties of rice, wheat and potato. He concluded that out of 275 released varieties, 76% of them originated outside Nepal, and over 95% were dependent on foreign germplasm for varietal development.

Dr B.N. Motagi, ICRISAT, Nigeria, discussed his work on '*Germplasm Enhancement for Increasing Groundnut Productivity and Production in West and Central Africa*'. He explained activities undertaken by the ICRISAT in West Central Africa for enhancing groundnut productivity. Twenty five varieties were released in five countries using 2,500 trait-specific advanced breeding lines supplied by ICRISAT. Most of these varieties were preferred by farmers for their high yield, disease resistance, drought tolerance, short duration, seed size, suitability for home consumption, seed colour and market demand and showed yield advantage up to 42% over local varieties.

Dr N.V.P.R. Ganga Rao, ICRISAT, Kenya, presented his work on '*Effective Utilization of Local Genetic Diversity on Pigeonpea, Sorghum, and Finger Millet in Eastern and Southern Africa: Impacts and Prospects*'. He mentioned that 30 new varieties of pigeonpea (8), sorghum (10) and finger millet (12), showing high yield, early maturing, resilience to abiotic stresses and resistance to biotic stresses were released using local diversity of these crops.

Dr M.P. Paulton, ICAR-CMFRI, India, presented his studies on '*Indian Edible Oyster, a Promising Bivalve for Aquaculture amidst the Challenges of Climate Change as Revealed through Thermo-Tolerant Studies*'. He discussed thermo-tolerance and underlying molecular mechanism in Indian edible oyster (*Crassostrea madrasensis*) for sustainable production and concluded that this species could be projected as a winner species with the ability to survive in challenges posed by climate change.

Dr F. Hamidou, ICRISAT, Niger, presented work on '*Abiotic Stresses Tolerance and Nutrient Contents in Groundnut, Pearl Millet and Sorghum Mini Core Collections for Food and Nutrition Security*'. He evaluated mini core collections of groundnut, pearl millet and sorghum for abiotic stresses (low phosphorus and drought stress) and nutrient content, and identified some promising genotypes.

Dr E.O. Manyasa, ICRISAT, Kenya, presented results of his studies on '*Exploiting Genetic Diversity for Adaptation and Mitigation of Climate Change: A Case of Finger Millet in East Africa*'. Out of 81 lines evaluated under eight environments for adaptation and grain yield stability, seven genotypes were identified for yield stability across the eight environments and nine showed adaptation to specific condition.

Recommendations - Technical Session 3: Adaptation and Mitigation of Climate Change

- *Generation of adaptive traits* to the changing climate should be facilitated by *in situ* on-farm conservation of genetically diverse populations, especially crop wild relatives.
- *Genetic base-broadening* approach at farm and landscape level should be promoted by introducing adaptive inter- and intra-species diversity.
- *Alternative crops and their associate diversity* should be identified for resilience and sustainable agricultural production systems, especially for marginal farming communities.
- *Discovery of useful traits and genes* by characterization of *ex situ* collections from the hot spots should be prioritized.
- *National climate strategies and action plans* should be developed on information, policies, institutions and capacity development.
- *Local seed systems* need to be strengthened, especially in the context of post-disaster revival of local diversity.

Plenary Session 3: Agrobiodiversity for Livelihood Security and Ecosystem Services

This plenary session was chaired by **Dr T. Mohapatra,** DARE & ICAR, India. **Drs Kavita Gupta** Rapporteur, also convened the session in the absence of **Dr S.C. Dubey,** ICAR-NBPGR, India. **Dr K.C. Bhatt,** ICAR-NBPGR, India, was the Rapporteur. Two lead lectures were delivered by **Drs Kamal Bawa** and **Anil Gupta**. Dr T. Mohapatra introduced both the speakers and highlighted their contributions in agrobiodiversity conservation.

Plenary Session 3

Dr Kamal Bawa, University of Massachusetts, USA, gave an overview of Himalayan biodiversity (by citing examples of orchids, primulas, rhododendron, rhubarb of Sikkim), glaciers sustaining one-third of humanity and cultural opportunity to integrate concerns about agrobiodiversity. He pointed out the rapid changes in agrobiodiversity due to climate change, land use pattern, expansion of human population, frontiers of agriculture and developmental activities. There is requirement for integrating climate change and livelihood needs, as the reliance of people on crops grown in small holdings would make them vulnerable to climate change, and due to non-availability of extension services. Interventions such as diversified livelihood, improved soil management, conserving and restoring of ecosystems, mitigating climate change, and strengthening of institutions and suitable policies, for enhancing livelihood options are needed. He opined that involvement of NGOs, government institutions and other agencies is a must for livelihood of small holders and management of agrobiodiversity. Ecosystem dis-services (natural calamities/floods, *etc.*) and misuse of wild life should be minimized, to the extent possible.

Dr Anil Gupta, NIF, India**,** gave a presentation on *'Grassroot Innovations for Market Mediated Livelihoods and Value Chain Development'.* He reiterated that farmers have thorough knowledge about crop characteristics in selecting process; hence specific attention should be given to those characters to which farmers pay more attention. Unique traits need to be identified for climate resilience, adaptation to stress and for low external input environment. Agrobiodiversity, as on indicator of climate change can play an important role if farmers' knowledge is used. To track biodiversity loss, empirical data should be provided to policy makers at macro-sites/ specific areas by undertaking longitudinal agrobiodiversity studies. Farmers owned/

Prof. Anil Gupta

developed varieties need to be identified as they can play an important role in climate resilience. Inclusive innovation program for biodiversity management and traditional food festivals should be organized at urban level for creating agrobiodiversity markets, as farmers know the value of their produce. Participation of local people in agrobiodiversity management is also necessary to overcome risky situations, such as flood or drought. Provision/portfolio of incentives to innovators for conservation of biodiversity in marginal lands should be given, keeping in view their role in protection of biodiversity. Issues related to traditional farmers' fairs, incentive to innovators, utilization of functional food should be adequately addressed.

Plenary lectures were followed by panel discussion by **Dr Gerry Jayawardena,**

Drs T. Mohapatra, K. Bawa, G. Jayawardena and N. Dzyubenko (from left to right)

Sri Lanka; **Dr Coosje Hoogendoorn,** KIT, Netherlands and **Dr Nikolay Dzyubenko,** VIR, Russia.

Dr Gerry Jayawardena mentioned that conservation of biodiversity is a continuous process and assessment for evaluation and utilization of germplasm should be done simultaneously. Empirical studies need to be conducted for adding value to germplasm for end-product. He also mentioned that implications of regulations need to be periodically evaluated.

Dr Coosje Hoogendoorn emphasized on the effective partnership among farmers and other stakeholders for livelihood security at the global, regional and national levels.

Ms Coosje Hoogendoorn

Linkages need to be strengthened between formal and informal seed system to strengthen ecosystem services. Formal (*ex situ* seed bank) and informal seeds systems (farmers'/ community seed banks) should work in harmony.

Dr Nikolay Dzyubenko discussed the genetic erosion of farmers' varieties and landraces, requiring focused attention for conservation and restoration in the ecosystem. Conservation of local cultivars and CWR

Dr Nikolay Dzyubenko receiving a memento from Dr T. Mohaptra

for future generation should be addressed globally.

Prof. M.S. Swaminathan in his concluding remarks emphasized that remarkable contributions made by Dr Virendra Kumar for conservation of floristic components of 'Valley of Flowers' need to be applied in biodiversity conservation. He also emphasized that

Prof. M.S. Swaminathan presenting a memento to Chair of the Session, Dr T. Mohapatra

attention should be paid on the use of traditional knowledge for management of biodiversity. Involvement of grassroots level workers in conservation is important. Activities pertaining to biodiversity conservation should be carried out in network mode.

Recommendations - Plenary Session 3: Agrobiodiversity for Livelihood Security and Ecosystem Services

- *Landscape management* should henceforth be accorded adequate importance.
- *Integrated approach* should be adopted for management of agrobiodiversity, livelihood, production and climate change adaptation.
- *Institutional and policy reforms* should be brought about by including strategies for fragile lands, ecosystem model development, sectoral approach, climate change adaptation action plan, coordination and linkages, and local knowledge.
- *Creativity among the marginal farmers* should be encouraged by focussing on innovation, enterprise, and investments.
- *Global sharing* of farmers' varieties having unique traits should be encouraged and promoted within the national and global framework and agreements.
- *Food processing and quality traits* related evaluation of genebank accessions should be carried out.
- *Social and cultural dimensions* of agrobiodiversity is necessary for sustainable conservation and should not be neglected.
- Innovative program for biodiversity management and traditional food need to be organized at urban level for promoting agrobiodiversity markets.

Technical Session 4: Science-led Innovations

This Technical Session had five Concurrent Sessions covering three separate sessions for presentation and discussion on PGR, including: (4A) Trait Discovery and Enhanced Use in Plant Genetic Resources, (4B) Plant Genetic Resources and Genomics and (4C) Plant Genetic Resources Informatics; and one each on (4D) Animal and Aquatic Genetic Resources and (4E) Microbe and Insect Genetic Resources. Various lead and rapid presentations were made during these Concurrent Sessions.

Concurrent Session 4A: Trait Discovery and Enhanced Use of Plant Genetic Resources

The session was co-chaired by **Dr G.S. Khush,** University of California, Davis, USA and **Dr Calvin Qualset,** University of California, Davis, USA. **Dr M.K. Rana**, ICAR-

Concurrent session on Trait Discovery and Enhanced Use of PGR

NBPGR, India was the Convenor and **Dr M. Elangovan,** ICAR-IIMR, India and **Dr V. Vikas,** ICAR-IARI, India were the Rapporteurs. Four lead presentations were presented by **Drs Ravi P. Singh**, **Andreas Graner**, **N.K. Singh** and **Kuldeep Singh**, followed by three rapid presentations by **Drs Zhang Zongwen, S. Gopala Krishnan** and **Sundeep Kumar.**

Dr Ravi P. Singh, CIMMYT, Mexico, gave a presentation on '*Utilizing Genetic Diversity in*

Dr Ravi Singh

CIMMYT Global Wheat Breeding Program'. He informed that about half of the catalogued genes, conferring resistance to stem (black) rust and leaf (brown) rust, were transferred to wheat from related species and genera. *Sr2*, an APR gene which is 100 years old, is durable and slow rusting. A majority of the race-specific genes effective against the Ug99 race group of stem rust fungus are of alien origin and some important genes like *Sr24* and *Sr36* have been overcome by new variants of Ug99. The identification of three pleiotropic multi-pathogen resistance genes, *viz. Lr34/Yr18/Sr57/Pm38/Sb1/Bdv1*, *Lr46/Yr29/Sr58/Pm39*, and *Lr67/Yr46/Sr55/Pm46*, and the cloning of two (*Lr34* and *Lr46*) have shown their novel nature in conferring disease resistance. Extensive search for genetic resources for wheat quality (gluten quality, bread making quality), and high Zn and Fe led to identification of some tall varieties, landraces, spelt wheat (*Triticum spelta*), tetraploid wheat (*T. dicoccum*), and some synthetic wheat accessions. High yielding competitive wheat varieties with 20-40% higher grain Zn concentration have been developed; one variety '*Zinc Shakti' (Chitra)* has been released and disseminated to thousands of farmers in eastern Gangetic plains of India.

Dr Andreas Graner, IPK, Germany, talked about the '*Challenges and Opportunities for Value Capture from Plant Genetic Resources*'. He informed that the Federal *ex situ* genebank in Germany is the largest genebank in the EU with 0.15 million accessions belonging to 3,168 species, and since 1946 it has distributed about 1 million accessions. He emphasized that the valuation of genetic resource collections i.e. quality, availability and information about the accession is very important. He discussed the work on phenotyping of barley, genetic choreography of biomass accumulation and QTL analysis. Using 1,485 landraces of barley, 648 accessions were categorized as customized core collections for phenotyping, trait mapping and gene discovery. He mentioned that re-sequencing of barley genomes helped in identification of duplicates, monitoring genetic authenticity and genetic structure of collections. Targeted re-sequencing for *rym4* and *rym11* helped to understand resistance

Dr Andreas Graner

to barley yellow mosaic virus complex. He was of the opinion that in the future, plant genetic resource centre would be "Bio-Digital Resource Centre" providing information on phenotype, genotype and metabolites data.

Dr N.K. Singh, ICAR-NRCPB, India, presented work on '*Indian Wild Rice - Diversity, Population Structure, Trait Value and Relation with Cultivated Rice*'. He did extensive expeditions/explorations around diversity hot-spots and collected more than 600 accessions of wild rice *Oryza nivara*, *O. rufipogon* and other species, representing wide range of ecological

Dr N.K. Singh

niches. Enormous variations were observed among these accessions while evaluating for 46 morphological descriptors. Cluster analysis revealed three major morphological groups but did not correspond to their geographical origin. Indian Wild Rice Database was developed with all the collection, characterization and molecular information. The genome-specific *pSINE1* DNA markers revealed that all accessions belonged to AA genome and they could be easily used for introgression of useful genes in the cultivated rice. Further characterization using ecotype-specific *pSINE1* markers classified these accessions into annual (for *O. nivara*), perennial (for *O. rufipogon*), intermediate (mixed type) and unknown types not described earlier. He also presented model based population structure analysis using genome wide unlinked bi-allelic SNP markers revealing three sub-populations, designated as 'Pro-Indica', 'Pro-Aus' and 'Mid-Gangetic' populations, which showed no correspondence to ecotypes or *O. nivara*/*O. rufipogon* distinctions. Haplotype analysis revealed haplotypes H5 and H1 of *HKT1*;*5* and *HKT2*;*3*, respectively, associated with high salinity tolerance. Amongst the two hypotheses of origin of rice (monophyletic and polyphyletic), his research supported polyphyletic origin.

Dr Kuldeep Singh, ICAR-NBPGR, India, talked on '*Introgression of Yield Component Traits and Biotic Stress Resistance Genes in Rice Following Inter-specific Hybridization*'. He mentioned that resistance in most of the rice has come from wild genes. He informed that PAU maintains 1,758 accessions of wild rice, which are being utilized for identification of productive traits and biotic and abiotic stresses. The transfer of yield and yield attributing traits from AA genome of wild rice led to the development of 3,000 BILs with superior agronomic performance, of which few lines are in the coordinated trials. A mention was made about his work on mapping of the bacterial blight resistance gene (*Xa38*) from *Oryza glaberima* and further introgression in high yielding background. Similarly, wild species of rice screened for resistance to disease like leaf and neck blast, insect pest such as brown plant hopper resulted in identification of resistant sources. Genetic

Dr Kuldeep Singh

variability for drought tolerance in wild species of rice was found in *O. rufipogan.* Rice bran oil *PLD* gene has been identified in 86 rice species.

Dr Zhang Zongwen, Bioversity International, China, talked on *'Managing the Biodiversity of Neglected and Underutilized Crops in China*'. He discussed about collection and conservation of neglected and underutilized crop species (such as barley, buckwheat, millets, oat and sorghum) in China. Some 85,751 accessions have been collected and conserved in the national genebank,

comprising foxtail millet (28,395), common millet (6,000), barley (20,000) and sorghum (22,000). The phenotypic diversity of buckwheat and barley were assessed and documented, including yield traits and nutrition components. Multi-location trials have identified the most adaptable varieties of buckwheat and oat in Lingshan, Sichuan. The local Yi ethnic group has relied on buckwheat and oat for livelihoods. It is vital in sustaining the nutrition and food security in marginal areas.

Dr S. Gopala Krishnan, ICAR-IARI, India, presented his work '*Genetic Enhancement of Rice* (*Oryza sativa* L.) *through Inter-Specific Crosses Involving Oryza rufipogon and their Potential in Improving Heterosis*'. He mentioned that limited use has been made from the 22 diverse wild species in rice, for improvement of pure line varieties. In the present study, *O. rufipogon*, an A genome wild rice relative was crossed with Pusa 6A, the female parent of a popular aromatic superfine grain quality rice hybrid, Pusa RH 10. The F_1 were found to be fertile, indicating the presence of fertility restorer in *O. rufipogon*. Through pedigree selection till F_6, a set of 144 introgression lines (ILs) were developed. These ILs showed significant variations for plant habit, days to 50% flowering, plant height, panicle length, number of productive tillers and yield per plot. Some ILs showed better panicle exertion as compared to Pusa 6A, and higher yield per plant (22.1g) as compared to 16.3g in Pusa 6B. An IL was backcrossed with Pusa 6A to produce improved restorer lines with better quality and produced heterotic hybrids with diverse CMS lines proving their potential in improving heterosis in rice.

Dr Sundeep Kumar, ICAR-NBPGR, India, presented his studies on '*Identification of Stable Heat Tolerant Wheat Germplasm Lines under Extreme Late Sown Condition*'. He evaluated 496 selected germplasm lines for various yield and phenology related traits at three different locations (Delhi, Karnal and Punjab). The daily average temperature ranged from 8-23°C during pre-heading period, and from 21-35°C during post heading period. Based on two years' trials, 47 germplasm lines were identified as superior to best checks. Accessions EC 445320, EC 445382, EC 445481, IC 252529, IC 252832, IC 290335 and IC 539221 with more than 40g TGW under very late sown conditions, high Fv/Fm values at all post anthesis stages and cell membrane stability (>45%); IC 531176, IC 564121 and IC 145815 for stay green habit and IC 532037, IC 531176 and IC 534434 for long peduncle were identified as promising heat tolerant lines.

Recommendations - Concurrent Session 4A: Trait Discovery and Enhanced Use of Plant Genetic Resources

- *Intensive use of trait-specific rice and wheat germplasm* for biotic and abiotic stress tolerance should be promoted in breeding programs.
- *Genebanks should function as "Bio-Digital Resource Centres"* to cater to disparate and evolving needs of crop improvement.
- *Pre-breeding* involving crop wild relatives should be employed to identify sources of tolerance to various biotic and abiotic stress related traits.
- *Exchange of trait-specific germplasm* should be facilitated for their deployment in national crop improvement programs.

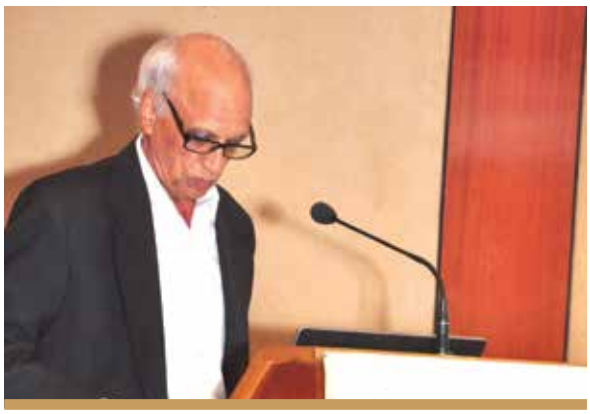
Concurrent Session 4B: Plant Genetic Resources and Genomics

This Concurrent Session was co-chaired by **Dr Edwin Southern,** Kirkhouse Trust, UK and **Dr Akhilesh Tyagi,** University of Delhi, India. **Dr Rakesh Singh,** ICAR-NBPGR, India was the Convenor, and **Drs Lalit Arya** and **Manjusha Verma,** ICAR-NBPGR, India were the Rapporteurs. Lead presentations were made by **Drs Robert Henry, Bikram Gill, Alice Muchugi** and **T.R. Sharma**, followed by three rapid presentations by **Drs T.R. Sharma, Rakesh Singh, Tilak R. Sharma**.

Drs Edwin Southern, Akhilesh Tyagi and Rakesh Singh

Dr Robert Henry, QAAFI, Australia, presented his lecture on '*Application of Genomics to Enhanced Utilization of Plant Genetic Resources*', wherein he exemplified advantages of genomics to capture the diversity in PGR. Evidences for flour yield gene (*14 DPA*) and C4 photosynthesis in wheat grains were presented to be used for increasing food security in the context of changing climate. The study emphasized on exploring wild rice genetic diversity from isolated locale like Australia for revealing pre-domestication polymorphism gene pools. Breeding for smaller fruit trees like mango, avocado and macademia nut was also highlighted.

Dr Bikram Gill, KSU, USA, spoke on '*Sears to Sequencing: Deciphering the Potential of Wheat for Hunger-Free World*'. He highlighted main advances since Sears, woven in the historical context most relevant to wheat improvement efforts worldwide. The contributions of Ernest Sears were acknowledged, who began his studies with wheat aneuploids, that ushered in the era of formal cytogenetic analysis and gene mapping of individual chromosomes and arms in wheat. Staining techniques used in the 1970s to analyze substructures of cereal chromosomes, helped in the development of a cytogenetic karyotype of wheat. Non-isotopic methods of mapping DNA sequences *in situ* on chromosomes on a glass slide were used to construct a molecular karyotype of wheat. These so-called molecular cytogenetic methods of genome analysis greatly facilitated cytogenetic analysis in wheat and related species, especially of alien transfers. The genetic linkage maps of common wheat, durum wheat and two of the progenitor species were developed in 1990s. The last century ended with production of powerful deletion stocks, which were used to develop cytologically based physical maps of molecular markers for the 21 wheat chromosomes. The targeted mapping and eventual cloning of agronomically significant genes in polyploid wheat, wheat genome sequencing and microsatellite map of wheat were discussed as major milestones that promoted wide application of advanced technologies in wheat breeding research.



Dr Bikram Gill

Dr Alice Muchugi, ICRAF, Kenya, presented the status, use and developments in tree conservation, evaluation and breeding in her lecture on '*Genome Sequencing to Unlock the Potential of African Indigenous Tree Species*'. Emphasis was placed on increasing production and on-farm diversity of fruit-trees. In Africa, around 200 trees are source of alleviation of hidden hunger, and require to be focussed on for research and development. Funding and research for tree conservation needs to be strengthened as most of the trees have recalcitrant seeds. Whole genome sequencing of seven tree genomes is being accomplished.

Dr Alice Muchugi

Dr T.R. Sharma, NRCPB, India, made presentation on '*Genome Analysis of Rice Genetic Resources for the Identification of Novel Genes and Alleles for Biotic Stress Resistance*'. He cited the loss to the tune of 1 million USD in India, owing to biotic diseases. Map-based cloning, orthologue cloning from *Oryza rhizomatis* and *O. officinalis* and functional analysis of rice blast resistance gene *Pi54* were elaborated. These genes have been transferred in *indica* rice and a model for molecular mechanism of functioning of *Pi54* has been proposed. Haplotype linked to resistance was found based on the alleles mined from 268 global accessions. Finally, the success story of release of resistant rice varieties (Pusa 1637 and Pusa 1612) based on marker-assisted breeding was narrated.

Dr T.R. Sharma

Dr Rakesh Singh, ICAR-NBPGR, India, presented his work on '*SNP Marker Based Genetic Diversity Study in Rice Germplasm of Arunachal Pradesh*'. He studied 7,000 genotypes of rice germplasm from Arunachal Pradesh with 36 SNP markers and made a core collection of 700 markers, which were finally characterized with 50 thousand SNP markers.

Dr Tilak R. Sharma, CSKHPKV, India, talked on '*Population Genetic Structure and Phylogenetic Relationships in Lentil Species as Revealed by Morphological and SSR Markers*'. He evaluated wild and cultivated lentil species through morphological and SSR markers and observed high diversity. He concluded that there is a need to revisit taxonomy of *Lens culinaris* subsp. *odemensis.*

Dr N. Anuradha, ICAR-IARI, India, presented her work on '*Molecular Diversity in Pearl millet Association Mapping Panel Revealed by Genomic and EST SSR Markers*'. She evaluated an association panel of pearl millet at two locations. Assessment of iron and zinc levels in the panel along with 30 genomic and 84 genic SSR markers revealed wide variations of the two elements in the panel.

Recommendations - Concurrent Session 4B: Plant Genetic Resources and Genomics

- *Power of DNA sequencing* should be applied to enhance utilization of PGR.
- *Power of plant breeding* should not be undermined and genomics be considered as complementary to breeding programs.
- *Genomic technologies* having a broader vision/approach should be deployed.

Concurrent Session 4C: Plant Genetic Resources Informatics

This Technical Concurrent Session was co-chaired by **Dr Stefano Diulgheroff,** FAO, Italy and **Dr Bhag Mal,** APAARI, India. **Dr Sunil Archak,** ICAR-NBPGR, India was the Convenor and **Dr D.P. Semwal** and **Mr Rajeev Gambhir,** ICAR-NBPGR, India were the Rapporteurs. In this session, two lead presentations were made by **Drs Stefano Diulgheroff** and **Eric Huttner,** followed by three rapid presentations by **Drs Sunil Archak**, **R.S.S. Ratnayke** and **V. Girish Nayak**.

Dr Stefano Diulgheroff and Dr Bhag Mal, co-chairs of the session

Dr Stefano Diulgheroff, FAO, Italy, spoke on '*Towards the Third Global Assessment on the State of PGRFA Conservation and Use*'. He began with the First Report on the State of the World's PGRFA (1996) comprising 158 country reports. Subsequently, he presented an overview of the significant changes since the Global Plans of Action (GPA) adoption in 1996, and new challenges in the PGRFA conservation and use. That was followed by

Dr Stefano Diulgheroff receiving a memento from Dr Bhag Mal

a 2nd SOW report on the PGRFA in 2010/2011 which focused on changes and developments and on gaps and needs which occurred since 1996. Both the reports paved the way for placing respective Global Plans of Action, the first GPA initiated the work while, the second revised priorities for conservation and sustainable use of PGRFA. He informed that in GPA 2, the commission sought a periodic reporting by the countries in a 'Reporting Format' based upon 63 indicators, 3 PGRFA targets (Conservation, Sustainable Use and Institutional and Human Capacities) and 3 Higher-order Composite Indices (HCIs). Dr Stefano also informed that the Commission through its Multi-Year Programme of Work has decided that a Third Report on the SOW PGRFA needs to be prepared in which monitoring of the implementation of the Second GPA would be fully integrated. For this, countries have been asked to report their activities through on-line WIEWS Reporting system. The first round of reporting for 2½ years (January 2012-June 2014) is expected by December 2017 and second round

would be of 4½ years (July 2014-December 2019), with reporting deadline scheduled for December 2020. He concluded that the new report would allow countries in monitoring their activities towards the contribution to implement the Sustainable Development Goal (SDG) target 2.5. Draft of the third report based on various country reports would be prepared by December 2020 and reviewed by the Inter-governmental Technical Working Group on the PGRFA in year 2022. The report after endorsement is expected to be published by mid/end 2023.

Dr Eric Huttner, ACIAR, Australia, presented a talk on '*Digital Technologies to Modernize Effective and Efficient Use of Plant Genetic Resources*'. He discussed effectiveness and importance of digital technologies in modern breeding programmes to produce improved landraces and cultivars. He informed that in addition to high quality phenotypic data, since 1990s, genotypic parameters like DNA profiling, genetic and molecular markers have gained prominence for breeders. Generation of high density marker profiles is now commercially economical and can also be outsourced to private players. He mentioned that hand-held high quality devices like barcode readers, smartphones and tablets reduce chances of errors in recording data and also increase productivity of staff. Drones and other high throughput measurement methods like multi-spectoral images and infra-red analyzers can suggest on crop quality on specifically developed applications for recording phenotypic data through these devices (FieldScorer and KDSmart), which provide easy data- porting compatibilities with other data-analysis tools. He emphasized that these systems need to be easily used and should respond specifically to breeders, needs. He mentioned that over past 15 years several such systems have been developed by the CGIAR institutes and many private companies, and are being adopted by modern breeders. According to Dr Eric, these digital technologies are excellent tools for genomic selection, saving time and efforts, and are useful for countries, which have adopted modern breeding systems. He gave examples like International Mungbean Improvement Program Open Network (IMIN); APSIM-Sorghum Improvement in Ethiopia and Development of Molecular markers for Wheat Breeding in India for successful use of these digital tools and technologies. He concluded by elaborating challenges and limitations on use of these digital technologies in terms of lack of skill and training, need of institutional changes, limited foreign currency in acquiring high quality tools like barcodes, seed bags and limited access to expanded diversity specially by developing countries.

Dr Eric Huttner

Dr Sunil Archak, ICAR-NBPGR, India, presented his paper on '*India as a Crucible to Develop Integrated Information System*'. He informed that NBPGR has established robust documentation systems and databases to facilitate genebank management. A web-based open-access resource *PGR Portal* was developed to retrieve accession level information, by any user. Other recent applications like *PGR Map, Genebank Dashboard, PGR Clim, IP-PGR, CWR Portal, Herbarium Portal, National Rice Resource Database, Genetics and Genomics of Vigna and Phaseolus, Inventory of Registered*

Dr Sunil Archak

Germplasm, etc. were also developed and being tested. Fragmentation of data; task of linking past, present and future electronic data; dynamic nature of evaluation trait data descriptors/states; and inclusion of cutting edge data and technologies (GIS and Genomics) were some factors that made development of an integrated PGR information system demanding.

Dr R.S.S. Ratnayake from Sri Lanka, presented his studies on '*Modelling Distribution of Neglected and Under Utilized Fruit Species in Sri Lanka for Sustainable Utilization*'. Although Sri Lanka is rich in diversity of fruit species (i.e. 237 species belong to 56 families), only a very few species are cultivated commercially. Distribution of 28 neglected and underutilized fruit tree species were modelled using 2,976 location data collected from field investigations, different field research stations and herbarium records. Data was used with DIVA-GIS and FloraMap software for development of tree distribution maps and potential area maps. As a priority species, Wood-Apple (*Limonia acidissima*) was selected to model with Maxent using 220 presence-only location data as a function of seven environment variables. The findings of this study is important not only for predicting the potential distribution of neglected and underutilized species but also as important information predicting the high potential environmental variables for distribution of these species in Sri Lanka.

Dr V. Girish Naik, CSRTI, India, made a presentation on '*Mulberry Genome Network: An Interactive Web Platform for Morus specific Genetic and Genomic Resources*'. A Mulberry Genome Network (MGN) has been developed as a centralized platform for mulberry-omics integrated platform, with innovative genetic tools, futuristic goals and network forum. The network is developed as a curated and integrated web-based database providing easier access with hyper-linking of related databases such as Mulberry Germplasm Database (MGD), MorusDB, MulSatDB, *etc*. The platform is also integrated with programs such as BLAST, CLUSTALW, Primer3Plus, Cmap, *etc*., along with useful graphical tools for analysis.

Recommendations - Concurrent Session 4C: Plant Genetic Resources Informatics

- *Availability-accessibility gap* of PGR information should be bridged by developing appropriate information technology tools.
- *Investments in PGR informatics* need to be enhanced at national, regional and global levels.
- *Capacity building programs to use digital technologies* should be organized for different stakeholders to facilitate greater access to PGR information.
- *Awareness campaigns,* through PGR informatics, for general public as well as policy makers should be organized for developing PGRFA strategies.

Concurrent Session 4D: Animal and Aquatic Genetic Resources

The session was co-chaired by **Dr Olivier Hanotte,** ILRI, UK, and **Dr J.K. Jena,** ICAR, India. **Dr Kuldeep K. Lal,** ICAR-NBFGR, India, was the Convenor and **Dr Rajeev K. Singh** , ICAR-INBFGR, India, and **Dr Rekha Sharma,** ICAR-NBAGR, India, were the Rapporteurs. In the session, four lead presentations were made by **Drs J.M. Reecy, Vindhya Mohindra, A.K. Srivastava** and **Kuldeep K. Lal,** followed by four rapid presentations by **Drs A.K. Singh, M.M. Chanda, Ravinder Singh** and **Grinson George**.

Drs Olivier Hanotte and J.K. Jena

Dr J.M. Reecy, Iowa State University, USA, delivered a lecture on '*Genetic Improvement of Production and Adaptive Traits in Livestock*'. He presented recent developments in genomics research of livestock. With continuous lowering in the cost of genome sequencing, increasing number of animals are being covered in genomic studies. Genome Wide Association Studies for understanding molecular basis of difference in stature (hip height) in cattle was explained where more than 58,000 daughters of cattle across the globe were investigated, making it the largest project for a non-production trait. He opined that India can also collaborate in the ongoing ADAPTmap project on goats. A recent approach of Functional Annotation of Animal Genomes (FAANG) should be followed to move forward from descriptive to predictive

Dr J.M. Reecy

biology. He stressed on genotype-phenotype linkage to precisely understand molecular mechanism governing expression/regulatory pathways. The genotype data can replace pedigree requirement for methodologies such as single trait BLUP, by providing GBLUP platform. Selection for breed improvement without overlooking conservation aspect was elaborated with the example of American Angus cattle, where breed association also plays an important role. This can be considered as an illustration of collaboration among producers, organizations and scientists.

Dr Vindhya Mohindra, ICAR-NBFGR, India, spoke on '*Genomic Resource Development for Aquaculture Species in India*'. At the outset, she apprised about fish biodiversity in India and its role in ensuring nutritional as well as livelihood security for the ever-increasing population.

Dr Vindhya Mohindra

Majority of fish food comes from freshwater aquaculture, and two varieties of shrimp *viz.*, *Peneaus monodon* and *P. vannamei* account for tapping brackish water potential. In this context, it becomes essential for genetic/genomic characterization of important commodities (carp and shrimp) for sustainable utilization. She informed that with emerging modern technologies, wealth of genomic resources has resulted in a paradigm shift in research on non-model species. *De novo* genome sequencing of Indian Major Carp, *Labeo rohita* and Indian catfish (*Clarias magur*) have been completed and is being assembled. Simultaneously, genomic architecture of Hilsa shad (*Tenualosa ilisha*) and *P. indicus* is being deciphered through whole genome sequencing. RNAseq, used for bioprospecting and allele mining of important fishes has been accomplished for salinity (*P. monodon*), hypoxia (*C. magur*) and cold tolerance. Over 4000 differentially expressed hypoxia responsive genes have been identified in *C. magur,* majority of which, are involved in signal transduction mechanism. Transcriptomic studies could identify 24 salinity tolerant genes in *P. monodon* while, GPDH expressed potential role in cold tolerance in *Schizothorax richardsonii*. She informed that genetic/linkage and QTL maps for important species are being established for working on performance traits.

Dr A.K. Srivastava, ICAR-NDRI, India, made a presentation on '*Advances in the Reproductive Biotechnologies as a Tool for Animal Multiplication, Conservation and Genetic Improvement*'. He informed that despite the advances in characterizing country's livestock resources, majority are still non-described. Endangered breeds can be revived and high yielding animals can be multiplied to maximally utilize superior germplasm. Positive and negative aspects of the first to fourth generation reproductive biotechnologies were discussed. Success of cloning and confirmation of normal reproductive cycle of cloned animals (both male and female) at the institution would be a promising step. Cloning of Chhattisgarh buffalo is the practical example of conservation and propagation using reproductive biotechnologies.

Dr A.K. Srivastava

Dr Kuldeep K. Lal, ICAR-NBFGR, India, made a presentation on '*Molecular Traceability of Spatial Genetic Diversity for Sustainability of Fish Genetic Resources*'. He emphasized that wild resources are important as more than 50% of the food still comes from the wild. He further added that the species-specific panels of markers (in line with human and livestock) should be developed along with phenotypic descriptors which would be uniformly applicable across the globe to generate genetic indices and characterize genetic stocks/breeds. He opined for simple assay protocols to quantify genetic parameters. In this context, there is a need for cluster based analysis on spatial scale in addition to river-wise assessment

Dr K.K. Lal

of genetic diversity. On-farm conservation of genetic diversity through molecular tags was emphasized. Simultaneously, tapping of the tradability potential should also be ensured as in the case of *Litopenaeus vannamei*; which is majorly produced in its non-native range. Research on genetic erosion and inbreeding at the farm level would enable protection from probable losses of germplasm. He suggested that socio-economic aspects attached to on-farm conservation should be added. There is an urgent demand for paradigm shift in seed production system, and implementation of Article 9.3 (Code of Conduct for Responsible Fisheries) may be a step forward in ensuring availability of aquatic resources for future.

Dr A.K. Singh, ICAR-Directorate for Coldwater Fisheries Research, India, made a presentation on '*Fishery Resources, their Conservation and Potential in the Himalayan Region*'. He emphasized on species diversification, propagation, transplantation and stock enhancement.

Dr M.M. Chanda, ICAR-NIVEDI, India, presented the work on '*Habitat Mapping of Deccani Breed of Sheep using Remote Sensing Variables: Implications for Breed Conservation and Disease Resistance*'. He discussed about generating habitat map of population by giving example of *Deccani* sheep.

Dr Ravinder Singh, ICAR-NBAGR, India, presented his work on '*Cytogenetic and Mitochondrial D-loop Sequence Based Characterization of Buffaloes of Odisha State in India*'. He described application of cytogenetic and mitochondrial D-loop sequencing approach for distinguishing indigenous populations such as *Chilika* buffalo of Odisha.

Dr Grinson George, ICAR-CMFRI, India, presented a case study on '*Biodiversity vis-à-vis Oceanography: Few Case Studies Indicate Ecosystem Responses as a Major Factor Governing Fish Distribution in Space and Time*'. He concluded that Gujarat fisheries is more diverse and suggested ecosystem/ecological approach for conservation.

Recommendations - Concurrent Session 4D: Animal and Aquatic Genetic Resources

- *Vertical integration* of biological resources, bioinformatics tools and databases should be ensured for effective conservation strategies.
- *Marker panels and uniform protocols* be established for assessing genetic indices on spatial scale, both for cultivated and wild accessions.
- *Brood stock banks and stakeholders* should be involved in the scientific management of animal genetic resources.
- *Integration of genetic improvement with conservation* of locally adapted breeds/varieties need to be achieved to sustainably use these sources possessing useful alleles.
- *Cost-effective reproductive technologies* such as Hand Guided Cloning Technique be developed and used for genetic enhancement.

Concurrent Session 4E: Insects and Microbial Genetic Resources

This session was co-chaired by **Dr S.N. Puri**, Ex-CAU, India, and **Prof. Anupam Verma,** NAAS, India. **Dr Chandish Ballal,** ICAR-NBAIR, India, was the Convenor and **Dr Sanjay Gupta,** ICAR-NBAIM, India, and **Dr Rekha Varshney,** ICAR-NBAIR, India, were the Rapporteurs. In the session, four lead presentations were made by **Drs Chandish Ballal**, **K.K. Pal**, **K. Subaharan** and **Alok Srivastava,** followed by three rapid presentations by **Drs Ruchira**

Dr S.N. Puri and Prof. Anupam Verma, chairing the session

Kodithuwakku, **Sanjay Kumar Gupta** and **Ram Nageena Singh**.

Dr Chandish Ballal, ICAR-NBAIR, India, gave a presentation on '*Insect Genetic Resources – Innovation for Utilization*'. She briefed about invasive pests and their management with bioagents and adapting panchayat model, where farmers join together and utilize bioagents. She gave a brief introduction about innovative technology of *Trichogramma* production with Eri silkworm eggs, extending shelf life of *Trichogramma* up to 6 months by inducing diapauses and production system of predatory mites with the help of storage mites. She discussed many innovative technologies, exploitation of endosymbionts in fitness attributes (enhanced adult longevity, fecundity, parasitism/predatory potential, temperature tolerance and insecticide degradation) of *Trichogramma*, *Chrysoperla* and *Cotesia plutellae;* Entomofungal pathogens such as *Beauveria bassiana, Metarrhizium anisopliae*, *Lecanicillium* sp., *Paecilomyces* sp., which are generally used as foliar spray and are found to occur naturally as endophytes in plant tissues. She also described entomopathogenic nematode and green technology which is a win-win public-private partnership. She emphasized on bilateral exchange of bioagents and streamlining procedures for import/export/ exchange of genetic material.

Dr Chandish Ballal

Dr K.K. Pal, ICAR-DGR, India, spoke on '*Exploiting the Essence of the Microbial Diversity of the Rann of Kutch for Devising Strategies for Salinity and Drought Tolerance*'. He informed that due to abiotic (salinity and drought) stresses, there is drastic reduction in yield owing to shut down of photosynthesis. There are some microbes which are salinity and drought tolerant. He studied some glyoxylate cycle involvement and concluded that in the absence of carbon dioxide, organisms can take carbon from unconventional sources and save energy. He explained involvement of Na/H/K pumps.

Dr K. Subaharan, ICAR-NBAIR, made a presentation on '*Innovation in Insect Pest Management*: *Interventions using Insect Derived Volatiles*'. He briefed about olfactory behaviour of insects and method of studying it. He mentioned that with help of nanoparticles, pheromones can work in the field for up to 180-200 days as compared to commercial lure, which works for only 100 days. He described an innovative technology in which food volatiles can be blended with pheromone to catch more number of pests. He gave examples of cashew stem and root borer, banana stem weevil, *etc.* He also briefed about plant volatiles which can go better with pheromones.

Dr Alok Srivastava, ICAR-NBAIM, India, presented his talk on '*Insights from Genome and Genome Based Informatics of Agriculturally Important Microorganisms*'. In the whole genome database, only 6.2% is related to agriculturally important microorganisms. He discussed about *Mesorrhizium* and phylogenetic relationship of *Mesorrhizium* spp. He also explained conservation of *Nif* genes, genome map of *Pseudomonas koreensis*, functional annotation, and use of microsatellite markers for *Fusarium*.

Ms Ruchira Kodithuwakku, Department of Export Agriculture, Sri Lanka, presented '*A Preliminary Study on Abundance of Selected Soil Organisms in Prominent Land Use Systems at Mid Country of Sri Lanka*'. She mentioned that below ground study is also important owing to excessive use of chemicals, earthworm and other beneficial microbes population have reduced. She observed that fallowing allows recovery of soil microorganisms. Earthworm can also be used as an indicator.

Dr Sanjay Kumar Gupta, ICAR-NBAIM, India, presented his work on "*Soil Metaproteomics*: *A Novel Tool for Deciphering Functional Diversity from Environmental Samples*'. He discussed the abundance of protein in soil isolates and novel molecular techniques to decipher functional diversity.

Dr Ram Nageena Singh, ICAR-IARI, India, talked on '*Draft Genome and Mining of Genes from a Phosphate Solubilizing Bacterium Burkholderia cenocepacia PS27*'. He discussed about plasmid variation, structure of genome and arrangement of genes in the particular species.

Ms Ruchira Kodithuwakku

Dr Ram Nageena Singh

Recommendations - Concurrent Session 4E: Insects and Microbial Genetic Resources

- *Streamlining exchange procedures* of genetic material should be carried out.
- *Scaling up of expeditions* to explore and document insect and microbial diversity should be done on priority with emphasis on unique species.
- *Biocontrol agents/bio-pesticides* need to be commercialized and popularized among farmers.
- *Registration procedures of bio-pesticides* should be reviewed at national and global levels in order to simplify and promote their commercialization.

Technical Session 5: Quarantine, Biosafety, Biosecurity Issues

This session was co-chaired by **Ms Kenza Le Mentec,** STDF (WTO), Switzerland, and **Dr A.K. Srivstava,** ICAR-NDRI, India. **Dr Ravi Khetarpal**, CABI, India, was the Convenor, and **Drs V. Celia Chalam** and **Bharat Gawade,** ICAR-NBPGR, India, were the Rapporteurs. This session was common across all targeted commodities of the Congress, and was organized by presenting three Lead Papers, one Panel Discussion and six Rapid Presentations. Lead presentations were made by **Dr Ravi Kheterpal, Ms Kenza Le Mentec** and **Dr P. Lava Kumar**.

Technical Session 5

Dr Ravi Khetrapal, CABI, India, discussed on '*Converging Provisions of CBD and WTO to Ensure Biosecurity*'. He emphasized on knowledge sharing at global, regional and national levels and South-South technical co-operation on cross-cutting issues pertaining to agrobiodiversity, biosecurity and biosafety. He also reiterated the need to increase awareness on linkages between climate change, trade, invasive alien species and agrobiodiversity to achieve pro-poor and climate-resilient cropping systems.

Dr Ravi Khetrapal

Ms Kenza Le Mentec, STDF (WTO), Switzerland, presented on '*Invasive Species and International Trade*'. She discussed various issues related to invasive species and international trade, including online trade. She emphasized the need to enable trade to play its role as a driver for agrobiodiversity conservation through promoting safe trade practices and taking full advantage of opportunities offered by market-based instruments and global demand for traditional foods and medicinal products.

Ms Kenza Le Mentec

She highlighted the need for convergence of provisions of WTO and CBD at the regulatory level both globally and nationally, as well as the subsequent trickle-down effect at the operational level to ensure conservation and biosecured use of agrobiodiversity.

Dr P. Lava Kumar, IITA, Nigeria, spoke on '*Biosecurity Issues in Germplasm Exchange*: *African Experience*'. He discussed the need for building sanitary and phytosanitary capacity in developing countries, including in SPS risk assessment methodologies taking into account

Dr P. Lava Kumar receiving memento from Dr A.K. Srivastava

the uncertainty introduced by climate change. He emphasized establishment of a globally agreed mechanism "Green Pass" to facilitate distribution of pest-free germplasm from the CG Centres to promote worldwide agrobiodiversity conservation.

Lead presentations were followed by panel discussion on '**Biosecurity and Biosafety Provisions *vis-à-vis* Agrobiodiversity'.** The Moderator for this panel discussion was **Dr J.L. Karihaloo,** APAARI, India and the Panelists were **Drs S. R. Rao,** DBT, India, **Gurinder J. Randhawa,** ICAR-NBPGR, India, **Vibha Ahuja** BCIL, India and **Neeraj Sood,** ICAR-NBFGR, India.

Various provisions of biosecurity and biosafety were discussed by the panellists with reference to agrobiodiversity and Indian and international regulatory mechanisms for safe movement and use of LMOs. There is a need to enable biosecurity frameworks to achieve public health outcomes through assessment and mitigation of the risks related to zoonoses and food-borne diseases.

Rapid presentations were made relating to biosecurity policies, safe movement of transgenic crop germplasm, invasive pests including insects and fish, and role of diagnostics in quarantine for PGR. These presentations were made by **Drs Shashi Bhalla, V. Celia Chalam, M. Mohan, Kavita Gupta, C. S. Kariyawasam** and **Pravata K. Pradhan.** They emphasized the need for national and regional Plant Pest Diagnostic Networks, accredited laboratories and need for strengthening early warning systems and regular surveillance for pests.

Dr Shashi Bhalla, ICAR-NBPGR, India, presented on '*Biosecuring Import of Transgenic Crops Germplasm into India under Quarantine Umbrella*'.

Dr V. Celia Chalam, ICAR-NBPGR, India, presented her work on '*Role of Viral Diagnostics in Quarantine for Plant Genetic Resources and Preparedness*'.

Dr M. Mohan, ICAR-NBAIR, India, made presentation on 'Tuta absoluta: *A New Invasive*

Alien Insect Pest of Solanaceous Crops in India, Threat Assessment and Management Options'.

Dr Kavita Gupta, ICAR-NBPGR, India, presented on '*Biosecurity Policies Influencing International Exchange of PGR*'.

Dr C.S. Kariyawasam, Ministry of Environment, Sri Lanka, presented his work on '*Comparative Study of the Reproductive Biology of Gorse* (Ulex europaeus) *in the Mount Lofty Ranges of South Australia and Central highlands of Sri Lanka*'.

Dr Pravata K. Pradhan, ICAR-NBFGR, India, described his work on '*Cyprinid Herpesvirus-2: Widespread Occurrence in Goldfish Populations in India*'.

Recommendations - Technical Session 5: Quarantine, Biosafety, Biosecurity Issues

- *Convergence of WTO and CBD provisions* at regulatory and operational level should be achieved for conservation and use of bio-secured agrobiodiversity.
- *Safe-trade should be promoted* as a driver for conservation of agrobiodiversity and control of invasive alien species.
- *National phytosanitary capacities for safe import,* including pest risk analysis, has to be improved, especially in sub-Saharan Africa, owing to recent emergence, resurgence, spread and outbreaks of many important crop pests.
- *Green Pass criteria for germplasm distribution* from international genebanks should be developed to provide credibility on health status to phytosanitary regulators.
- *Seed certification program, early warning system and pest surveillance* have to be strengthened in the developing countries.
- *Plant Pest Diagnostic Networks* with accredited laboratories, at national and regional levels, should be established to ensure biosecurity while exchanging germplasm.

Plenary Session 4: ABS in the Context of Regulatory Systems

This Plenary Session was co-chaired by **Prof. Adel El-Beltagy,** IDDC, Egypt and **Dr B. Meenakumari,** NBA, India. **Dr Pratibha Brahmi,** ICAR-NBPGR, India, was the Convenor, and **Drs Shashi Bhalla** and **Vandana Tyagi,** ICAR-NBPGR, India, were the Rapporteurs. The Co-Chair Prof. Adel El-Beltagy opened the session with remarks on long debated issues on access to biological resources, and emphasized on revisiting and redefining scope of the ITPGRFA and to minimize conflicts. Dr B. Meenakumari talked about the salient features of Biological Diversity Act, 2002 (BDA) as supporting system/component for ABS mechanism for use of biological resources and highlighted progress in the implementation of BDA in India. In the session, two plenary lectures were given by **Prof. Ronnie Coffman** and **Dr Rai S. Rana,**

Drs R.S. Rana, Adel El-Beltagy, Meenakumari, Ronnie Koffman and R.S. Hamilton (from left to right)

followed by a panel discussion. The panellists were **Drs R.S. Hamilton** IRRI, Philippines; **Sudhir Kochhar**, Ex-ICAR, India, and **Ms Neeti Wilson,** Anand and Anand, India.

Prof. Ronnie Coffman, Cornell University, USA**,** made a brief presentation on '*Borlaug Global Rust Initiative (BGRI) Programme and Impact of Germplasm Exchange*' for development of improved rust-resistant varieties. He pointed out that global food security depends on the free movement and open sharing of plant genetic resources. Dr Coffman presented highlights of the Borlaug Global Rust Initiative (BGRI) and the Durable

Prof. Ronnie Coffman

Rust Resistance in Wheat (DRRW) projects. Both BGRI and DRRW are excellent examples of importance of free germplasm exchange. However, in the current scenario, exchange of wheat germplasm is controlled in forms and legal documents with the advent of multilateral treaties and conventions. These treaties and conventions provide for stringent regulations, and germplasm exchanges among countries are restricted, and this is critical for agriculture and horticulture. Exchange of seed and germplasm is necessary for global plant breeding programmes. Wheat germplasm and pathogen exchanges have been essential in the DRRW project, and would be more so under the DGGW project as plant breeders broaden their investigation to deliver new traits for wheat to combat diseases, pests, drought and other challenges brought about by global climate change.

Dr Rai S. Rana, Ex-NBPGR, India**,** presented a talk on '*Regulating Access to Genetic Resources and Benefit Sharing: International Treaties and Indian Experience*'. He overviewed existing national and international regulations, treaties and conventions and highlighted about ABS. He mentioned that ABS regulations with its relevance to adaptation to climate change, is the most debatable issue and occupies the centre stage during negotiations. India, being a contracting party impacting on ABS to several international treaties, needs to be fully equipped with provisions laid out. He expressed that National Biodiversity Authority, though an autonomous public-funded institution, has received full support from the Central Government, particularly in policy guidance and making rules and regulations. The Biological Diversity Act, 2002 implementing provisions of the CBD, has come out as an overarching ABS legislation by providing effective linkages to other relevant national Acts and enabling legislation for effectiveness of the national ABS system. While national ABS legislations of most other biodiversity-rich countries appear to target primarily bio-survey and bio-utilization of their bio-resources by foreign companies, the Indian national legislation focuses on promoting conservation

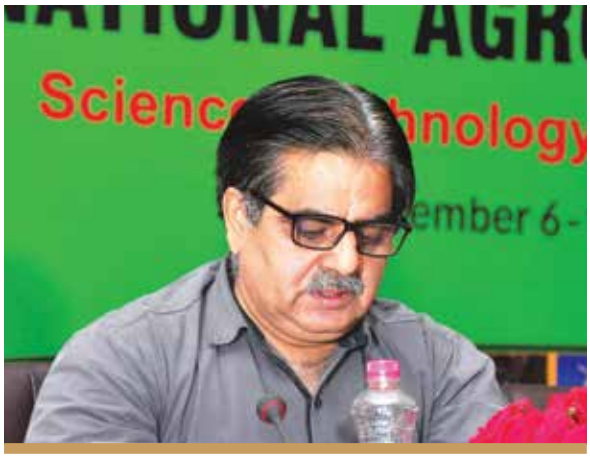
Dr R.S. Rana

and sustainable use of bio-resources linked to fair and equitable sharing of benefits. Investing in biodiversity conservation is the first step to safeguard natural bio-wealth for future use.

Dr R.S. Hamilton, IRRI, Philippines, expressed his concerns regarding facilitated exchange of PGRFA, exchange of germplasm as per national legislation and progress of IPR applications and benefit sharing arrangements approved so far. He stressed the need to simplify procedures, create awareness, and on clarity of ownership issues, transparency and legal certainty of the mechanism.

Dr R.S. Hamilton

Dr Sudhir Kochhar, Ex-ICAR, India, discussed salient features of the multilateral system of access and benefit-sharing, as set out in Article 10 of the ITPGRFA reaffirming



Dr Sudhir Kochar

recognition by contracting parties to sovereign rights of other nations over their own PGRFA, including authority to determine access to those resources resting with their governments and subjected to national legislation. He stressed on understanding the variety of legal dimensions and instruments for utilization of genetic resources and associated traditional knowledge both at the national level as well as the international level to balance 'access' and 'benefit sharing' concerns, raised by the stakeholders.

Ms Neeti Wilson, Anand and Anand, India, highlighted the importance of ABS and also briefed the audience about the pre-IAC 2016 event which was held on October 22, 2016. She expressed that there are still many areas of intricacies or complexities in which the stakeholders need to be fully aware or to be sensitized. Skills have to be upgraded on both sides for smooth and effective implementation of the ABS mechanism, now in place. Stakeholders also need to be sensitized on arrangements for an interface between biodiversity, plant varieties and farmers' rights authorities, and also industrial policy and promotion under new IPR

Ms Neeti Wilson receiving memento from Dr Meenakumari

policy, if any, to resolve processing ambiguities arising in individual cases of agrobiodiversity/ PGRFA access and use *vis-a-vis* innovation management.

Recommendations - Plenary Session 4: ABS in the Context of Regulatory Systems

- *CBD framework* should guide the use of biological resources and associated traditional knowledge to ensure sustainable food security.
- *National legislation* (e.g. Biological Diversity Act, 2002 of India) should help in developing collaborative research projects involving germplasm sharing and the approval process of such projects should be time bound.
- *Annex I crops of ITPGRFA* need to be expanded to include other food and agriculture related crops for the global benefit.
- *Benefit sharing funds* should have mechanisms for resource generation, including user-based payment mechanism.
- *Agro-ecological zone based maps of agrobiodiversity* should be prepared to investigate impact of climate change on agrobiodiversity.
- *Alternative niches* need to be identified to safely conserve genetic resources, under serious threat in their present ecological system, to avoid their permanent loss.

Technical Session 6: IPRs, ABS and Farmers' Rights

This session was co-chaired by **Prof. R.B. Singh,** CAU, India and **Dr Lim Eng Siang,** Malaysia. **Dr Pratibha Brahmi**, ICAR-NBPGR, India, was the Convenor. **Dr Poonam J. Singh,** ICAR-NBAIM, India, and **Ms Shakti Khera,** ICAR-NBPGR, India, were the Rapporteurs. In this session, three lead presentations were made by **Drs R.R. Hanchinal**, **Lim Eng Siang** and **Ilse Kohler-Rollefson**. Followed by rapid presentations by **Drs Pratibha Brahmi**, **C. Thomson Jacob**, **Sherry Rachel Jacob** and **Prabha S. Nair**.

Dr R.R. Hanchinal, PPV&FRA, India, made a presentation on '*Indian Initiatives on Farmers' Rights*'. He discussed the Indian PPV&FR Act and informed about unique farmers' varieties conserved by Indian farmers. He urged to maintain farmers' variety at agrobiodiversity hotspots. Their use and exchange needs to be encouraged through establishment of community seed banks. Promotion of traditional crops with value addition for maintaining diversity of PGR for food and nutritional security

Prof. R.B. Singh and Dr Lim Eng Siang, Co-chairs of Technical Session 6

Dr R.R. Hanchinal

was also stressed. He emphasized registering farmers' varieties through establishment of linkages between PPV&FRA, NARS and KVKs. He also stressed the need for farmers' varieties in formal seed chain, and informed that a mechanism for commercialization of farmers' varieties is underway.

Dr Lim Eng Siang from Malaysia, delivered lecture on '*The Role of ITPGRFA in Agrobiodiversity Management*: *Future Strategies and Actions*'. He informed about the process of deliberations at the ITPGRFA meetings regarding expansion of Annex 1 crops and the possibilities to include all PGRFA. He

Dr Lim Eng Siang

also discussed the development of a supply and value chain for biodiverse food systems and their modalities. He suggested that Benefit Sharing Fund should be invested in developing biodiverse seed market through farmers' participation. This would lead to biodiverse seed markets and biodiversity based farms, ultimately enriching markets with biodiverse food for consumers.

Dr Ilse Kohler-Rollefson, League for Pastoral Peoples, Germany, talked on '*Access and Benefit Sharing of Animal Genetic Resources*'. She discussed on the issues of ABS in the AGR and highlighted specific need of maintaining animal breeds and resources *in situ* within respective ecological and social context to conserve rich

Dr Ilse Kohler-Rollefson

germplasm for future. She informed about using healthy heritage products from farm animals, especially camel, and using community protocol for documenting to understand AGR as enshrined in Nagoya Protocol and by including epigenetic considerations for conserving livestock. She informed about Biocultural Community Protocols (BCP) initiative by League for Pastoral Peoples and Life Network, which is currently scattered, underfunded and needs to be expanded on a country to country basis with the goal of creating a global *in vivo* Community Breed Repository as equivalent to Svalbard Global Seed Vault.

Dr Pratibha Brahmi, ICAR-NBPGR, India, made presentation on '*Alternative Options for Benefit Sharing under ITPGRFA*'. She discussed the Multilateral System (MLS) of the ITPGRFA envisaging monetary benefit sharing, accrued from utilization of PGRFA, as a major contribution towards Benefit Sharing Fund (BSF). However, practically there were no fund generation from utilization of the PGRFA since the implementation of the Treaty. While discussing alternate options for benefit sharing, she stressed that there is a need for brainstorming among countries/regions in view of the basic objectives of the Treaty to be balanced with ABS. SMTA template also needs to be amended for different options/ users.

Dr C. Thomson Jacob, NBA, India, talked on '*Mainstreaming Biodiversity into Agricultural Sector*'. She mentioned that traditional knowledge available with local communities need to be documented. She concluded that mainstreaming agrobiodiversity would also help achieve Aichi targets and SDGs. This would lead to increase in the wealth of agrobiodiversity, by minimizing genetic erosion.

Dr Sherry Rachel Jacob, ICAR-NBPGR, India, presented an analysis on '*The Global Conservation Status of Indian Germplasm and its Implications*'. During 1997 to 2008, a decline of germplasm exchange was indicated, as germplasm exchange policy was being formulated by different countries during the period. Finally, interplay of national legal system and international treaties is going to ease access of germplasm.

Ms Prabha S. Nair, NBA, India, presented an account on '*Germplasm Exchange from India under the Multilateral System vis-à-vis the Biological Diversity Act, 2002: A Critical Appraisal*'. She discussed various regulatory provisions of the Biological Diversity Act for exchange of germplasm, and emphasized about the implementation of the Act in harmony with the Multilateral System of the ITPGRFA.

Recommendations - Technical Session 6: IPRs, ABS and Farmers' Rights

- *Annex I crops of ITPGRFA* should be expanded to include other crops related to food and agriculture.
- *Biodiverse food systems* should be developed by defining supply and value chain, strengthening local seed systems and improving their safety net for better livelihoods.
- In situ *conservation of animal genetic diversity* should be carried out within their eco-regional and social contexts to ensure climate change adaptation.
- *Non-monetary benefit* options such as grazing rights, capacity building, veterinary care, infrastructure/value chain development for local processing and assistance in marketing be also explored for genetic resource conserving farmers, pastoralists and livestock breeding communities.
- *Agrobiodiversity hotspots* need to be protected and *in situ* conservation of farmers' varieties be ensured through establishment of community seed banks on priority basis.
- *Revision of SMTA* for exchange of PGRFA should be done carefully and in consonance with provisions of ABS, especially using Nagoya Protocol for providing bilateral exchanges.

Technical Session 7: Partnership, Networks and Capacity Building

The session was chaired by **Dr H.S. Dhaliwal,** Eternal University, India, and the Convenor was **Dr S.P. Ahlawat,** ICAR-NBPGR, India. **Dr S.K. Yadav**, ICAR-NBPGR, India and **Dr Anurag Khanujia,** NISCAR, India, were the Rapporteurs. In the session, seven lead presentations were made by **Drs Stephan Weise**, **Darshan Singh Brar**, **Raghunath**

Dr H.S. Dhaliwal, Chair of the Session

Lead presentors of Technical Session 7

Ghodake, **G.G. Koppa**, **Devendra Gauchan**, **Tiziana Ulian** and **Paul Quek**.

Dr Stephan Weise, Bioversity International, Italy, spoke on '*International PGR Networks on Commodity Crops - Lessons Learned and Success Stories*'. He gave detailed information on genetic resources networks (MusaNet, CacaoNet and COGENT), regional research-for-development networks (BAPNET, BARNESA, MUSALAG and Innovate PLANTAIN) and researcher network (ProMusa). He explained the objectives of these networks in maximizing use of genetic diversity through comprehensive characterization, identification and evaluation of accessions.

Dr Darshan Singh Brar, PAU, India, delivered a lecture on '*Capacity Building in Application of Biotechnology for Germplasm Enhancement*'. He emphasized on the importance of capacity building in biotechnology. The suggested avenues for capacity-building are by allocation of adequate resources to cover high cost of inputs and development, creation of trained manpower and budget allocation for in-house training of scientists in the ICAR and SAUs. Special emphasis was given to retention of experts and trainers in each department to maintain a continuum of new researchers. Priority should be given to integrate biotechnology with conventional crop improvement/plant breeding programs. This would strengthen pre-breeding programs and efficient utilization of agrobiodiversity for germplasm enhancement.

Dr Raghunath Ghodake, APAARI, Thailand, gave a presentation on '*Implementation of Suwon Declaration*'. He focused on the conservation and use of genetic resources through implementation of Suwon agrobiodiversity framework and partnerships in Asia and the Pacific. He emphasized on strengthening of network programmes on regional issues, collaborations among national and international research institutions, network activities for underutilized crops and their wild relatives, regional collaborative projects, focusing on participating countries and their roles and mobilization of resources/funds.

Dr G.G. Koppa, FAO, India, made a presentation on '*Transforming Indian Agriculture for National and Global Environmental Benefits and Biodiversity Conservation*'. While laying emphasis on the need to increase food production, he expressed his concern for conservation of natural resources amid changing climate, which would impact food security. To catalyse transformative change for India's agricultural sector, it is critical to conserve biodiversity. Government of India and FAO are going to implement GEF 6 Project on Green Agriculture, a multi-focal point project involving large

Drs G.G. Koppa, Raghunath Ghodake and Darshan Singh Brar (front row left to right)

number of stakeholders, including poor and marginal farmers, especially women.

Dr Devendra Gauchan, Bioversity International, Nepal, presented on '*Post-disaster Revival of the Local Seed System and Climate Change Adaptation: A Case Study of Earthquake Affected Mountain Regions of Nepal'*. He urged to bring new diversity to farmers' fields, more efficiently and more effectively, based on the local conditions and farmers' preferences and interests. He

Dr Devendra Gauchan

emphasized on building new linkages and forms of cooperation: *ex situ* and *in situ* conservation, national genebank and community seed bank, plant breeders and farmers.

Dr Tiziana Ulian, Royal Botanical Garden, Kew, discussed her paper on '*Plant Diversity*

Dr Tiziana Ulian

to Improve Food Security and Livelihoods of Local Communities'. She emphasized on capacity building for local communities and partners. She explained the importance of participative approach by working with project collaborators, governments and communities.

Dr Paul Quek, Bioversity International, Malaysia, updated on use of digital tools in data collection in the field. He listed benefits like resource saving in data compilation, less efforts in checking of data, timely compilation and analysis of data, reduced paper usage, improved staff productivity, participatory approaches and affordable devices by using digital tools for data collection.

Recommendations - Technical Session 7: Partnership, Networks and Capacity Building

- *ICT based approaches* (e.g. mobile apps based crowdsourcing, crowdfunding, crowdbonding, *etc.*) should be explored to develop partnerships with effective involvement of stakeholders.
- *Governments and donors* need to provide sustained support for building networks and partnerships among conservers, research institutions and development agencies.
- *Commodity-based networks* should be established for lesser known crops and their wild relatives.
- *Pre-breeding and participatory breeding* for utilization of agrobiodiversity should be strengthened by effective integration of biotechnology with conventional plant breeding.

Round Table Discussion: Genebank Management: Challenges and Opportunities

This session was co-chaired by **Ms Marie Haga,** GCDT, Germany and **Dr Kuldeep Singh,** ICAR-NBPGR, India. Moderators for this session were **Dr H.D. Upadhyaya,** ICRISAT, India and **Dr R.K. Tyagi,** ICAR-NBPGR, India. Genebank managers from 41 countries participated in the discussion. **Dr P.N. Mathur,** Bioversity International, India presented the major issues for discussion. Following points emerged from the discussion:

1. Gap Analysis and Completeness of Collections

- Genebanks should add new collections on the basis of gap analysis, with reference to the origin of the collections, available in respective genebanks.
- Divergent views were expressed with respect to need for further collecting. While some opined that collections are complete in major crops, others felt that judicious collecting needs to be done as new germplasm continue to evolve in nature.

2. Rationalization of Collections in Genebanks

- Duplication of collections are found within and between genebanks.
- Major issues were (i) should all available collections be conserved in genebanks and (ii) how to identify duplicates?
- It is extremely difficult to identify 'true duplicates'. A consensus was reached that possible duplicates may be identified:
  - Through a strong system of documentation
  - Using different sets of data (passport, characterization, molecular)
  - Sequencing data of all accessions, depending on the availability of funds

Drs P.N. Mathur, Kuldeep Singh, Marie Haga, R.K. Tyagi and H.D. Upadhyaya (left to right)

3. Documentation

- Irrespective of the size of collections in genebank, strong online database system should be developed by all the genebanks, with quality data which should serve the purpose of providing information to all users.
- GENESYS or GRIN Global System may be used by all the genebanks for ease of operation. Customized database may not be cost-effective to maintain.
- *Ex situ* and *in situ* collection databases need to be integrated.

4. Capacity Building

- Representatives from most of the countries expressed that for best genebank management practices, there is an urgent need for training scientists/ genebanks staff in all areas, particularly for application of new methodologies (*in vitro* conservation, cryopreservation, sequencing, documentation).
- Availability of funds should be ensured for capacity building.
- Organizations like FAO, GCDT, and Bioversity International need to take responsibility at the global level. It was mentioned that Bioversity International is focusing on *in situ* on-farm conservation. Therefore, possibilities should be explored about availability of funds for capacity-building with the FAO and GCDT.

Recommendations - Genebank Management: Challenges and Opportunities

- *Completeness of collections in genebanks* should be achieved on the basis of gap analysis and targeted germplasm collections.
- *Rationalization of collections in the genebanks* (*e.g.* avoid adding new, informed decision on elimination of duplicate accessions) should be ensured for effective conservation and use of germplasm.
- *Global common platform of documentation* of accession level information with quality data should be developed and made available to breeders in order to facilitate their enhanced use.
- *Capacity building programs* should be organized regularly on modern genebank management techniques, molecular techniques and genetic resource documentation.

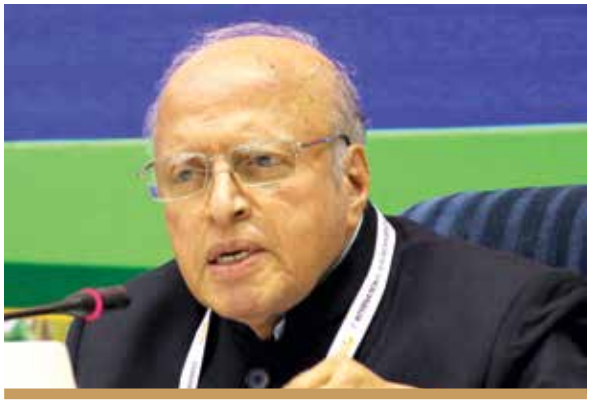
Evening Lectures

In addition to the seven theme-based Technical Sessions, two evening lectures were also organized, which were open to all the participants of the Congress, including to other invited guests. These lectures covered the challenges in the use of agrobiodiversity to achieve food and nutrition security. The following lectures were delivered by eminent scientists in the field of agrobiodiversity conservation and their sustainable use:

1. Agrobiodiversity and achieving zero hunger challenges by **Prof. M.S. Swaminathan**
2. Biodiversity, food and the future by **Prof. Peter H. Raven**

Agrobiodiversity and Achieving Zero Hunger Challenges - Prof. M.S. Swaminathan

The first evening lecture was co-chaired by **Ms Ann Tutwiler,** Bioversity International, Italy and **Dr S. Rajaram,** RSM, Mexico. Convener for the session was **Dr Anuradha Agrawal,** ICAR-NBPGR, India. **Drs D.B. Parakh** and **Chithra Devi Pandey,** ICAR-NBPGR, India, were the Rapporteurs. Dr Anuradha Agrawal welcomed the Co-chairs and gave a brief introduction about the theme of presentation and of the speaker, **Prof. M.S. Swaminathan**. Ms Ann Tutwiler initiated the session by introducing Prof. Swaminathan and his significant contributions and lifetime achievements.



Prof. M.S Swaminathan

In his presentation, Prof. Swaminathan highlighted briefly about the history of agricultural development in India, including domestication of rice by women-folk. He explained that genetic resources of agrobiodiversity include a wide range of organisms, from microbes to man. He talked about the well-established organizational structure of the ICAR for taking care of conservation and use of genetic resources of all commodities of agrobiodiversity, through establishment of five National Bureaux of plant, animal, fish, microbes and agriculturally important insect genetic resources. He also gave the genesis about various laws enacted in India following CBD, such as PPV&FRA, BDA, *etc.*, for conservation and sustainable use of these genetic resources. Emphasising the use of agrobiodiversity, he mentioned that these genetic resources are not only valuable to address food security of the growing population, but also important for addressing nutrition security, which is

a major problem in most developing countries. Therefore, he reiterated the need for enlargement of the food basket by including nutri-millets and other orphan crops in the Public Distribution System. He described the five pillars of Zero Hunger Challenge as: (i) access to food round the year, (ii) arrest malnutrition in growing children, (iii) prevent wastage of food, (iv) sustain small farm holdings, and (v) small farm families.

Prof. Swaminathan mentioned gaps in achieving food and nutrition security, and raised his concern over the alarming state of malnutrition in India - it ranks 80 out of 104 countries in the 2015 global hunger index including macro and micro-nutrition deficiencies. He mentioned three major dimensions of hunger as calorie deprivation, protein deficiency and micronutrient deficiency. This requires bringing together agriculture, nutrition and health through Farming System for Nutrition. He further emphasized that fighting hidden hunger can also be achieved through three major approaches of biofortification: (i) naturally occurring biofortified plants like moringa, tamarind, sweet potato, nutri-millets, milk, eggs and other forms of animal protein; (ii) biofortified varieties selected by breeding and selection of iron, vitamin A, zinc and folate rich crops; and (iii) genetically biofortified crops like Golden Rice and iron-rich rice (after appropriate regulatory clearance). He also discussed importance of horticultural plants, medicinal and aromatic plants, diversity of lichens and super crops like tamarind and moringa, which provide good biomolecules of pharmaceutical importance. Regarding conservation of genetic resources, he made special mention of reasons for degradation of mangroves and bleaching of coral reefs; community food and water security system; role of *in situ*/on-farm conservation in continuous evolution; role of botanical gardens; and new crossbreds with high production and poultry species.

Dr S. Rajaram, Co-chair congratulated Prof. M.S. Swaminathan for a thoughtful

Audience giving a standing ovation to Prof. M.S. Swaminathan

Ms Ann Tutwiler and Dr S. Rajaram presenting a memento to Prof. M.S. Swaminathan

presentation. He said that tribal people all over the world, who conserved and preserved agrobiodiversity through traditional practices, made it possible for the present and coming generations to acclimatize to climate change. Further, he added that strong pre-breeding programs and research should be conducted for the benefit of farming community. In addition, he stated that a reminder should be given to the scientific and political communities on how to handle ongoing problem of burning stubbles, which causes environmental pollution.

Recommendations

- *International Year of Agrobiodiversity* and International Year of Millets should be proposed to the UN for consideration.
- *Millets* be promoted as nutritious food at all levels, including their use in school meals.

Biodiversity, Food and the Future - Prof. Peter H. Raven

The second evening lecture was co-chaired by **Prof. M.S. Swaminathan,** MSSRF, India, and **Prof. Ronnie Coffman,** Cornell University, USA. Convener for the session was **Dr G.J. Randhawa,** ICAR-NBPGR, India. **Dr Sunil Neelam**, IIMR, India and **Dr Anitha Pedapati,** ICAR-NBPGR, India, were the Rapporteurs. Prof. Swaminathan gave introductory remarks about **Prof. Peter H. Raven**, a world leading botanist and an advocate of conservation of biodiversity.

Prof. M.S. Swaminathan, Prof. Ronnie Coffman, Dr G.J. Randhawa and Prof. Peter Raven (left to right)

Prof. Peter H. Raven, in his opening remarks voiced his concern about the burgeoning population and rapid rise in food consumption since the last two centuries, leading to unprecedented environmental problems. According to estimation of foot print network, people of the world are consuming about 164% of planets capacity for sustainable productivity on a continuous basis. In other words, 64% more capacity is needed for sustainable productivity to achieve food security for the current status of population. In addition

Prof. Peter Raven

to the problem of increasing population, climate change is another important issue, which would effect the hit target of food security. At the global level, it might have already become impossible to hold global temperature increases within 2°C target set in Paris. The global level of carbon dioxide in the atmosphere, 280 ppm at the start of the Industrial Revolution, reached to 400 ppm in autumn of 2016, and is still increasing. For India, increased monsoons, higher temperatures, melting glaciers, intensified use of water that accompanied the Green Revolution and projected two meter rise in sea level by the end of this century would adversely affect agricultural productivity, that would suffer major losses locally and globally unless and until climate change is contained through common action.

Prof. Raven mentioned that many millions of Indians starved to death from the time of Bengal Famine in 1943 to the beginning of Green Revolution in 1967. India's Green Revolution resulted in increasing the extent of croplands, double-cropping through intensive irrigation, applying more fertilizer, and introducing improved genetic strains of crop plants. With three times as many people in India from the time of the Green Revolution, it is not strange that some agricultural practices which proved successful then are being questioned. Heavy fertilization and application of pesticides and herbicides, double cropping (sometimes now triple, with no regards for the soil), and wasting water all contribute to the problem of climate change. He emphasized more on the process that would necessitate full empowerment of women, adequate feeding of people, and demand maintaining a level human population that might not be as large as the rapidly-growing one that we now have.

Prof. M.S. Swaminathan presenting a memento to Prof. Peter Raven

Prof. Raven highlighted the importance of application of modern genetic techniques in the improvement of Indian crops, since they have been responsible for gains in agricultural yield worldwide. Feeding people using the breeding protocols, such as transgenics may be the way forward, as GMO bring nothing common to foods produced from plants or animals in whose origin this particular genetic strategy has been employed. In support of his views, Prof. Raven has pointed out that many medicines (including virtually all insulin used worldwide) and virtually all beer, cheese, and bread produced anywhere use genetically modified organisms in their production. He mentioned that India is fully dependent on its biological diversity and is likely to lose even more than half of its species, the great majority of them unknown, over the course of coming decades.

Recommendations

- *Sustainable productivity* should be achieved by containing human population growth and by keeping consumption at socially justifiable levels.
- *Agriculture should change* both to limit and to adapt to global climate change.
- *Women and children empowerment* process should be initiated/strengthened globally for food and nutritional security.

Farmers' Forum: Farmers' Role in Conservation of Genetic Resources

A special session was organized to understand role of farmers' in conservation and use of genetic resources and for further enhanching it through public-private partnership, so that farmers and communities continue conservation of traditional genetic resources on-farm and have escalation of use of traditional knowledge. Many innovative farmers were invited to participate and share their experiences with others. The Moderators for this session were **Dr R.R. Hanchinal,** PPV&FRA, India; **Dr A.K. Singh,** ICAR, India; and **Mr Vipin Kumar,** NIF, India. **Dr R.C. Agrawal,** PPV&FRA, India the the Convenor and **Mr Satya Singh,** NIF, India, was the Rapporteur.

Drs A.K. Singh, R.R. Hanchinal and Vipin Kumar (left to right)

Dr R.R. Hanchinal gave an introduction about importance of PGR and its conservation in providing food nutritional and health security. He also highlighted main features of the PPV&FR Act, 2001, underlining provision of giving equal rights to farmers and breeders. The recently announced national IPR policy was also highlighted. He reiterated main issues concerning conservation and use of agrobiodiversity as follows: (i) mainstreaming of farmers' varieties; (ii) establishment of community seed banks and genebanks; (iii) promotion of traditional crop varieties, value-addition and market linkages; and (iv) benefit-sharing and policy support to the farmers. The following were his suggestions:

(i) Increase registration of numbers of farmers' varieties

(ii) Emphasis should be on value-addition and market linkages

(iii) Organization of awareness training programs

Prof. Anil Gupta, NIF, India, emphasized importance of farmers' role in conservation of traditional varieties. He also gave impetus on inclusion of special characters of the crop, apart from yield and yield attributing traits in the guidelines for development of new varieties, which was not being attended by the scientific community. Dr Gupta mentioned importance of the role of linking food produce of traditional varieties at the local levels to consumers to popularize such traditional varieties by organizing fairs like 'Satvik' (traditional food festival, organized by SRISTI, Ahmedabad).

Mr Vipin Kumar, NIF, India, stressed that collaboration between farmers and scientists is the need of the hour for proper documentation and characterization of agrobiodiversity. He emphasized the role of "open source channel" that farmers use to disseminate their technology. He discussed about the establishment of seed funds and seed companies by farmers and providing technical information to the farmers on taxation, regulations for seed packaging, labelling, *etc*. Role of NIF, India, in supporting the innovative farmers was also highlighted.

Dr A.K. Singh, ICAR, India, strongly stressed the role of KVKs in connecting farmers to scientific community and knowledge sharing, and training programs for farmers to make them aware of the latest technologies. He also mentioned the need for new research at farmers' level, where farmers, scientists and experts can add value to research at farmers' level. He opined that "Farmer Innovation Meets" should be organized at research institutes, KVKs, *Kisan Melas*, SAUs, CAUs for maximizing exchange of information and display of local technologies.

A large number of innovative farmers also participated in the discussion and presented their views and suggestions which are as follows:

Mr Gopal Sangwan, Farmers' Rights Activist, India, advocated setting up of companies by farmers which should be tax free, provisions can also be made under special acts, and exemption of fees for farmers can be for participating in conferences, *Kisan melas*, and scientific gatherings. He also mentioned for inclusion of farmers' varieties in State Seed Corporation and National Seed Corporation. He emphasized on linking food security with farmers' security.

Mr Kamalbhai Ambalal Patel, Biofertilizer Industry, India, emphasized on the role of bio-control approaches for organic farming. He advocated liberal laws for bioagents in agriculture, and suggested exclusion of biopesticides from the CIB regulations.

Ms Anjamma, a woman farmer from Telengana, India, emphasized that farmers should have appropriate price of traditional varieties in the market, which would help the farmers to conserve traditional varieties. He mentioned that traditional millets should be promoted for ensuring food and nutritional security.

Ms Anjamma

Dr Sanjay Patil, BAIF, India, suggested upscaling of important landraces and preparation of region-wise compendium and technical support to farmers. Conservation and upscaling of farmers' varieties and conservation of animal biodiversity was stressed by him. He opined that seed keepers at the state and national levels should be identified and properly documented. As incentives, fellowship/stipends to biodiversity conservers at the individual level may be given by the government.

Mr Biharilal Sharma from Himachal Pradesh, India, discussed important role of youth in sustainable development and revival of old crops which are being lost. He mentioned that State Biodiversity Board/state government departments should work on identification, characterization, proper maintenance, research and registration of old varieties.

Dr Prabhat Kumar, IARI, India, emphasized that balance needs to be maintained between conservers and consumers of biodiversity. He suggested that awards may be instituted by the State Biodiversity Boards and National Biodiversity Authority in recognition of farmers (conservers) and KVKs for exemplary work in conservation of genetic resources.

Mr P.N. Unni from Kerala, India, said that incentives should be provided on a regular basis to the farmers on conserving specific local varieties as it is a costly and time consuming process. Effective linkages between value-addition from growing of crops to packaging and marketing to farmers was also suggested.

A view of the audience

Mr Sharma, Gokaran, India, requested for government support for medicinal plant growers and healers.

Mr Devkanta from Manipur, India, pointed out problems faced by North-East farmers and suggested region-specific programs addressing local issues.

Mr Prakash Singh Raghuvanshi from Varanasi, India, emphasized on the need for self-employment of farmers by producing their own seeds, uniformity in seed selling norms of government all-over the country, for easy procedures, purity maintenance in seeds and recommendations from local officials/ KVKs for certification/sale of seeds.

Mr Hariman Sharma from Himachal Pradesh, India, stressed on proper valuation of farm goods; specially fruits like apple and kiwi. Research and control of fruit fly on vegetables and fruits should be carried out in HP region to avoid damages.

Mr Pandurang Lokhande from Madhya Pradesh, India, emphasized on the use of soyabean for farmers' welfare through seeds and products developed from soyabean.

Recommendations - Farmers' Forum: Farmers' Role in Conservation of Genetic Resources

- *Uniform guidelines for encouraging local conservers* be laid down by the governments.
- *Region-specific pilot projects* on conservation and utilization should be initiated, with reference to climate change, involving farming communities and gene saviours.
- *Biodiversity hotspots* be revisited and documented for development of strategies and action plans.
- *Coordination at various levels of governance* (*e.g.* in India, national, state, district, village and community levels) should be established for incentivizing the conservers and upscaling activities.
- *Incentives to farmers and communities*, conserving valuable genetic resources be ensured through increased allocations for the National Gene Fund.

Public Forum: Role of Stakeholders in Agrobiodiversity Management

This special session on Public Forum was for better understanding of the role of all stakeholders involved directly or indirectly for management of agrobiodiversity. This was co-chaired by **Prof. Peter Raven**, Missouri Botanical Garden, USA, India and **Dr R.S. Paroda,** President, ISPGR and TAAS, India. There were four panellists for this session: **Dr Adel El-Beltagy,** IDDC, Egypt; **Prof. Anil Gupta,** NIF, India; **Dr Ajay Jakhar,** BKS, India; and **Ms Sunita Sreedharan,** SKS, Law, India. The main highlights of discussion are as follows:

Prof. Peter Raven and Dr R.S. Paroda co-chairing the public forum

1. Habitat destruction, climate change and spread of introduced species are affecting all biodiversity (terrestrial, aquatic, marine). Monitoring of biodiversity and of its rate of loss is an urgent issue as population and consumption of many countries has increased many-fold.

View of the audience

2. Agrobiodiversity is a subset of biodiversity, generally that has been selected by human beings over past 12,000 years of a 2.8 million-year history; and all of biodiversity, largely unknown, deserves attention for its future potential and intrinsic worth.
3. Public awareness, institutional mechanisms, prioritization of *in situ* and *ex situ* conservation for biodiversity should be taken up in mission mode. Special attention should be given to agrobiodiversity in vulnerable regions.
4. Marine biodiversity should be documented on a priority as it is reducing at a fast pace.
5. Women should be empowered for conservation and preservation of the knowledge associated with conservation and use of biodiversity.
6. Urgent attention is needed to develop a sound policy for checking of biodiversity as stakeholders do not have much choice but the dictates of government policies for conservation and use of biodiversity.
7. Pilot projects should be developed for *in situ* conservation.
8. There is a need to harmonize various laws and better coordination among the various ministries for effective implementation of laws.
9. Financial resources and institutional mechanisms are required to address farmers' concerns.
10. Governments need to address livelihood security through use of biodiversity and ensuring incentives for farmers and developing marketing system to encourage conservation of biodiversity.

Recommendations - Role of Stakeholders in Agrobiodiversity Management

- *Sound strategy for checking agrobiodiversity loss* needs to be formulated as government policies dictate both biodiversity conservation and use in most nations.
- *Pilot projects for* in situ *conservation* need to be developed through proper incentives to farmers for the mitigation and adaptation to climate change.
- *Harmonization of various laws* and better coordination among concerned ministries need to be ensured for effective implementation of laws related to agrobiodiversity management and use.

Satellite Sessions

Satellite Session 1: Harnessing Biodiversity for Food Security and Sustainable Development

This session was organized by the International Maize and Wheat Improvement Center (CIMMYT) and was chaired by **Dr Martin Kropff,** CIMMYT, Mexico and **Dr B.S. Dhillon,** PAU, Ludhiana, India, was the Panel Chair. **Dr Sukhwinder Singh,** CIMMYT, Mexico, was Session Convener. **Dr Prashant Vikram,** CIMMYT, Mexico, was the Rapporteur. The Session was organized to chalk out the rationale for enhancing use of diverse genetic resources for agriculture, and how this would contribute to the achievement of several of the United Nations Sustainable Development Goals (SDGs) for 2030. Presenters for this session were partners, scientists, students, and stakeholders of the Seeds of Discovery (SeeD) Initiative of CIMMYT. While working with numerous partners, SeeD (www.seedsofdiscovery.org) encompasses characterization of genetic resources to identify trait and allele donors, development of an informatics platform to enable efficient harnessing of these resources, pre-breeding to validate and incorporate novel diversity into elite germplasm, and capacity-building to ensure potential impacts on realization and equitable accessibility. SeeD is a pioneering partner in the DivSeek (www.divseek.org) initiative of CIMMYT, which seeks synergies among projects to harness diversity of crop species to feed humankind.

Drs Martin Kropff (centre), B.S. Dhillon (right) and Sukhwinder Singh (left)

CIMMYT team who organized the satellite session

During the session discussion focused on the following issues:

1. Describing SeeD project, its vision for impact, and its technical achievements;
2. Inviting stakeholders and partners in the public sector, private sector and funding agencies to share their visions and experiences regarding SeeD and like-minded projects;

3. Follow-up actions to generate new partnerships and synergies, focused on harnessing biodiversity to address global agricultural challenges facing humanity; and;
4. Formulate an action plan.

Dr Martin Kropff, DG, CIMMYT, Mexico, gave keynote address in the session. He mentioned about importance of genebanks of wheat (150K accessions) and maize (20K accessions) at CIMMYT as well as other genebanks harbouring wild relatives of crop species and accentuated for their linkage with breeding programs to meet our current and future needs. He also emphasized on following a proactive approach, anticipating problems (as was done in wheat blast outburst in Bangladesh) and finding solutions in advance.

Dr Kevin Pixley, Director, Genetic Resource Program, CIMMYT, Mexico, provided an overview of CIMMYT-SeeD project and explained entire impact pathway. He recommended SeeD, DivSeek and GCDT as models for focusing Genebank use in forth coming years. **Dr Sukhwinder Singh**, SeeD-Wheat Pre-breeding In-Charge and Convener of satellite session, presented research accomplishments and impact of wheat pre-breeding in Mexico and India. **Dr Anthony Hall**, Professor in Genetics, University of Liverpool, explained the role of genomics in Genebank use. **Dr Gilberto Salinas**, CIMMYT, Mexico, presented capacity building work performed as part of the CIMMYT's SeeD project in Mexico.

Speakers from UK, Mexico and India presented achievements of CIMMYT's SeeD project work, progress and impact of wheat pre-breeding in India and Mexico, role of high density genomics in wheat pre-breeding as well as capacity-building work done through SeeD project support. They also gave valuable suggestions for future work and emphasized the use of high density genomics for wheat pre-breeding, especially in understanding genetics of trait prior to incorporation in pre-breeding pipeline. BBSRC, USAID and ICAR advocated for impact through increasing partnership and strengthening downstream research work. Overall, this satellite session was well perceived and highly appreciated by the audience. Audience unanimously advocated the strengthening of the ongoing wheat pre-breeding work in developing countries through leveragine sources, enhancing partnerships and focusing towards an impact oriented approach. Session Chair and Convenor greatly acknowledged Mexican government for their investment in CIMMYT's SeeD project; aiming towards harnessing Genebank for food security.

Panel Discussion

Eleven panellists participated in this session and presented their views, as follows:

Prof. B.S. Dhillon, VC**,** PAU, India: Green revolution had an impact due to a number of factors, but the basic was germplasm strength. Elite × Elite crosses have strength world-wide, including India, USA and other countries but considering climate change, change in cropping/farming pattern and other emerging needs, we should look beyond elite germplasm *i.e.* Exotic × Elite crosses (pre-breeding). He also talked about importance of Karnal Bunt disease in wheat pre-breeding initiatives.

Dr N.N. Singh, Secretary, TAAS, India, appreciated CIMMYT's wheat pre-breeding

Dr N.N. Singh

efforts under the SeeD-wheat project. He mentioned that system change is dynamic, and demand is changing and hence bottoms-up approach is required. Collecting on-farm diversity, and close association of farmers with breeders in wheat pre-breeding should be fruitful. Involvement of rural youth and women on a large scale would be instrumental in the process.

Dr R.K Singh, Former Country Representative, IRRI, Philippines, emphasized that pre-breeding program is very important for eastern India. Climate change is prominent in eastern India, and this is the reason why more genetic variation in crops of the farmer's field is needed. Broadening of cultivated wheat gene pool through pre-breeding is urgently required. He quoted an example from rice, *Sahbhagi dhan,* which came out from the similar approach, and has had a significant impact in rain-fed regions of the eastern India.

Dr Steve Visscher, BBSRC, UK: As a funding agency representative, he emphasized that there is need for partnership with the NARS in target ecosystems. It is important for SeeD scientists to convince donors on "how investment will have impact at farmers' fields". He finally mentioned the three challenges of SeeD project: (i) convey the work of SeeD project in layman words; (ii) what are the impacts of SeeD work on breeding programs, and (iii) what are the real potentials and practical impacts of SeeD. Overall, Steve suggested channelizing Seed-Wheat investment for impact at the farmer's field level.

Ms Lisa Wilson, USAID, USA, drew attention to commanalities between mandates of the USAID and SeeD projects. She stressed on increasing partnership in low and middle income countries for a wider impact of the SeeD-Wheat project, for example Bangladesh in South Asia and also in African countries.

Dr Pawan Kumar Agrawal, ICAR, India, spoke on the need to have utmost clarity before a scientist goes to funding agency about 'how to deliver impact at the farmer's field level'.

Dr Kuldeep Singh, ICAR-NBPGR, India: He focused on criticism of breeders that "biotechnology is taking money from breeding" According to him biotechnology is helping in Genebank use for wheat pre-breeding. He quoted examples of wheat landrace core formulation by the NBPGR, as well as Mexican landrace core development in SeeD-Wheat project using high-density genomics approach.

Dr Ravi Singh, CIMMYT, Mexico, drew attention to the fact 'in plant breeding, when you bring something good, you also bring bad things'. Therefore, there is a great need to understand the genes underlying different traits. He said we should decode the genetics, then mine genes carefully to avoid one step forward, two steps back approach of conventional breeding. He suggested taking extra care while doing wheat pre-breeding in the SeeD-Wheat project.

Dr Gurdev Kush, University of California, Davis, USA, suggested utilising all possible technologies in an intelligent fashion for developing pre-breeding germplasm. His contribution of the classical variety 'IR64' in rice, was developed through a similar approach.

Dr Sanjay Rajaram, RSM, Mexico: He mentioned that the program was very well presented, including integration of students. However, he enquired for a possible role for old cytogenetics tools in bringing diversity - translocations. Dr Rajaram suggested utilization of cytogenetics tools and also incorporating "red grain × white grain" crosses in the SeeD-Wheat pre-breeding work for widening of gene pool.

Dr Nagendra Kumar Singh, ICAR-NRCPB, India, emphasized that it is important to break unwanted linkage of gene(s)/QTL(s)/traits with desirable ones prior to pre-breeding. As an

example, in rice an unholy linkage between drought QTL (*qDTY*$_{1.1}$) and green revolution gene (*sd1*) has been broken and semi-dwarf genotypes have been developed which are being utilized in broadening of genetic base. Similar efforts need to be followed in wheat pre-breeding process, and genomics approaches can efficiently help in this regard.

Recommendations - Satellite Session 1: Harnessing Biodiversity for Food Security and Sustainable Development

- *Wheat pre-breeding* work has a significant role, in the era of changing climate and demand pattern, in ensuring food security in the developing countries, including India; ongoing pre-breeding efforts in SeeD-Wheat project component should be scaled up for a wider impact.
- *Partnership between CIMMYT and NARS of the developing countries* need to be developed on priority for pre-breeding in order to secure future funding as well as to deliver at the farmers' field.
- *Participatory approach with greater involvement of farmers and students* need to be ensured for leveraging greater impact and for capacity building. In the process, gender inequality should be specially taken care of.

Satellite Session 2: Agrobiodiversity for Nutrition and Health

This satellite session was organized jointly by Bioversity International, National Institute of Nutrition and the United Nations University. The session was Chaired by **Dr Soumya Swaminathan,** DG, ICMR, India. Convenors for this session were **Dr T. Longvah,** Director, National Institute of Nutrition, and **Dr M.S. Suneetha,** United Nations University. The main objective of the session was to deliberate on mainstreaming agrobiodiversity into programs and policies to improve food and nutrition security and health. It aimed to review agriculture, nutrition and health policies for enabling environment to mainstream agrobiodiversity. Discussions were held on the following two themes:

Dr Soumya Swaminathan

1. **Agrobiodiversity, health and nutrition -State-of-the-art**: To highlight both quantitative and qualitative studies of food composition, dietary intake, new methodologies, documenting indigenous knowledge and local availability of agrobiodiversity.
2. **Mainstreaming agrobiodiversity into programs and policies to improve food and nutrition security and health**: To illustrate, with examples, integration of agrobiodiversity into programs (such as integrated home gardening and other agriculture approaches) to improve nutrition and health as well as integration of agrobiodiversity into social safety net schemes, and of locally sourced foods into school feeding or other programs.

Presentation of Dr Gina Kennedy, Bioversity International, Rome, was made in absentia by **Dr Stephen Weise**, DDG, Bioversity International, Rome, on *'Rediscovering our Future: How Neglected and Underutilized Biodiverse Foods can Nourish the Planet'* . It indicated that the nutrition community has refocused on ending malnutrition in all its forms. This includes problems of 'hidden hunger' and diet-related chronic diseases. Many of the world's nutrition and health problems are associated with diet. Most meals around the world are bland, starchy staples with only small amounts of vegetables, with little to no protein. They lack in important micronutrients, vitamins and minerals. Low intake of fruits and vegetables and whole grains are now the leading cause of global death and disability, particularly child and maternal malnutrition. There is no one size fits all solution to a healthy diet, as it depends on many factors, including age, culture and geography. It was mentioned that while we are concerned about food security for a growing global population, nutritional insecurity is equally serious. Research suggests that we need to invest much more in cultivating agricultural biodiversity (fruits, vegetables, nuts and seeds) rather than investing more in grain, fish, and meat - where major CGIAR programs and national programs are focusing. We need to promote uptake of scientific evidence, diversified production, value-chains and markets, enabling policies and consumer demand. Research has shown considerable nutrient variations between varieties of the same species. Highlighting some of the examples, including the large-scale screening of banana genepool by Bioversity International and partners, and confirmed substantial variability in levels of provitamin A in banana cultivars (from zero up to 8.5µg). Bioversity International is working in banana-based systems in Eastern Africa to promote uptake of provitamin A carotenoid among communities vulnerable to vitamin A deficiency.

In conclusion, some action points mentioned were: (i) informed public policies on food and nutrition (*e.g*. generate food composition data for >150 species of nutritional importance) and (ii) raising awareness and consumer demand for traditional varieties (*e.g.* food fairs, gastronomy workshops, school programmes, food markets). She also mentioned that nutritious and drought resistant millets were once part of traditional Indian diets. Now that India's Food Security Act-2013 adds millets into public distribution system, plans should be to add millets in school lunches, on menu in restaurants and sold on the streets. It was observed in Zambia that documentation of traditional recipes, increased awareness, local pride and motivation to produce and consume local, nutrient-rich foods.

Dr T. Longvah, National Institute of Nutrition, India, spoke on *'Agrobiodiversity and Wild Foods for Improving Nutrition, Health and Well-being'*. He highlighted seriousness of iron deficiency anaemia, vitamin D deficiency and subclinical Vitamin A deficiency as the silent epidemics of micronutrient deficiencies, and pointed out that solution lies in the dietary diversity through biodiversity in food systems, including fermented/processed foods, uncultivated wild foods, garden crops, cultivated cereals, wild game animals, animal source foods, variety of insects, fresh water river fish, crab, frog, snail, etc. Significance of micronutrient rich indigenous millets, carotenoid rich wild green leafy vegetables and wild fruits, and protein rich mushrooms, animals and insects inhabiting

Dr T. Longvah

agro-ecosystem was narrated. This is evident in the strikingly superior nutritional status, lower prevalence of NCDs among the Chakhesangs tribe of Nagaland, as compared to the rest of India. He concluded that native-food based strategies were the key to address hunger and malnutrition and for determining nutritional and health protecting properties of indigenous foods for using them in nutrition intervention strategies.

Dr Satoru Muranaka, JIRCAS, Japan, presented efforts in West Africa on *'Harnessing Traditional Foods for Nutrition and Health'*, and described how traditional crops and foods hold great potential to bolster livelihoods, nutrition and health. He mentioned succinctly critical roles of traditional crops in: (i) enhancing resilience of the system by diversifying cropping system and conserving soil and soil fertility; (ii) taking care of nutrition and health status by

Dr Satoru Muranaka

reducing food importation, broadening food base and enhancing nutritional status; and (iii) improving quality of life by meeting regional demands/cultures as well as increasing household cash income. In spite of so many advantages, there has been a low level of investment to fully utilize the potential of these crops. Through the example of EDITS-Cowpea (www.jircas.go.jp/en/database/edits-cowpea/introduction), he identified the necessary basic information and evaluation tools to popularize native crops such as: (i) key traits for better utilization; and (ii) identifying genetic material that has the target key traits.

Dr Jitendra Kumar, ICAR-DMAPR, India, made presentation on *'Medicinal Plants Diversity for Health, Wellness and Livelihood in Indian Perspective'*. Diverse climatic zones of India (tropical, sub-tropical, temperate, alpine) meant that great number of medicinal plant species thrive in India, especially, in Western and Eastern Ghats and North-East states. Medicinal plants are used in India in traditional preparations, herbal teas, and galenicals. They are also used as health food, phyto-pharmaceuticals, intermediates for drug manufacturing, industrial and pharmaceutical auxiliary products as well as for developing new drugs. The Indian flora has about 17,500 plant species. Tribal communities have the knowledge to use about 8,000 spp. for medicinal purpose. Records show that 900 spp. are used in *Ayurveda*, 700 in *Unani,* 600 in *Siddha*, 250 in *Tibetan* and as few as 30 spp. in modern medicines. In India, 80% supply of raw drugs (319,500 MT annually) comes from wild. On the other hand, 134 species are cultivated and 160 are partially cultivated. Global market for medicinal herbs in 2050 would be worth USD 5,000 billion. He elaborated on individual medicinal plants and their uses. He concluded that industry is facing shortage of raw material, and the major factors are habitat loss and degradation, excessive nutrient load, over exploitation, unsustainable use, invasive alien species, *etc*.

Dr Jitendra Kumar

Dr S. Subananthan, a farmer and traditional Siddha healer from the Tamil Nadu Parampariya Siddha Vaidhya Maha Sangam, Tamil Nadu, gave a practitioner's perspective on *'Community Health and Nutrition'*. He introduced *Siddha* principle of health and nutrition to be 'food is medicine and medicine is food'. He elaborated on the Healers' network, Healers' exchange, home herbal gardens, participatory program for documentation, assessment and promotion of local health traditions, training programs for tribal communities and education program for children, health camps, especially anaemia program, and Accreditation and Certification of Prior Learning (ACPL). Anaemia program began with participatory documentation workshop of 24 local health tradition-based recipes used by 11 folk healers and three knowledgeable women. As many as 41 ingredients (based mainly on plant products, milk products, honey and jaggery) identified were fruits or vegetables, or edible food items. Multiple recipes were documented for these ingredients. It was stressed that native landraces and breeds are essential for preparations. He concluded that there is an urgent need for inter-generational learning of *parampara* (tradition) and conservation by practice.

Dr Veena Gupta, ICAR-NBPGR, India, presented a case study carried out in seven villages in Chamba district of Himachal Pradesh, India through participatory approach entitled *'Curative Agrobiodiversity and Indigenous Knowledge: Case Studies on Conservation through Farming Communities'*. Her team found that 29 species were extensively used in home remedies, while nine species were collected for marketing. Community members prepared multiple home remedies to treat infections of eye, stomach and skin, fever, rejuvenation of hair, mind and body vigour, and as a cure for diabetes and impotency. Species mainly used were *Trillidium govanianum (nag-chatri), Paris polyphylla (shiv-joda), Podophyllum hexandrum (bankakri), Voila serpens (banfsha), Aconitum heterophyllum (ateesh), Dactylorhiza hatagirea (salem panja) and Morchella esculenta. (guchchhi)*. Veterinary ailments were treated using *Angelica glauca (chora), Podophyllum hexandrum (bankakri)* and *Artemisia vulgaris (chammra)*.

Dr V.K. Vikas, ICAR-IARI-Regional Station, Wellington, India, gave a talk on *'Triticum dicoccum*: *A Low Glycaemic Index (GI) Food for the Diabetics'*. Emmer wheat is known locally as *Samba* (Tamil Nadu), *Jave*, *Sadaka* (Karnataka), *Khapli* (Maharashtra), *Popathiya* (Gujarat), *Farro* (Italy). Compared to rice (GI>70) and bread wheat (GI=55-69), *T. dicoccum* wheat has GI>55. Landraces and old varieties produce high quality grains but are tall, lodging, and low yielders. Popularizing *emmer* cultivation among farmers requires development of semi-dwarf, high yielding with high quality *dicoccum* varieties, NP 201 was gamma-irradiated, and a stable semi-dwarf (20% height reduction) and high yielding (35% increase) M5 line was developed and released as variety HW1098.

Ms Julia Boedecker, Bioversity International, Kenya, reported achievements of work on *'Participatory Approach to Improve Dietary Diversity in Vihiga County, Western Kenya'*. Her study included a diagnostic phase (data collection on agrobiodiversity, nutrition practices, anthropometry and dietary intakes), a participatory development of activities phase (community workshops) and a participatory implementation phase. Vihiga county is rich in local food biodiversity with 67 cultivated and 38 wild edible plant species. But only 75% of the children and 45% of the women meet minimum dietary diversity leading to 28% of the children affected by stunting. It was concluded that only a community-based participatory approach has the potential to diversify diets through agrobiodiversity in Western Kenya.

Dr K.T. Hoang, Health Bridge Foundation of Canada and Bioversity International presented

work on *'Linkage between Child Nutrition and Agrobiodiversity, Gender Role in Home Gardening in North West of Vietnam'*. Nutrition security for children in highland ecosystems faces a reduction of nutrient-rich species often due to changing gender roles in agriculture. Home garden is one optimal approach to enhance nutrition and food security. A study across 177 households of the North West Vietnam showed that higher species diversity from home-gardens with full involvement of both parents led to higher child dietary diversity score.

Dr T.R. Suma, MSSRF Community Agrobiodiversity Centre, India, presented a case study carried out in Wayanad, Kerala on *'Micro Level Politics of Land Use Impacts Agrobiodiversity and Rural Food and Nutritional Security*. A 60-year time line analysis was performed on changing food baskets of three tribal communities - *Paniya* (landless agricultural labourers), *Kuruma* (landed agriculturalists, individual land ownership, fragmented land), and *Kurichya* (landed agriculturalists with joint ownership of land and farming). It was observed that diversity of food baskets (mainly leafy greens, fruits and vegetables) shrunk by 67%. *Paniya* community lost 90% diversity (owing to degradation and inaccessibility of common land), *Kuruma* community lost 65% diversity (owing to government policies on PDS and ecosystem degradation) and *Kurichya* community lost 48% diversity (owing to ecosystem degradation). The study indicated lack of land ownership, access to biodiversity; power to take decision on land use; health of ecosystems and the agroecological landscapes as deciding factors for diversity of food baskets. She concluded that "Right to food comes with food sovereignty".

Dr Suneetha M. Subramanian, UNU, presented on *'Biodiversity, Traditional Knowledge and Community Health'*, focussing on the knowledge part. Out of 50,000 plants used as medicine, 3.000 are traded and 21% are endangered. Although the traditional knowledge is codified, institutionalized, and available in public domains, level of expertise is heterogeneous; internal methods differ despite underlying epistemological coherence, natural product development is time-consuming and resource intensive, protection of knowledge is complicated due to interculturality. Issues of quality, safety, efficacy, access, and rational use need to be addressed. She concluded that road ahead includes: (i) integrated resource assessment methods; (ii) knowledge validation, research and innovation; (iii) education and capacity building; (iv) inter-sectoral coordination; (v) expanding partnerships; and (vi) linking to development objectives.

Recommendations - Satellite Session 2: Agrobiodiversity for Nutrition and Health

- *Native-food based strategies* to address malnutrition should include raising awareness and consumer demand, enhanced investment, informed public policies, identification of trait-specific germplasm and linking traditional food to all development related objectives.
- *Participatory approach coupled with knowledge validation* should be pursued to diversify diets using agrobiodiversity.
- *Traditional medicinal practices* need to be supported by mitigating threat-factors (habitat loss and degradation, excessive soil nutrient load, over exploitation, unsustainable use and invasive alien species), conservation through use of native landraces and animal breeds, and preserving inter-generational learning of tradition (*parampara*) as well as documentation of traditional knowledge.

Satellite Session 3: Climate Change as an Opportunity for Agrobiodiversity Management in the North-Eastern Region of India

This Session was organized by GIZ, Germany and North-Eastern Hill University (NEHU), India. **Dr Uwe Scholz** of the GIZ CCA-NER project mentioned the purpose for the organization of this session, and introduced all speakers of the session. The session focused on the positive and negative effects of climate change on agrobiodiversity. During the sessions outcome of a bilateral cooperation arrangements between India and Germany on 'Climate change adaptation – North-Eastern region of India (CCA-NER)', being implemented by the GIZ in partnership with Ministry of Development of North Eastern Region, Government of India, in Meghalaya, Nagaland and Sikkim were presented and discussed. Eminent sectoral and thematic experts, who made presentations were as follows.

Drs N Ravindranath, **Saroj Barik**, **Amba Jamir**, **Subhash Ashutosh**, **Werner Kosemund**, **Friedrike Kraemer** and **Luis Waldmuler**, who illustrated effect of scientific intervention on climate change adaptation in the North-Eastern Region, including policy advise, using and conserving water and forests and on agricultural production such as rice, Eri silk, indigenous fish species, *etc*.

Dr Uwe Scholz in his presentation began with the introduction of GIZ as an organization and the CCA-NER project on "Climate Change Adaptation - North Eastern Region (CCA-NER)", which is a bilateral project between the Government of India and the Federal Government of Germany. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, is mandated by the German Federal Ministry for Economic Cooperation and Development (BMZ) to implement technical cooperation in partnership with the Indian Ministry of Development of North Eastern Region (MoDoNER), the lead executing agency at the national level. The Project CCA-NER in Phase 2 is being implemented under the broader framework of the Indo-German Environment Programme – Rural Areas (IGEP-RA). In the North-Eastern Region of India access of 7,000 rural households to food has improved on the basis of resource-saving and climate resilient agricultural practices. The CCA-NER is being implemented in Meghalaya, Nagaland, Sikkim, Mizoram and Arunachal Pradesh. Dr Scholz enumerated some winners and losers as a result of climate change. The Royal Bengal Tiger and Assam Tea were impacted negatively by the climate change while opportunities in coffee in new geographies, Eri Silk in Meghalaya, emerged as positive impact of climate change.

Dr N.H. Ravindranath in his keynote address explained many long-term negative impacts of climate change leading to food insecurity, soil degradation, water scarcity and need for climate change adaptation, especially in vulnerable and fragile regions like the North-East India. He mentioned that prediction of climate variability for the NER would be in the form of delay and long dry spells during monsoon leading to overall low rainfall,

Dr N.H. Ravindranath receiving a memento from Dr Uwe Schloz

unseasonal rainfall during harvest season, floods due to high intensity or excessive rainfall events, excessive heat events, etc. However, there are also many short-term opportunities due to climate change impact such as rice production would be able to benefit due to CO_2 fertilization in some locations and coconut yield is projected to increase with increase in rainfall and relatively less increase in temperatures. He also mentioned that legume-crops such as soybean and groundnut are likely to benefit from increased temperature/CO_2, if water availability is not limited; there is likelihood of increase in soybean yields by 8-13%, groundnut yield by 5-7% compared to current yields. Global climate change may raise production of potato in Punjab, Haryana and Western and Central Uttar Pradesh by 3.46 to 7.11% in about 2030 scenario. Warmer winter could mean feasibility of additional crop, reduced frost damage, increased length of growing period, as well as increased crop yield of potato and other horticultural crops. He concluded that climate change in the long-term would have overall negative impact on agriculture, water resources, biodiversity, oceans, *etc.* However, in the short-term (between 2020 and 2050) it may have many positive implications for some of the ecosystems and crop production-systems.

Dr S.K. Barik from the North-Eastern Hill University, in his presentation *'Changes in Agrobiodiversity and Arising Opportunities in the North-Eastern Region of India'* mentioned that more CO_2 in the atmosphere would boost productivity. He explained how higher levels of CO_2 would stimulate photosynthesis in C3 plants as increased CO_2 tends to suppress photo-respiration. Experiments based on a 50% increase of current CO_2 concentrations confirmed that CO_2 fertilization can increase mean yields of C3 crops by 15% under optimal conditions. C4 plants would also use water more efficiently. He concluded that under moderate change scenario, i.e. RCP

Dr S.K. Barik

2.6, selected species are predicted to gain in climatically suitable areas. However, under harsher scenario *i.e.* RCP 8.5, all species would lose substantially in areas of North-East India. New areas are predicted to become suitable for selected species. Some of the present suitable areas would remain so in the future too.

Drs F. Kraemer and **L. Waldmüller** from the GIZ Headquarters in Germany, co-presented '*Lessons Learned from Planning and Implementation of Agrobiodiversity Measures in Asian (GIZ) Projects'* wherein they elaborated two success stories from China and Timor Leste, *viz*., "Sustainable agro-biodiversity management in the mountain areas of southern China" and "Managing agro-biodiversity for sustainable livelihoods in Timor-Leste". The steps to integrate agrobiodiversity into agricultural practices are - sensitization, agro-biodiversity assessment, group formation, participatory planning, Farmers Field School (FFS) activities, on-farm (*in situ*) conservation, off-farm (*ex situ*) conservation, link to markets, species monitoring and upscaling. They recommended that: (i) ABD conservation should include economic aspect - "use it or lose it"; (ii) ABD activities should be linked with community development initiatives; (iii) FFS should be used as platform for both technical training and internal knowledge exchange; (iv) women be involved in ABD conservation and be considered their traditional knowledge

and needs; and (v) traditional knowledge and cultural aspects of the ABD crops should be used promotion of agrobiodiversity.

Dr Werner Kosemund from the INBAR in his presentation on *'Bamboo in North East India - Importance and New Utilization Opportunities under the Angle of Climate Change and Inclusive Agro-Economic Development'* brought out the importance of bamboo in the NER, as fuel, food, handicraft, housing/ construction, sticks/*agarbatti*, furniture,

Dr Werner Kosemund receiving a memento from Dr Uwe Schloz

boards/flooring, paper and pulp, textiles, *etc*. He listed the constraints in the sector and discussed conditions for success, which may include: (i) professional and strategic guidance and support, (ii) government kick-start and taking entrepreneurship forward, (iii) compliance with needs and requirements of the market, (iv) ease of the technology, and (v) appropriate institutional model and finance scheme and access to information. With the above, INBAR proposed to address strengths and opportunities of the development from resource side and evaluates and tests products from the market side, then equally from product side for the bamboo species *Melocanna baccifera*. The focus would be on producing primary processed bamboo commodities like shoots, pellets, flattened laths, slats and slivers; production of (activated) charcoal, briquettes, biochar, bamboo vinegar; as well as CO_2 neutral bamboo biomass gasifier power units. Some suggestions for capacity development include training and study tours, network of market actors for exchange of experiences and getting up-to-date data and information leading to improved performance. The above would provide ground evidence and facilitate review and updating of the State Bamboo Policy.

Mr Subhash Ashutosh, Department of Environment Forest and Climate Change, Government of Meghalaya, in his presentation on *'Integrating Perception and Traditional Knowledge of Indigenous People of Meghalaya with Climate Model and GIS derived Information for Vulnerability Assessment and Adaptation Actions'* detailed efforts of Government of Meghalaya in looking into the impacts of climate change and its adaptation through a community lens. Government of Meghalaya has made a unique effort to bring traditional knowledge and perceptions as well as high-end climate models into one platform to develop a comprehensive strategy to combat climate change impacts in Meghalaya.

Dr Subhash Ashutosh

Dr Amba Jamir, Sustainable Development Forum Nagaland (SDFN), India, in his presentation on *'Advocacy for Shifting Cultivation in the Context Climate and Beyond'* gave valuable insights into the *Jhum* system

of cultivation in the local context. Two domains were presented *viz*. *jhum* with fallow cycles less than or more than 10 years, and two phases, one agriculture or production phase and one forestry or fallow phase, as well as two lines of opinion - *jhum* as a destructive, primitive, unproductive, unsustainable and *jhum* as a systematic, knowledge based, productive system with crop diversity, strong adaptation and coping mechanisms. His presentation ended with a message that a *jhum* system should be considered as synonymous with life and the institutions for the Naga community.

The discussions brought in fore experiences of several opportunities for agrobiodiversity conservation while adapting to impacts of climate change. The success stories and recommendations on agrobiodiversity conservation through integrated adaptation activities and varied approaches for the same were the major takeaways from this session.

Recommendations - Satellite Session 3: Climate Change as an Opportunity for Agrobiodiversity in the North Eastern Region of India

- *Positive implications of climate change* in the short term (2020-2050) for some of the ecosystems and crop production systems should be studied and exploited (*e.g.* expected enhanced yields of soybean, groundnut, coconut and opening new geographies for cultivation of coffee and Eri silk in NE India)
- *Traditional knowledge and cultural aspects for climate change adaptation* should be documented and used to enhance the positive effects of climate change. For instance, looking at *Jhum* as a systematic, knowledge based, productive system with crop diversity, strong adaptation and coping mechanisms.

Satellite Session 4: Crop Wild Relatives: Back to the Wild to Save the Future

This Session was organized jointly by Bioversity International and the University of Birmingham. The session was co-chaired by **Dr Ehsan Dulloo,** Bioversity International, Italy, and **Dr Bikram Gill,** Kansas State University, USA. The objective in this session was to develop a scientific and policy framework for establishing a global strategy for CWRs conservation and use. Deliberations focused on the CWR as a proven source of genetic diversity for crop improvement and adaptation to climate change, as well as reviewing the inadequacy of current actions for their conservation and use to achieve SDGs. In recent years, several projects and studies across the globe have attempted to document diversity of CWR and for addressing their *in situ* and *ex situ* conservation. Discussions are underway to establish a global network for *in situ* conservation and on-farm management of plant genetic resources for food and agriculture (including CWR), within the framework of FAO Commission on Genetic Resources. It is imperative to develop and implement conservation strategies at the national,

Dr Bikram Gill and Dr Ehsan Dulloo

regional and global level to ensure that these resources are safeguarded. The session aimed at providing a platform for presentation of ongoing research activities, exchange of experiences and promotion of discussion for their policy implications, as a step towards the development of a cohesive network.

Dr J.S. Sandhu, ICAR, India, gave a presentation on *'Utilization of Crop Wild Relatives in the Indian Breeding Programs: Progress, Impact and Challenges*. He recognized importance of CWR globally for breeding high yielding varieties to feed budgeoning population and to combat variety of stresses owning to climate to thrive in a drier, warmer, more variable climate. He mentioned that the Indian gene centre is rich in diversity of domesticated crops- having 168 species out of 2,489 species distributed in 12 regions of diversity of cultivated plants. Among the CWR, 326 documented species have originated and/or developed diversity in different phyto-geographical regions of India. However, a pragmatic exercise by the ICAR-NBPGR to further shortlist and update CWR of 168 native crops, in India, resulted in 817 taxa, belonging to 730 species, including wild/ weedy form(s) or populations of 142 crop species. CWR are crucial for maintaining genetic diversity and their loss may have serious consequences on food, nutrition and environmental security. Nevertheless, use of CWR has been successful only for a few crops. Many genes still lie untapped in CWR, primarily due to lack of useful genetic information as well as genetic bottlenecks. Previously, the crop breeders were struggling with many problems including linkage drag while using CWR in plant breeding. But, the advances in DNA sequencing technology particularly combination of *de novo* sequencing and resequencing are being used efficiently to explore useful genetic variation in CWR and their use in plant breeding. There is need to design altogether new crops, plant types and varieties which can perform well under adverse contemporary environmental conditions. Breeders should be well supplied with genes to be one-step ahead of the rapidly evolving pests and diseases and even the climate regimes. It is natural genetic diversity in CWR taxa and populations that would sustain crop production in future.

Dr J.S. Sandhu

Dr J. Magos Brehm, School of Biosciences, University of Birmingham, UK, presented his work on *'CWR Conservation Planning in the SADC Region'*. He focused on the conservation planning for CWR diversity in the Southern African Development Community (SADC), one of the components of the EU-ACP funded 'SADC Crop Wild Relatives' project. The results of the regional CWR checklist development and prioritization, and the hot-spots as well as the priority sites for *in situ* conservation were shown and discussed. In addition, considerations on how to integrate both regional and national conservation priorities to address conservation of CWR in a holistic manner have been made.

Dr A.R. Contreras Toledo, School of Biosciences, University of Birmingham, UK delivered lecture on *'A Strategic Approach to Crop Wild Relative Conservation in Mega-diverse Mexico'*. CWRs globally and specifically in Mexico are threatened by impacts of climate change, habitat degradation, increasing human population, among other factors.

Since the number of CWRs is large there, creation of a national CWR inventory is the baseline for development of a national CWR conservation strategy. Main procedures for the preparation of a national CWRs inventory were: (i) producing a list of national crop species, (ii) matching crop genera names with the list of national flora to produce a CWR checklist and (iii) prioritizing CWR checklist using selection criteria and a ranking system to produce an inventory for active conservation. The prioritization criteria applied were relative geographical distribution, threat status, socio-economic values of the related crops and level of relationship to the crop, based on the gene pool and taxon group concepts. Using these criteria, 313 priority CWR taxa were selected (about 2% of the national CWR diversity), and these formed the national CWR inventory. These taxa were then used to develop *in situ* and *ex situ* conservation actions, as part of the national CWR conservation strategy.

Dr N.L. Maluleke Mpolokeng Mokoena, National PGR Centre, Department of Agriculture, Forestry and Fishery, Pretoria, South Africa, made a presentation on *'Identification and Collection of Priority Crop Wild Relatives in Three Provinces of South Africa'*. She mentioned that CWR can be a source of genes for food crops, however, researchers have neglected these species and they are becoming more threatened in the wild. The objective of this study was to identify and collect priority CWRs occurring in three provinces of South Africa. Prioritization of CWR process was conducted using criteria such as potential use in crop improvement, socio-economic value, threat and relative distribution, and 292 species were recorded. Field survey was conducted in three provinces (Mpumalanga, Limpopo and KwaZulu-Natal). Thirty-one species were identified in terms of conservation status. Out of these collected species, families with higher number of species in all provinces were Solanaceae (7 taxa) and Poaceae (2 taxa). Species were found in both unprotected and protected areas. Although most of these species occurred in all three provinces across the country, *Oryza longistaminata* was only in one province (Limpopo) in a *wetland in Nylsvley Nature Reserve. KwaZulu-Natal had* significantly high number of 34 localities with Miscanthusjunceus found in 5 of these localities on private land (plantations), compared to Mpumalanga with 18 and Limpopo with 12 localities. Out of the 31 species, 20 were collected along the roadsides, especially in disturbed areas, exposed to threats requiring sufficient attention for conservation.

Dr I. Thormann, Bioversity International, Italy, spoke on *'Re-collection to Assess Temporal Variation in Wild Barley Diversity in Jordan'*.

Dr I. Thormann

Using the Bioversity's Collecting Database as data resource, they identified original wild barley, *Hordeum vulgare* subsp. *spontaneum* samples collected in 1981 in Jordan, and re-collected new samples in 2012 from the same sites. Sample pairs collected from the same 18 sites during both years were genotyped and phenotyped. The data showed increased genetic diversity, reduced population differentiation and maintenance of phenotypic variation. This was an evidence of additional possible response in a CWR exposed to a variable and changing environment. The decrease in differentiation is indicating a generalized increase in seed dispersal among

populations since 1981 owing to intensification of agriculture and grazing. She emphasized that it would be useful to include seed systems and farmers' practices in future studies on genetic erosion in CWR like wild barley, which grow in disturbed and agricultural areas.

Dr Nora P. Castañeda-Álvarez, International Center for Tropical Agriculture (CIAT), Cali, Colombia, talked on *'Crop Wild Relatives in Changing Climates'*. CWRs are the sources of traits and genetic diversity for crop, and plant breeding has immensely benefited from them for developing nutritious plant varieties, as well as biotic and abiotic stresses-tolerant ones. Their use in plant breeding is expected to continue. She mentioned that for effective use, CWRs need to be available to plant breeders and researchers through genebanks. However, large gaps in *ex situ* collections have been identified, highlighting need for conservation on a priority basis. The potential effects of climate change on CWR distributions related to 29 crops were assessed and identified areas where collections can be conserved *ex situ* and also *in situ* conservation. Results suggest that CWR taxa may lose on an average of 20.8% of present distributions, with the wild relatives of potato, finger millet and cowpea being worst affected. Highest value *in situ* conservation target regions include parts of Andes, Central America, the Near East and Northern Australia.

Dr D. Ng'uni, Zambia Agriculture Research Institute, National Plant Genetic Resources Centre, Zambia talked on '*Spatial Analyses of Occurrence Data of CWR Taxa as Tools for Selection of Sites for Conservation of Priority CWR in Zambia'*. He mentioned that partial checklist of 459 CWR species of 29 priority crops has been developed for Zambia. Spatial analyses of occurrence data of 30 priority CWR taxa generated a species-richness map revealing four possible areas with highest number of species in the Northern, Eastern, Lusaka and Copperbelt Provinces of the country. Gap analysis indicated that priority CWR taxa were not actively conserved through both *in situ* and *ex situ* strategies.

Dr N.C. Gupta, ICAR-National Research Centre on Plant Biotechnology, India, made a presentation on *'Exploring the Wilds: Harnessing Genetic Potential for Crop Improvement'*. He said that the CWR are being gradually recognized and taken into breeding efforts in preparing for climate-resilient agriculture. However, the genetic diversity of most of the crop plants has been significantly reduced during the process of domestication and rigorous breeding. The reduction in diversity specifically in Indian mustard has placed a major constraint over the brassica breeder's ability in expanding its cultivation into varying climate and stress conditions. Wild relatives of *Brassica* possess wide genetic diversity with more numbers of adaptive traits of agricultural significance, including seed oil quality and resistance to numerous abiotic and biotic stresses. However, focused efforts for a specific trait to be introgressed into adapted cultivars have been meager. While expedient, this approach has omitted the prospect to test various traits and explore the full potential of wild relatives to counter the imminent challenges appeared in oilseed crop. Finding resistance to stem rot (SR), orobanchae, white rust and alternaria blight, are the major challenges ahead of brassica researchers to curb yield losses. As the resistance source for SR and orobanchae has not yet been found in the existing cultivars, wild relatives of brassica are being explored, including those earlier reported to be resistant to alternaria and other diseases. The present study is expected to yield a germplasm resistant to SR that can be used as donor for introgression into high-yielding mustard varieties.

Dr S.K. Pattanashetti, ICRISAT, India, delivered a lecture on *'Genetic Variability for Nutritional Traits among Wild Relatives of Pearl Millet'*. He mentioned that wide genetic variability was

observed for Fe (20.9 - 325.5 ppm), Zn (21.5 - 86.1 ppm), and protein (8.8 - 23.2%) content in seeds of the CWR of *Pennisetum violaceum* germplasm (319 accessions) belonging to primary genepool of *Pennisetum* conserved at the ICRISAT Genebank, India. A large number of accessions were identified superior to the best controls for Fe (197), Zn (91), and protein (316 accessions). Research is in progress to identify stable sources for developing nutrient dense, broad based, open-pollinated and hybrid cultivars of pearl millet.

Dr J. Phillips, School of Biosciences, University of Birmingham, UK, presented on *'Impacts of a Changing Climate on National Conservation Priorities for Crop Wild Relatives'*. To determine changes owing to climate change, species distribution modelling was used to examine threats of climate change on CWRs in Norway. The results indicated a shift in CWRs distribution from the South to the North, areas of high species turnover in northern Norway and an increase in severity of threat to CWRs. Based on these findings both *in situ* and *ex situ* conservation are recommended, at national level.

Dr Nigel Maxted, School of Biosciences, University of Birmingham, UK, talked on *'Horizon Scanning Exercise for Global Crop Wild Relatives Action for the Short, Medium and Long Term Future'*. He mentioned that conservation budgets continue to be under pressure and specifically, funding for CWR conservation and use has been limited as PGRFA agencies have only recently realised the true value of CWR diversity in crop improvement; therefore there is an urgent need to address conservation before CWR species and genetic diversity are lost. The scarcity of funding makes it imperative to maximize efficiency of conservation expenditure. An activity that helps target expenditure effectively

Organizers of Satalite Session 4

is advantageous, and horizon scanning is a participatory approach for establishing future priorities.

The Satellite Session participants were first asked, issues that they feel need prioritization for CWR conservation and use in the short (0-10 years), medium (11-25 years) and long term (26-50 years). Finally, the participants voted on five issues that each of them supported. The results were as follows:

Short-term Priorities (0-10 years)		Medium-term Priorities (11-25 years)		Long-term Priorities (26-50 years)	
Votes	**Activity**	**Votes**	**Activity**	**Votes**	**Activity**
11	Inventories /checklists	12	Global, regional and national networks for *in situ* CWR conservation	11	Trait specific valuation and use in breeding programmes
10	Trait discovery/pre-breeding				
8	*Ex situ/In situ* conservation and use of major and minor CWR	6	Training/capacity building (taxonomy, GIS analysis, *in situ* management, etc.)	4	Establish and maintain botanic gardens/ Bioversity parks
6	Training in conservation and use in developing countries	4	Pre-breeding and seed conservation	4	Targeted re-sampling of CWR populations
5	Prioritizing CWR based on crops, countries and traits	4	Characterisation and make web-enable data	3	Ensure natural evolution
4	Gap analysis *ex situ/ in situ*	2	Restoration of ecosystems	2	Predictive characterisation of *in situ* population traits
4	Genomic based characterisation	2	Confirm status in original habitats and re-collect		
4	Clarify if farmers use CWR diversity	2	Biosystematic and crossability studies	1	Creation of a new elite cultivars resistant to extreme environments
3	Record CWR indigenous knowledge in wild	1	IUCN threat assessment		
3	Raise public awareness of CWR value	1	Population management regimes		
2	Establish baseline network CWR monitoring sites	1	Genome editing to transfer traits CWR to crops		
1	ELC based collection for *ex situ* conservation				

Recommendations - Satellite Session 4: Crop Wild Relatives: Back to the Wild to Save the Future

- *Creation of CWR inventories* and checklists and trait discovery/pre-breeding should be a short-term high priority.
- *Establishment of global, regional and national networks* for *in situ* CWR conservation should be the medium-term objective.
- *Trait-specific valuation* and use in breeding programs should become long-term goal.

Poster Sessions

Technical Session 1-A: Food Nutrition and Environmental Security - Concurrent Session: Plant Genetic Resources

There were 53 posters representing 64 different organizations from countries such as USA, Italy, Colombia, UK, Uganda and India, including international research organizations like CIAT, United States Department of Agriculture, National Crops Resources Research Institute, University of Bath and University of Birmingham. Posters mainly focused on accessing genetic diversity and environmental security. Topics included: accessing genetic diversity in wild African oil palm germplasm; phytoremediation of heavy metals from polluted water using *Bacopa monnieri*; salient traits in major vegetable crops; winter weeds; conserving millets; genetic diversity and conservation of landraces of *Phaseolus vulgaris*, *Perilla frutescens*, Jack bean, sunflower, aromatic rice, wheat, wild leafy vegetables and leguminous species of North-East India, palm, coffee, sweet gourd, mango, jack fruit, brinjal, rice, pigeonpea, *Vigna*, kala bhat, garden pea, mangrove, oil palm, sunflower, maize and cotton. This session also had posters on utilization pattern of some wild edible plant biodiversity under ethno-agricultural system by the tribals; conservation and propagation of medicinal plant *Rhodiola*; gardening of *Citrus*; effective suberization on sprouting and survival of cactus pear in arid region; studying the genetic viability and interrelationships of total phenolics in coloured radish; agro-morphological variation of *Hibiscus canabinus*; resurrecting brown top millet - an endangered small millet crop in South India; and collecting of major genetic resources of North-East region of India.

Technical Session 1-B: Food Nutrition and Environmental Security - Concurrent Session : Animal, Aquatic, Insect Microbial Genetic Resources

There were 45 posters representing 43 different research organizations of the National Agricultural Research System (NARS) of India (42) and Tanzania (1). Posters focused on food, nutrition and environmental security with reference to animal, aquatic, microbial and plant genetic resources. The key areas were genetic diversity/variability, species diversification, characterization of animals (Kashmir geese germplasm, Teressa goat, indigenous cattle, indigenous dog, buffalo, yak, sheep), aquatics (fishes, crustaceans, mollusks, corals), insects (parasitic Hymenoptera), poultry, microbes (*Colletotrichum falcatum*, arbuscular mycorrhizal fungi, *Rhizobium*, bacteria) and plants (cowpea, fodder species).

Technical Sessions 2A: Conservation Strategies and Methodologies – Concurrent Session: Seed Genebanks

There were 18 posters from research organizations of the NARS of India (5) and an international organization ICRISAT. The posters mainly focused on various aspects of genebank management

and PGR conservation. Most of the studies were on developing strategies and conservation diversity in crops such as food legumes, oilseeds, soyabean and rice. Assessment of recalcitrance in forestry, conservation gaps in CWRs and development of key for identification of *Brassica* spp. were also addressed.

Technical Sessions 2B: Conservation Strategies and Methodologies – Concurrent Session: *In situ* and On-farm Conservation

There were nine posters from research organizations of the NARS of India (6) and Bangladesh (2) including one international organization, Bioversity International (1). The posters mainly focused on various aspects of *in situ* and on-farm conservation of agrobiodiversity. These included assessment of diversity of orchids in Bangladesh, assessment of loss of on-farm diversity due to earthquake in Nepal, community based seed genebank to conserve local crop diversity, selection of best practices for enhancing the use of nutritious small millets in India, developing *Aegilops* identification key characters, *etc.*

Technical Sessions 2C: Conservation Strategies and Methodologies - Concurrent Session: *In vitro,* cryopreservation, and DNA banking

There were 10 posters presented by five research organizations of the NARS of India. The posters mainly focused on protocol development for *in vitro* conservation and *in vitro* cryopreservation of plant species such as *Inula racemosa* (endangered medicinal plant), *Capparis decidua*, *Dahlia, Elletaria cardamomum*, *Fragaria* spp. and *Musa* spp. Related important issues of virus indexing and its eradication using cryotherapy were also highlighted.

Technical Sessions 2D: Conservation Strategies and Methodologies - Concurrent Session: Animal and aquatic genetic resources

There were 15 posters presented by nine research organizations of NARS of India. The posters were on setting conservation strategies and conservation of diversity of domestic animals, indigenous carpine (using *Cauda epididymal* sperms), fishes (endangered musheer and flatfish), pig, *etc*. Other aspects were *in silico* mining of conserved miRNAs, rehabilitation of giant freshwater prawn, salinity tolerance of endangered Canara Peralspot, cryostorage of cell lines from threatened species of Groupers (Serranidae) and issues related to traditional community fishing festivals in Himalayan river in conservation.

Technical Sessions 2E: Conservation Strategies and Methodologies - Concurrent Session: Microbial and Insect Genetic resources

There were two posters from research organizations of India, focussed on diversity of arthropods and analysis of multiple viral infections.

Technical Sessions 3: Adaptation and Mitigation to Climate Change

There were 58 posters representing research organizations of NARS of India (51) and seven from six different countries, namely, Indonesia, Italy, Kenya, Namibia, Nepal and United Kingdom, including an international organization, ICRISAT. The posters were on germplasm enhancement for increasing productivity and use of trait-specific germplasm during unpredictable weather and climate change.

Most of the studies were conducted in cereals (rice, wheat and maize), millets (sorghum, finger millet and pearl millet), oilseeds (groundnut and soybean), pulses (pigeon pea, green gram and cowpea) vegetable (tomato and bean) and cotton. Climate change increases the concern for meeting the demand of ever-increasing population for food, nutrition and clothing. Amongst various methods, development of broad-based population for development of varieties is one of the rational and cost-effective methods to improve resilience in crop species. In addition, identification of crop specific quality traits such as abiotic and biotic stress, nutritional and agronomical characters, would not only add value but also can be used as sources of resistance for crop improvement. Unexpected natural calamities *i.e.* floods, drought, tsunami which caused great loss of agrobiodiversity during the last decade has provoked interest in utilising the germplasm better adapted to such situations. Importance of integrated farming was also highlighted to conquer climate change. Posters related to the animal genetic resources (sheep, cattle and buffalo), fishes (Indian mackerel, sardine) and microbes (rhizospheric bacteria, pseudomonas) also emphasized their tolerance to abiotic stresses and their adaptability and survival under various stresses. Online guide for enhanced use of genetic diversity in crop breeding was also presented, which may be of importance for plant breeders.

Technical Session 4A: Science-led innovations – Concurrent Session: Trait discovery and enhanced use of PGR

There were 111 posters representing 72 different research organizations of the NARS of India (63) and abroad (9) from countries such as USA, China, Kenya, Australia and Bangladesh, including international organizations like CIMMYT, ICRISAT and ILRI. Most posters focused on use of molecular tools and other latest science-led innovations for various applications such as identification/screening/evaluation of germplasm in wheat, cotton, linseed, potato, maize, sesame, brinjal and cowpea; genetic enhancement and pre-breeding in banana, rice, wheat and Indian mustard; development and evaluation of core sets in safflower and wheat; germplasm utilization in physic nut, gourd, vegetables, medicinal plants and durum wheat; diversity analysis and polymorphism surveys in rice, wheat, maize, buck wheat, linseed, tall fescue grass, kalmegh, fababean, soybean, potato, oil palm, *Capsicum*, tobacco, greater yam, sorghum, *Brassica*, jackfruit, *Hyacinth* bean, green gram, Marvel grass and *Cucumis melo*; inbred development in maize; germplasm characterization in sorghum, ashwagandha, sunflower, *Bixa orellana*, maize, *Bougainvillea* and popcorn; distant hybridization in sugarcane, *Solanum*, soybean and *Momordica*; molecular mapping in rice and wheat; genetic profiling in marigold; disease resistance breeding in rice, eggplant, wheat, maize, finger millet, bottle gourd, cotton and *Corchorus*; hybrid development in apple; genic diversity in durum wheat and maize; cryo-conservation of cassava pollen; DNA barcoding in *Nicotiana*, mutagenesis in wheat/rye derivatives, and marker-aided selection in maize.

Technical session 4B: Science-led-innovation –Concurrent session: PGR and Genomics

A total of 38 posters were presented from 29 NARS and three international organizations including QAFFI, Australia; CIMMYT and NARC, Japan. The posters focused on topics related to development and application of genomics tools to understand the genetic diversity in lands races and germplasm collections in agri-horticultural crops such as rice, wheat, pearl millet, *Luffa,* teasel gourd, *Musa*, cotton, linseed; identification and utilization of trait specific markers such as Fe, tocopherol and Zn

content in maize, shell trait in oil palm, tomato leaf curl virus in *Solanum chilense*; allele mining in rice for *Pup1* gene; identification of genomic regions associated with shoot fly tolerance in maize; transcriptome analysis for molecular understanding of grain development adult plant rust resistance in wheat. The topics highlighted the potential of genomics in unravelling the worth of crop genetic resources.

Technical session 4C: Science-led-innovation - Concurrent session: PGR Informatics

A total of 15 posters were presented in this session by 21 institutes from NARS of India (15) and international organizations (6). The posters were on the application of IT tools in germplasm management and utilization. The topics revolved around development of crop germplasm databases, National Rice Resource Database of India, decision support database maize inbred germplasm; DIVA-GIS based diversity analysis in *Abelmoschus tuberculatus,* maize inbred lines*;* web based tools such as PGR map, PGR portal Seridup for accessing germplasm collection related information, digital herbarium of weed seeds; development of software package PGRdup for identification of duplicates in genebank collection, *etc*.

Technical session 4D: Science-led-innovation - Concurrent session: Animal and aquatic genetic resources

In this session, 18 posters were presented by researchers from 17 institutes; 16 from NARS and one from NACA, Bangkok, Thailand. The focus was mainly on the generation of genomic resources and their exploitation in characterizing animal and aquatic genetic resources. Some of the important topics were application of genomics tools in LD (linkage disequilibrium) and haplotype block structure in the Indian milch cattle breeds, association analysis of reproductive traits in goat; generation of genomic resources for hypoxia tolerance in Indian Catfish, SSR marker in catfish and great snakehead, GBS (genotyping by sequencing) based genome wide variation analysis in Indian native cattle, genetic diversity for myostin gene in Marwari goats and Bikaneri camel.

Technical Session 5: Quarantine, Biosafety and Biosecurity Issues

There were 13 posters from 14 different research organizations of the NARS of India (11) and Sri Lanka (3). Posters related to quarantine, biosafety and biosecurity with respect to plant, microbial, insect, aquatic and animal genetic resources. The key areas were biosecurity concerns, invasive pests, diagnostics for pests of quarantine significance, and capacity-building for living modified organisms.

Technical Session 6: IPRs, ABS and Farmers' Rights

There were 14 posters representing 15 different research organizations of the NARS of India (12) and one each from China, Italy and Nepal. They focused on benefit sharing under the ITPGRFA, global conservation status of Indian germplasm, germplasm exchange from India, identification of cultivars using DUS, chemotaxonomical methods, initiatives for enhancing access and benefit sharing, IPR issues, registration of varieties in India and access and benefit sharing in South West China.

Technical Session 7: Partnership, Network and Capacity Building

There were 11 posters representing 12 different Indian research organizations. The posters focused on refined action plan for effective

management of PGRFA - an internationally accepted framework for effective management of PGR; Ecotourism through agroforestry: -a potential to secure the growing food insecurity by diversified nature of agroforestry giving enhanced farm production and income; startups in remote areas can help to validate access and develop the ideas of business concepts; National Herbarium of Cultivated Plants: a resource for study of crop gene pools; joint forest management and building partnership with farming communities for community management mechanisms in crop diversity; management of fish germplasm resources; informing the debate in GM food in India; effective use of germplasm resources of *Musa* spp.; empowering farming community to conserve traditional varieties; information sources and utilization behavior of vegetable growers in Rajasthan.

Satellite Session 1: Harnessing Biodiversity for Food Security and Sustainable Development

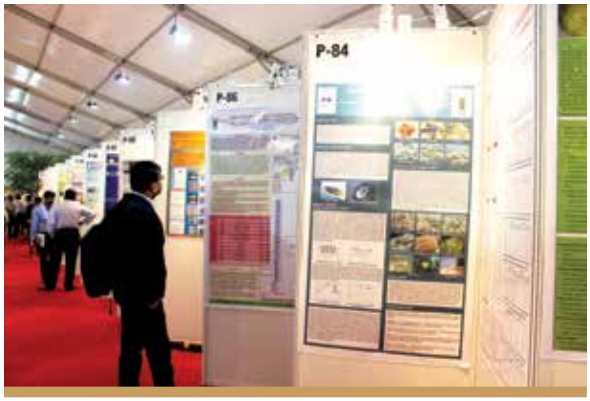
This session included three posters on wheat, in which importance of PGR management was presented. The demand of wheat in developing countries is anticipated to increase by 60% by 2050, thus necessitating increase in production with climate change in forthcoming decades. Although, enough germplasm is available with various genebanks, but identification of sources of resistance and its validation is very important for better utilization. The various groups working on wheat need to come together to share the existing information for proper identification of gaps and thereby developing future programmes. The Seeds of Discovery (SeeD*) is a multi-project initiative, providing* a platform for characterizing and utilizing maize and wheat genetic resources, with lessons that can be applied to other crops, and is funded by Mexican government. Under this, pre-breeding programme is being strengthened to bridge the germplasm that is already being evaluated by breeders in Mexico and India and in future will extend to other African countries. SeeD project is an evolving model for the benefit of global public which is working mainly on conducting workshops, online training modules, graduate student mentorship and visiting scientist research projects. Such programs need to be developed/strengthened for other major crops to contribute and satisfy the nutritional challenges of growing population.

Satellite Session 2: Agrobiodiversity for Nutrition and Health

There were 30 posters from research organizations of NARS of India (25) and abroad (5) from countries, namely, Italy, Kenya, Malaysia, Nepal and Vietnam. Importance of home/kitchen gardens were considered as good practice for small-holders, livelihood and to promote household consumption of quality and diverse foods resulting in better household nutrients. Curative agro-biodiversity (including all components of diversity at all levels) along with local knowledge and cultural practices, leading to sustainable health security requires to be validated and strengthened for its utilization. Lack of dietary and nutrient-diversity is the main cause of malnutrition prevalent in developing world. The importance of major micronutrients, protein, starch, fats, carbohydrates are studied to control various diseases such as diabetes, blood pressure and malnutrition, *etc*. The power of antioxidants from some traditional plants for the improvement of health was discussed. Gluten-free wheat for people with celiac disease, an auto-immune disorder was also suggested. The role of anti-nutritional factors, dietary polyphenols *etc*. for management of various health related issues were discussed.

Satellite Session 4: Crop Wild Relatives: Back to the Wild to Save the Future

There were 11 posters in the session representing NARS organizations of India (9), Mauritius(1) and UK (1). The focus was on prioritization, survey and collection, and conservation of wild species. Other aspects included genetic diversity analysis (in *Hevea* and yams), use of CWRs in India and Mauritius, and impact of climate change on conservation priorities at the national level.



A Poster Award Committee was constituted to judge best posters in each theme. Members of the Committee were: (i) **Dr K.S. Varaprasad**, Ex-Director, IIOR, Hyderabad, (ii) **Dr Bart Panis**, Bioversity International, Rome, (iii) **Dr Arjava Sharma**, Director NBAGR, Karnal, (iv) **Dr V.V. Belvadi**, Professor Entomology, UAS, Bengaluru, (v) **Dr Anil K. Saxena**, Director, NBAIM, Mau, (vi) **Dr S. Uma**, Director, NRC Banana, Trichi and (vii) **Dr K.K. Lal**, Director, NBFGR, Lucknow. The session-wise results of categories of awards are as follows:

IAC 2016: Poster Session Results

Poster No.	Abstract No.	Title of Poster	Authors	Affiliation of presenting author	Session	Award Category
P-22	426	Crop Diversification in Coffee Based Agroforestry Ecosystem for Sustainable Farm Income-planter's Experience	**Rudragouda**, C. Babou, G.F. D'Souza, A.N. Manjunath, Y. Raghuramalu and B.T. Hanumanthu	Central Coffee Research Institute, Chickamagaluru Dist. Karnataka, India	Technical Session 1-A: Food Nutrition and Environmental Security Concurrent Session: Plant Genetic Resources	Best Poster Award
P-43	1282	Role of Food Habit of Tai Phake Community in the Buildup of Local Biodiversity in Assam	**Mridula Saikia Barooah** and Barnali Mahela	Departmet of Food Science and Nutrition, College of Home Science, Assam Agricultural University, Jorhat, Assam, India	Technical Session 1-A: Food Nutrition and Environmental Security Concurrent Session: Plant Genetic Resources	Best Poster Award
P-124	1089	Methods and Best Practices for Enhancing the Use of Nutritious Small Millets in India	**Israel Oliver King** and Stefano Padulosi	M.S. Swaminathan Research Foundation, Tamil Nadu, India	Technical Session 2-B: Conservation Strategies and Methodologies Concurrent Session: In-situ and On-farm Conservation	Best Poster Award
P-178	1185	Impact of Climate Change on Crop Productivity in Long Term Experiments in India	**Muneshwar Singh** and R.H. Wanjari	AICRP on LTFE, ICAR-Indian Institute of Soil Science, Nabibagh, Bhopal, India	Technical Session 3: Adaptation and Mitigation to Climate Change Common Session	Best Poster Award
P-229	682	Development of Wheat Genetic Stocks Imparting Resistance to Ug99 Pathotypes	**Hanif Khan**, S.C. Bhardwaj, P. Prasad, O.P. Gangwar and Subodh Kumar	ICAR-IIWBR Regional Station, Shimla, India	Technical Session 4-A: Science-led Innovation Concurrent Session: Trait Discovery and Enhanced Use of PGR	Best Poster Award
P-276	1470	Scouting New Sources of Rust Resistance and Various Traits Contributing to Yield in Wheat (*Triticum aestivum*) Germplasm	**Sukhmani Singh**, Kanwaljit Rana, Achla Sharma, Puja Srivastava, Jaspal Kaur, Jyoti Kumari and N.S. Bains	Department of Plant Breeding and Genetics, Punjab Agricultural University, Ludhiana, India	Technical Session 4-A: Science-led Innovation Concurrent Session: Trait Discovery and Enhanced Use of PGR	Best Poster Award
P-322	1245	Identification of SSR Markers Linked to Short Stature of Oil Palm (*Elaeis guineensis* Jacq.)	B. Kalyana Babu, **R.K. Mathur**, G. Ravichandran and P. Naveen Kumar	ICAR-Indian Institute of Oil Palm Research, West Godavari (Dt), Andhra Pradesh, India	Technical Session 4-B: Science-led Innovation Concurrent Session: PGR and Genomics	Best Poster Award

Poster No.	Abstract No.	Title of Poster	Authors	Affiliation of presenting author	Session	Award Category
P-355	652	PGRdup – An R Package to Facilitate Discovery of Probable Duplicates from Plant Genetic Resources Collections in Genebanks	**J. Aravind**, J. Radhamani, Kalyani Srinivasan, B. Ananda Subhash and R.K. Tyagi	Division of Germplasm Conservation, ICAR-National Bureau of Plant Genetic Resources, New Delhi, India	Technical Session 4-C: Science-led Innovation Concurrent Session: PGR Informatics	Best Poster Award
P-399	280	Cashew Germplasm Exchange: Problems and Prospects	**G.S. Mohana**, M.G. Nayak and P.L. Saroj	ICAR-Directorate of Cashew Research, Puttur, Dakshina Kannada, Karnataka, India	Technical Session 6: IPRs, ABS and Farmers' Rights	Best Poster Award
P-419	1629	Empowering Farming Community to Conserve Traditional Varieties	**Preeti Mamgai** and Ashish Murai	ICAR-ATARI, Zone-I, Punjab, India	Technical Session 7: Partnership, Network and Capacity Building	Best Poster Award
P-430	1014	Underutilized Medicinal Plants of Sikkim for Health	**K.C. Bhutia**, S.O. Bhutia, A. Pariari and R. Chatterjee	Dept. of Spice and Plantation Crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, India	Satellite Session 2: Agrobiodiversity for Nutrition and Health	Best Poster Award
P-456	1433	Genetic Diversity Analysis of Wild Yams in India	**Irfa Anwar**, M.N. Sheela, K.I. Asha , Athira Jyothy, B.S. Prakash Krishnan and P.V. Abhilash	ICAR-Central Tuber Crops Research Institute, Sreekariyam, India	Satellite Session 4: Crop Wild Relatives - Back to the Wild to Save the Future	Best Poster Award
P-16	277	Wild Leafy Vegetables of North Eastern Hill Region of India: Diversity and Domestication Potential	**Soyimchiten**, K. Pradheep and Anjula Pandey	ICAR-National Bureau of Plant Genetic Resources, New Delhi, India	Technical Session 1-A: Food Nutrition and Environmental Security Concurrent Session: Plant Genetic Resources	Best Poster Award - Consolation
P-99	1922	Improved Facilities and Methodologies for Regenerating Unadapted and Wild Groundnut Germplasm at ICRISAT Genebank	**D.V.S.S.R. Sastry**, Hari D. Upadhyaya and V. Rameshbabu	International Crops Research Institute for the Semi-Arid Tropics, Genebank, Patancheru, India	Technical Session 2-A: Conservation Strategies and Methodologies Concurrent Session: Seed Genebanks	Best Poster Award - Consolation
P-127	1193	Evaluation of Germplasm of and Standardization of Propagation Techniques of *Inula Racemosa* Hook.F. : An Endangered Medicinal Crop of North Western Himalayas	**Bhupender Dutt**, Harpal Singh, K.R. Sharma and S.S. Sharma	Department of Forest Products, College of Forestry, Dr YS Parmer University of Horticulture and Forestry, Nauni-Solan Himachal Pradesh, India	Technical Session 2-C: Conservation Strategies and Methodologies Concurrent Session: In vitro, Cryo, and DNA Banking	Best Poster Award - Consolation

Poster No.	Abstract No.	Title of Poster	Authors	Affiliation of presenting author	Session	Award Category
P-200	1779	Collection, Documentation and Conservation of Local Maize Germplasm of Tribal Areas of Madhya Pradesh, India	**Kiran B. Gaikwad**, Divya Ambati, G. Rama Prashat, Abhinav Saha and Raj Gupta	Division of Genetics, ICAR-Indian Agricultural Research Institute, New Delhi, India	Technical Session 3: Adaptation and Mitigation to Climate Change	Best Poster Award - Consolation
P-218	506	New Vistas for Utilizing *Saccharum* Complex through Distant Hybridization for Diversification of Sugarcane Agriculture as well as Industry	**Sanjeev Kumar**, P.K. Singh and J. Singh	ICAR-Indian Institute of Sugarcane Research, Lucknow, Uttar Pradesh, India	Technical Session 4-A: Science-led Innovation Concurrent Session: Trait Discovery and Enhanced Use of PGR	Best Poster Award - Consolation
P-300	1632	Trait-specific Genetic Resources of Leafy Vegetables for Conservation and Utilization	**C.D. Pandey** and S. Pandey	ICAR-National Bureau of Plant Genetic Resources, New Delhi, India	Technical Session 4-A: Science-led Innovation Concurrent Session: Trait Discovery and Enhanced Use of PGR	Best Poster Award - Consolation
P-323	1314	Development of A and B Genome Specific Markers in Banana	**S. Backiyarani**, S. Uma, G. Tharani, P. Durai and M.S. Saraswathi	ICAR-National research Centre for Banana, Trichy, Tamil Nadu, India	Technical Session 4-B and C: Science-led Innovation Concurrent Session: PGR and Genomics	Best Poster Award - Consolation
P-387	1207	Identification of High-Risk Agro-Ecological Regions Using Species Distribution Modeling	**C.S. Kariyawasam**, H.K. Kadupitiya, R.S.S. Ratnayake, R.M.C.S. Ratnayake and A.K. Hettiarchchi	Ministry of Mahaweli Development and Environment, Colombo, Sri Lanka	Technical Session 5: Quarantine, Biosafety and Biosecurity Issues	Best Poster Award - Consolation
P-406	1646	Access and Benefit Sharing of Marine Genetic Resources in Areas beyond National Jurisdiction for Sustainable Conservation	**Poonam Jayant Singh** and Atul Kumar Tiwari	ICAR-National Bureau of Fish Genetic Resources, Lucknow, India	Technical Session 6: IPRs, ABS and Farmers' Rights	Best Poster Award - Consolation
P-11	134	Characterization and Evaluation of Jack bean [*Canavalia ensiformis* L. (DC)], an Underutilized Wild Legume collection from Peninsular India	**N. Sivaraj**, S.R. Pandravada, V. Kamala and B. Sarath Babu	ICAR-National Bureau of Plant Genetic Resources, Regional Station, Hyderabad, India	Technical Session 1-A: Food Nutrition and Environmental Security Concurrent Session: Plant Genetic Resources	Best Poster Award - Consolation

Poster No.	Abstract No.	Title of Poster	Authors	Affiliation of presenting author	Session	Award Category
P-220	536	Assessment of Genetic Variability of Wheat Landraces from North-western Himalaya and their Differential Resistivity to *Sitophilus oryzae* L.	**Kuldeep Tripathi**, Gayacharan, Padmavati G. Gore, Sundeep Kumar and Shashi Bhalla	ICAR-National Bureau of Plant Genetic Resources, New Delhi, India	Technical Session 4-A: Science-led Innovation Concurrent Session: Trait Discovery and Enhanced Use of PGR	Best Poster Award - Consolation
P-81	1494	Microbial Inoculants Modulated Plant Growth Promotion and Nutrient Uptake in Chickpea (*Cicer Arietinum* L.)	**Renu**, Upasana Sahu, Munish Kumar, Udai Bhan Singh, Pramod Kumar Sahu, Manish S. Bhoyar, Hradesh Kumar and Rajiv Kumar Singh	ICAR-National Bureau of Agriculturally Important Microorganisms, Kushmaur, Maunath Bhanjan, India	Technical Session 1-B: Food Nutrition & Environmental Security Microbial Genetic Resources	Best Poster Award - First
P-72	1212	Isolation and Characterization of Plant Growth Promoting Microbes from Rhizospheric Soil of Chickpea (*Cicer Arietinum*)	**Sangeeta Pandey**	Amity Institute of Organic Agriculture, Amity University, Sector 125, Noida, Uttar Pradesh, India	Technical Session 1-B: Food Nutrition & Environmental Security Microbial Genetic Resources	Best Poster Award - Second
P-77	1410	A Comprehensive Study of Simple Sequence Repeats (SSRs) from the Genome of the *Exiguobacterium Profundum* PHM 11	**Alok K. Srivastava**, Ruchi Srivastava, Anjney Sharma, Anchal K. Srivastava, K. Pandiyan, Hillol Chakdar, Prem L. Kashyap, M. Kumar and Anil K. Saxena	ICAR-National Bureau of Agriculturally Important Microorganisms, Kushmaur, Mau, Uttar Pradesh, India	Technical Session 1-B: Food Nutrition & Environmental Security Microbial Genetic Resources	Best Poster Award - Consolation
P-84	1510	Hard Coral Diversity of Minicoy Island, Lakshadweep	**S. Jasmine**, L. Ranjith, Miriam Paul, S. Ramkumar, K.S. Sobhana3, K.K. Joshi and Jose Kingsly	Research Centre of CMFRI, Vizhinjam, India	Technical Session 1-B: Food Nutrition & Environmental Security Concurrent Session: Animal, Aquatic, Insect Microbial Genetic Resources	Best Poster Award
P-55	56	Documentation of Kashmir Geese Germplasm and Rearing Practices	**H. Hamadani** and A.A. Khan	Division of Livestock Production and Management, Faculty of Veterinary Sciences and Animal Husbandry, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Srinagar, Jammu and Kashmir, India	Technical Session 1-B: Food Nutrition & Environmental Security Concurrent Session: Animal, Aquatic, Insect Microbial Genetic Resources	Best Poster Award

Poster No.	Abstract No.	Title of Poster	Authors	Affiliation of presenting author	Session	Award Category
P-139	789	Prioritized Management Strategies for Conservation of Endangered Mahseer, *Tor putitora* in Mid Himalayan region, India	**R.S. Patiyal**, A.K. Singh, S. Chandra and P. Kumar	ICAR-Directorate of Coldwater Fisheries Research, Bhimtal, India	Technical Session 2-D: Conservation Strategies and Methodologies Concurrent Session: Animal and Aquatic Genetic Resources	Best Poster Award
P-364	1342	Molecular, Cellular and Transcriptomic Evidences of Superior Heat Tolerance Potential of Indian Native Cattle	**Manishi Mukesh**, Ankita Sharma, Monika Sodhi, Umesh Shandilya, Preeti Verma, Ashok Mohanty, Sandeep Mann and Amit Kishore	ICAR-National Bureau of Animal Genetic Resources, Karnal, India	Technical Session 4-D: Science-led Innovation Concurrent Session: Animal and Aquatic Genetic Resources	Best Poster Award
P-370	950	Evaluation of Prolificacy in Different Crossbred Ewes (GMM and Avishaan)	**L. Leslie Leo Prince**, V. Prakash, R.C. Sharma, G.R. Gowane, I. Chauhan, A. Kumar and S. Kumar	Central Sheep and Wool Research Institute, Avikanagar, Rajasthan - 304501, India	Technical Session 4-D: Science-led Innovation Concurrent Session: Animal and Aquatic Genetic Resources	Best Poster Award - Consolation
P-60	697	Buffalo Genetic Resources of India	**Vikas Vohra**, R.S. Kataria and Arjava Sharma	ICAR-National Bureau of Animal Genetic Resources, Karnal, Haryana, India	Technical Session 1-B: Food Nutrition and Environmental Security Concurrent Session: Animal, Aquatic, Microbial Genetic Resources	Best Poster Award - Consolation
P-386	249	Invasive Western Flower Thrips, *Frankliniella occidentalis* (Pergande) (Thripidae: Thysanoptera): A Potential Pest and Tospovirus Vector	**R.R. Rachana** and A.N. Shylesha	ICAR-National Bureau of Agricultural Insect Resources, Bengaluru, India	Technical Session 5: Quarantine, Biosafety and Biosecurity Issues	Best Poster Award - First
P-177	1145	Influence of Weather Parameters on Population Dynamics of Aphids in Cowpea	**N. Manjunatha**, K.T. Rangaswamy, N. Nagaraju, H.A. Prameela and R.N. Puspha	ICAR-IGFRI, India	Technical Session 3: Adaptation and Mitigation to Climate Change	Best Poster Award - Second
P-385	200	Evaluation of *Nesidiocoris tenuis* (Reuter) (Hemiptera: Miridae) Preying on Invasive Insect Pest Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae) in Tomato	**Richa Varshney**, Chandish R. Ballal and M. Mohan	ICAR-National Bureau of Agricultural Insect Resources, Bangalore, Karnataka, India	Technical Session 5: Quarantine, Biosafety and Biosecurity Issues	Best Poster Award - Consolation

Exhibition on Agrobiodiversity

An exhibition on agrobiodiversity named as “Glimpses of Agrobiodiversity” was organized during the IAC 2016 at NASC Complex, New Delhi, to display the variability in some indigenous genetic resources of India. The exhibition was mainly organized by National Innovation Foundation and Protection of Plant Varieties and Farmers Rights Authority. A total of 27 stakeholders exhibited genetic diversity from all over the country (Table 1).

It included National Research Institutes, Bureaux, Statutory Organizations, Agricultural Universities; State Biodiversity Boards; CGIAR institutes; and NGOs. The crop diversity in the form of live samples of cereals, millets, pulses, oilseeds, fruits and vegetables, tuber crops, fibre crops, medicinal and aromatic plants, spices, fodder and grasses along with fish, animal, microbes, insects diversity was a major attraction for all the participants of IAC 2016. Farmers from many parts of the country depicted their unique plant varieties with specific traits. The exhibition was inaugurated by Prof M.S. Swaminathan., MSSRF. Based on the presentation, diversity displayed and message communicated, a committee of experts evaluated the exhibits and recommend following exhibits for prizes

Entrance of exhibition on agrobiodiversity

Table 1. List of exhibitors who participated in the exhibition held during IAC 2016

S. No.	Name of Exhibitor
1.	ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi
2.	ICAR-National Bureau of Fish Genetic Resources (NBFGR), Lucknow
3.	ICAR-National Bureau of Agriculturally Important Microorganisms (NBAII), Mau
4.	ICAR-National Bureau of Agricultural Insect Resources (NBAIR), Bengaluru
5.	ICAR-National Bureau of Animal Genetic Resources (NBAGR), Karnal
6.	ICAR-Indian Institute of Vegetable Research (IIVR), Varanasi
7.	ICAR-Directorate of Floricultural Research (DFR), Pune
8.	ICAR- National Research Centre for Banana (NRCB), Tiruchirapalli
9.	Protection of Plant Varieties & Farmers' Rights Authority(PPV&FRA), New Delhi
10.	National Biodiversity Authority (NBA), Chennai
11.	State Biodiversity Board (SBB), Madhya Pradesh
12.	Indira Gandhi Krishi Vishwavidyalaya (IGKVV), Raipur, Chhatisgarh
13.	Central Agricultural University (CAU), Imphal, Manipur
14.	Mahatma Phule Krishi Vidyapeeth (MPKV), Rahuri, Maharashtra
15.	Sher-e-Kashmir University of Agricultural Sciences and Technology (SKUAST), Srinagar
16.	University of Agricultural Sciences (UAS), Dharwad
17.	M.S. Swaminathan Research Foundation (MSSRF), Kalpetta, Wayanad, Kerala
18.	Navara Eco Farm (NEF), Palghat, Kerala
19.	BAIF Development Research Foundation, Pune
20.	Blue Star Engineering and Electronics, New Delhi
21.	National Innovation Foundation (NIF), Ahmedabad
22.	Association of Biotechnology Led Enterprises-Agriculture Focus Group (ABLE-AG)
23.	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH (GIZ)
24.	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
25.	International Center for Agricultural Research in the Dry Areas (ICARDA)
26.	International Maize and Wheat Improvement Center (CIMMYT)
27.	Bioversity International

Table 2. Recognition of Exhibitors of IAC 2016

Recognition	Institute/Organization
First Prize	ICAR-National Bureau of Animal Genetic Resources, Karnal
	
Second Prize	University of Agricultural Sciences, Dharwad
	
Third Prize	National Innovation Foundation, Ahmedabad
Consolation Prizes	1. BAIF Development Research Foundation, Pune 2. Bioversity International 3. Central Agricultural University, Imphal, Manipur 4. Navara Eco Farm, Palghat 5. ICAR- Directorate of Floricultural Research, Pune 6. ICAR-National Bureau of Fish Genetic Resources, Lucknow 7. ICAR-National Bureau of Plant Genetic Resources, New Delhi

Stall of ICAR-NBPGR

Stall of BAIF

Stall of Navara Eco Farm

Stall of Bioversity International

Stall of ICAR-NBFGR

Stall of ICAR-DFR

Concluding Session

This session was Co-Chaired by **Prof. M.S. Swaminathan,** MSSRF, India and **Dr R.S. Paroda,** ISPGR and TAAS, India.

Dignitories on the dais during concluding session

Dr Sunil Archak, Member Secretary, Technical Program Committee, presented the major recommendations that emerged from the discussions of the four-day Congress which are included in this document. He also presented the '***Delhi Declaration on Agrobiodiversity Management***' which was adopted unanimously during concluding session of the IAC 2016.

Dr R.K.Tyagi

Dr R.S. Paroda mentioned that IAC 2016 was a very important milestone in present era because agrobiodiversity is the most important commodity for solving food and nutritional problems at world level. He profusely thanked Prof. Swaminathan, for his guidance and support for effective organization of IAC 2016.

Dr Paroda expressed his confidence that this Congress would be a 'Rolling Event' and would be organized at a 4-year interval, for which he thanked Ms Ann Tutwiler, Director General, Bioversity International, Rome, who kindly agreed to facilitate the organization of next IAC. Dr Paroda thanked all the co-organizers, sponsors and other partners for supporting the organization of IAC 2016. He also thanked all the members of all committees constituted for organization of IAC 2016.

Prof. M.S. Swaminathan expressed his satisfaction on the organization of IAC 2016. He added that response of participants (1,000) from all over the world (~ 60 countries) was overwhelming, showing great importance of the subject, which had been deliberated during past four days. He appreciated the presentations made by various delegates. He thanked Dr R.S. Paroda and his vision to conceive the organization of IAC 2016 and implement it in the best manner. He also appreciated the members of International Advisory Committee, National Steering Committee, Technical Program Committee and Core Organizing Committee for their sincere efforts to organize IAC 2016 in the most professional manner. Prof. Swaminathan thanked all the delegates for their presence throughout the Congress, which reflected their commitment to the cause of agrobiodiversity. Finally, he hoped that the recommendations emerging out of the Congress would be useful for managing agrobiodiversity for the welfare of human beings to combat climate change threats and ensure livelihood security.

Dr R.C. Agrawal

Dr Anuradha Agrawal, Member Secretary, Core Organizing Committee, extended a vote of thanks to Prof. M.S. Swaminathan, for his continuous guidance and support to organize the IAC 2016 by providing new ideas and suggestions. She thanked Dr R.S. Paroda for his visionary approach for conceiving, guiding, supporting and implementing the whole program with great zeal and professionalism. Dr Agrawal also expressed her gratefulness to all organizers, co-organizers, sponsors, knowledge partners, Co-chairs, Coveners, Rapporteurs, speakers, all members of various committees and most importantly all the participants attending the Congress.

Dr Anuradha Agrawal

Recommendations of IAC 2016 for Effective Management and Sustainable Utilization of Agrobiodiversity

Policy Issues

1. *Integrated approach* has to be adopted for the management and use of agrobiodiversity for improved livelihood, sustainable agriculture and adaptation to climate change. For this, the *government policies need to be supportive for developing native-food based strategies* to address malnutrition by raising awareness and consumer demand, enhanced investment, informed public policies relating to agrobiodiversity markets, identification of trait-specific germplasm and linking traditional food to all development related objectives.
2. *National legislation* (*e.g.* Biological Diversity Act, 2002 of India) suiting to each country should be enacted to ensure enhanced access to genetic resources and associated benefit sharing.
3. *Institutional and policy reforms* should be brought about by including strategies for fragile lands, ecosystem model development, sectoral approach, climate action plan, coordination and linkages, as well as documentation of local knowledge; *Social and cultural dimensions* of agrobiodiversity must not be neglected.
4. *List of crops of Annex 1 of the ITPGRFA* has now to be expanded to include other crops of food and agriculture significance for global benefits; *Revision of SMTA* should be done carefully and in consonance with provisions of ABS, especially using Nagoya Protocol to facilitate bilateral exchanges.
5. *National Gene Funds* will have to be created/ expanded in diversity-rich countries for supporting conservation and sustainable use of agrobiodiversity at farm and community levels; *Benefit sharing funds* should have multiple mechanisms for resource generation including user-based payment mechanism.
6. *Non-monetary benefit options* such as grazing rights, capacity building, veterinary care, infrastructure/value chain development for local processing and assistance in marketing should also be explored for communities of farmers, pastoralists and livestock breeders involved in genetic resource conservation.
7. *Enabling environment* for access to genetic resources should be created by harmonizing existing conservation Acts and Regulations, including genetic resources informatics. *A single window system* must, therefore, be developed for enhancing accessibility and effective use of genetic resources.
8. *Coordination among various government ministries* needs to be ensured for effective implementation of laws related to agrobiodiversity management and use.

9. *Exchange of trait-specific germplasm*, including *farmers' varieties* should be facilitated for their deployment in the national crop improvement programs; *Streamlining exchange procedures* of microbial and insect genetic resources has to be carried out as a matter of urgency.
10. *Urgent policy directives are needed to arrest agrobiodiversity loss* at the national, regional and global level.

Quarantine, Biosafety, Biosecurity

1. *Convergence of WTO and CBD provisions* at regulatory and operational level has to be achieved for conservation and use of bio-secured agrobiodiversity.
2. *Safe-trade* should be promoted as a driver for conservation and exchange of agrobiodiversity and to prevent spread of invasive alien species.
3. *National phytosanitary capacities* for safe import, including pest-risk analysis, should be built, especially in the sub-Saharan Africa, owing to recent emergence, resurgence, spread and outbreaks of many important agricultural pests.
4. *Green Pass criteria for the germplasm* distribution from international genebanks should be developed to provide credibility on health status of germplasm to phytosanitary regulators.
5. *Seed certification programs, early warning system and the pest surveillance* have to be strengthened in all developing countries.
6. *Plant Pest Diagnostic Networks* should be established through accredited laboratories, at the national and regional levels, in order to ensure biosecurity while exchanging germplasm.

Genebank Management

1. *Completeness of collections in genebanks* should be achieved on the basis of gap analysis and targeted germplasm explorations/collecting.
2. *Rationalization of collections in the genebanks* should be ensured for effective conservation and use of germplasm (*e.g.* avoid adding new accessions, informed decision on eliminating duplicates).
3. Genebanks should function as "*Bio-Digital Resource Centers*" and complementary conservation strategy be promoted through enhanced utilization of genetic resources in active breeding programs and farmers' participatory plant breeding.
4. *Global common platform for documentation* of available accession-level information be developed and made available to breeders in order to ensure their enhanced use.
5. *Global Cryovault*, similar to Svalbard Global Seed Vault, should be established for safety back-up of vegetatively propagated crops; *Cryopreservation of threatened plants and crop wild relatives* should be prioritized; *Pollen and DNA* should be cryopreserved as complimentary conservation strategy and to aid basic research.
6. *Capacity building programs* should be organized regularly on modern genebank management methods, molecular techniques and genetic resource documentation.

In situ On-farm Conservation and Traditional Knowledge

1. *Incentivize* in situ*/on-farm conservation* and genetic approaches be adopted for sustainable on-farm management of landraces diversity.
2. *Pilot projects for* in situ *conservation* should be developed for the mitigation and adaptation to climate change effects.
3. In situ*/on-farm conservation* should be supported by providing scientific inputs, monitoring, measuring transitions and proper documentation.
4. *Agrobiodiversity hotspots* are to be protected and *in situ* conservation of farmers' varieties be ensured through establishment of community seed banks.

5. *Landraces and traditional farmers' varieties* should be "conserved through use" by ensuring their continuous availability; by supporting community seed banks and *strengthened local seed systems*.
6. *Traditional knowledge* available with rural and tribal communities, especially with women farmers, be documented on priority for effective use of agrobiodiversity.
7. *Creativity among farmers* be encouraged by required incentives for their innovation and enterprise initiatives.
8. *Alternative niches* need to be identified to safely conserve genetic resources, especially under serious threat, in their present ecological system, in order to avoid permanent loss.

Adaptation and Mitigation of Climate Change

1. *National climate strategies and action plans* be developed concerning information, policies, institutions and capacity-building.
2. *Identification of the adaptive traits* to the changing climate should be facilitated by *in situ*/on-farm conservation of genetically diverse populations, especially the crop wild relatives.
3. *In situ conservation of animal genetic diversity* be ensured within their eco-regional context.
4. *Agro-ecological zone based maps* of agrobiodiversity should be prepared to asses both spatial and temporal changes due to climate change.
5. *Genetic base-broadening* approach at farm and landscape level be promoted by introducing adaptive inter- and intra-species diversity.
6. *Discovery of useful traits and genes* by characterization of *ex situ* collections under the hot spots be given high priority.
7. *Pre-breeding*, involving crop wild relatives, should be accelerated to identify sources of tolerance to various biotic and abiotic stress factors; *Partnership between IARC and NARS* of developing countries for pre-breeding should be developed in order to deliver at the farmer's fields.
8. *Positive implications of climate change* in the short term (2020-2050) for some of the ecosystems and crop production systems need to be studied (*e.g.* expected enhanced yields of soybean, groundnut, coconut and opening new geographies for cultivation of coffee and *Eri* silk in North East India)
9. *Traditional knowledge and cultural aspects* for climate change adaptation should be documented and used to enhance positive effects of climate change. For instance, looking at *Jhum* (practice of shifting cultivation in North Eastern India) as a systematic, knowledge-based, productive system with crop diversity, strong adaptation and coping mechanisms.

Research and Development

1. *Agrobiodiversity Index* should be developed and implemented to help monitor on-going genetic resource conservation and management efforts, with particular emphasis across existing agrobiodiversity hot spots.
2. *Greater emphasis on use of wild species and landraces* be given by employing conventional as well as modern genetic techniques; *Pre-breeding* involving crop wild relatives should be employed to identify sources of tolerance to various biotic and abiotic stress factors.
3. *Regional and national CWR strategic action plan* be put in place for their effective assessment, management and utilization.
4. *Technological advances* in genomics, nanotechnology, space and bioinformatics should be employed judiciously for better conservation and utilization of agrobiodiversity; *The role of plant breeding* should not be undermined and efforts on genomics be considered as complementary.
5. *Core and mini-core collections* should be developed in selected important crops for

enhanced use; *Trait-specific germplasm* should be intensively used to develop varieties that are tolerant to biotic and abiotic stresses, and are aligned with better quality and *food processing traits*.

6. *Integration of genetic improvement with conservation* of locally adapted breeds/ varieties of animals and fishes be encouraged to sustainability use these resources/useful alleles; *Improved reproductive technologies* for rapid multiplication of fish and animal genetic resources be also employed for their effective conservation.
7. *Genotypic and phenotypic characterization* of genetic materials stored in the genebanks as well as non-descript populations must be carried out on priority for effective documentation and use.
8. *Marker panels and uniform protocols* also need to be established for assessing genetic indices of animal genetic resources on spatial scale, both at the farm level and in wild habitats.
9. *Value addition of animal and fish genetic resources* and certification of their bio-products may be initiated/ intensified at local level to enhance their sustainable use; Also the *registration procedures of bio-pesticides* need to be simplified to ensure their commercialization.
10. *Natural extreme environments* have to be identified and conserved for microbial and insect genetic resources; *unique niches of non-culturable* microbes be explored through metagenomics approach; trees of the natural habitats should be protected to preserve birds.
11. *Scaling up of expeditions* to explore and document insect and microbial diversity has to be done with greater emphasis on unique species.
12. *Diversity dynamics around hotspots* for the microbial communities be analysed; *Indicator species* be also identified for indexing fauna change; *national catalogue* on microbial communities must be prepared.
13. *PGR Informatics* be strengthened to bridge *availability-accessibility gap* and to enhance germplasm utilization; *Vertical integration* of biological resources, bioinformatics tools and databases should be ensured. Also the *investments in PGR informatics* be enhanced at the global, regional and national levels.

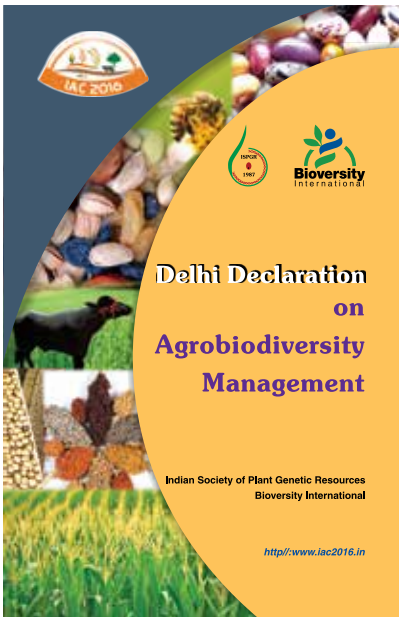
Capacity Building, Networks and Partnerships

1. *Regular, structured, systematic and sustainably funded capacity building programs* be organized at the local, national, regional and global levels. Need of capacity building is perceived for modern genebanking techniques, cryopreservation, molecular techniques, climate resilience, informatics, IPRs, and rights of communities as well as gender equality.
2. *ICT based approaches* should be explored (*e.g.* mobile apps based crowdsourcing, crowdfunding, crowd bonding, *etc.*) to develop partnerships with effective involvement of stakeholders and to bridge digital device.
3. *Sustained support of the governments and donors* must be sought to facilitate networks and partnerships among stakeholders, research institutions and development agencies.
4. *Indicators for a successful partnership* be also developed in order to evaluate and strengthen these across disciplines, commodities and regions.
5. *Regional and international cooperation* needs to be established/ strengthened to facilitate accessibility of germplasm in genebanks.
6. *Synergy between formal and informal seed sectors* be also sought by adopting integrated seed sector development approach.
7. *Brood stock banks and stakeholders* must be involved in the scientific management of animal genetic resources.

Annexure 1
Delhi Declaration on Agrobiodiversity Management

The **1st International Agrobiodiversity Congress** held in New Delhi, India, from 6-9 November, 2016 was attended by over 900 participants from 60 countries. Congress delegates discussed various aspects of conservation, management, access and use of agrobiodiversity in 16 technical sessions, four satellite sessions, a genebank roundtable, a public forum, a farmers' forum and poster sessions. Based on detailed deliberations, the delegates unanimously adopted the following declaration in the concluding session on November 9, 2016:

Preamble



- Agrobiodiversity includes crop varieties, livestock and fish breeds, and agriculturally useful insect and microbial species. Significant progress has been made towards the documentation, collection, conservation and use of agrobiodiversity related genetic resources, yet much more needs to be done towards their sustainable use, greater exchange and knowledge and technology transfer.
- If conserved and used sustainably, agrobiodiversity could make an important contribution towards resolving problems of hunger, food insecurity, malnutrition and climate change, thus help in attaining the Sustainable Development Goals (SDGs) and the Aichi Targets of the Convention on Biological Diversity.
- Limitations in policies, investment, infrastructure, technical capacity as well as cross-sectoral coordination and partnerships have often prevented efficient use of agrobiodiversity. This is particularly alarming since it is projected that the world, where almost 795 million people go hungry today, will need 70% more food to feed 9.6 billion people by 2050 (FAO, 2015). Hence, high priority and policy support by world leaders and organizations is warranted for enhanced use of agrobiodiversity.

- The world is also facing rapid loss and extinction of biodiversity. It is estimated that species are being lost at 1,000 to 10,000 times the rate at which natural extinction took place at any time during the past 66 million years mainly due to explosive population growth and overexploitation of natural resources. Extinction of agrobiodiversity and associated traditional knowledge is an irreversible process and hence must receive priority attention. In fact, loss of a gene is a major loss for our future generations.

Declaration

1. We call upon nations to accord top priority to the shared vision of agrobiodiversity conservation and sustainable use towards achieving the Sustainable Development Goals (SDGs) and the Aichi Targets of the Convention on Biological Diversity addressing poverty alleviation, food, nutritional and health security, gender equity and global partnership.
2. We recognize the importance of traditional agrobiodiversity knowledge available with farm men and women, pastoralists, tribal and rural communities and its central role in the conservation and use for a food secure and climate resilient world. We, therefore, call upon countries to develop the necessary legal, institutional and funding mechanisms to catalyze their active participation.
3. We urge researchers and the policymakers to initiate, strengthen and promote complementary strategies to conserve agrobiodiversity through use, including greater emphasis on using crop wild relatives. We call for them to ensure a continuum between ex situ, in situ, on-farm, community-based and other conservation methods with much greater and equal emphasis on each.
4. We propose that researchers employ modern technologies including, but not limited to, genomics, biotechnology, space, computational, and nano-technologies for genetic resources characterization, evaluation and trait discovery. The aim must be to achieve efficiency, equity, economy and environmental security through diversified agricultural production systems and landscapes.
5. We reemphasize the necessity of global exchange of plant, animal, aquatic, microbial and insect genetic resources to diversify agriculture as well as our food basket and to meet the ever-growing food and nutritional needs of all countries. To ensure this, nations need to be catalysed to adopt both multi-lateral (as envisaged in the International Treaty on Plant Genetic Resources for Food and Agriculture) and bilateral (as per the Nagoya Protocol) instruments to facilitate the exchange of genetic resources, while ensuring equitable access and benefit sharing opportunities.
6. Countries are also expected to harmonize their existing biosecurity systems, including phytosanitary and quarantine, and enhance their capacities to facilitate safe trans-boundary movement of germplasm.
7. We also expect that the governments and civil societies lay much greater emphasis on public awareness and capacity enhancement programs on agrobiodiversity conservation in order to accelerate its effective and efficient use.
8. We recommend the development and implementation of an Agrobiodiversity Index to help monitor on-going genetic resource conservation and management efforts, with particular emphasis on agrobiodiversity hot spots.
9. It is also urged that public and private sectors and civil societies henceforth actively

invest in and incentivize the utilization of agrobiodiversity to mitigate malnutrition, increase the resilience and productivity of farms and farming households and enhance ecosystem services. Such efforts should lead to equitable benefits and opportunities, with particular emphasis on women and youth.

10. We urge countries to reprioritize their research and extension with increased investments to support the conservation and use of agrobiodiversity. Furthermore, we strongly recommend to create an International Agrobiodiversity Fund as a mechanism to assist countries and communities in scientific *in situ* and *ex situ* conservation and enhanced use of agrobiodiversity.
11. We urge the United Nations to consider declaring a 'Year of Agrobiodiversity' in order to draw worldwide attention and catalyse urgent actions for effective management of genetic resources by the global community.
12. Finally, we recommend that the *International Agrobiodiversity Congress* be held every four years, with Bioversity International playing the facilitator's role, to maintain the momentum gained in 2016 and continue emphasizing the need to implement the 'Delhi Declaration on Agrobiodiversity Management' and monitor the progress so made by the different stakeholders and countries.

Annexure 2
Technical Program

1st International Agrobiodiversity Congress
Science, Technology, Policy and Partnership

PROGRAM SUMMARY

Day One: 6th November, 2016 Vigyan Bhawan

10:30-11:30	**Inaugural Session**		
12:00-13:30	**Plenary Session 1**	**Agrobiodiversity for Sustainable Development Goals (SDGs)**	
14:30-17:30	**Technical Session 1**	**Food, Nutrition and Environmental Security**	
	Concurrent Sessions (2)	Plant Genetic Resources	Animal, Aquatic, Microbe and Insect GR
18:00-19:00	**Evening Lecture**	**Agrobiodiversity and Achieving the Zero Hunger Challenge**	

Day Two: 7th November, 2016 NASC, Pusa

09:00-10:40	**Plenary Session 2**	**Conservation through Use**			
11:00-13:15	**Technical Session 2**	**Conservation Strategies and Methodologies**			
	Concurrent Sessions (5) **Plant Genetic Resources**				
	2-A Seed Genebank	**2-B** *In Situ* and On-farm	**2-C** *In Vitro*, Cryo and DNA Bank	**2-D** Animal and Aquatic GR	**2-E** Microbe and Insect GR

14:15-16:40	**Technical Session 3**	**Adaptation and Mitigation of Climate Change**
14:15-16:40	**Satellite Session 1**	**Harnessing Biodiversity for Food Security and Sustainable Development** (*Organized by CIMMYT*)
14:15-16:40	**Satellite Session 2**	**Agrobiodiversity for Nutrition and Health** *(Organized by Bioversity International and NIN)*
14:15-16:40	**Farmers' Forum**	**Farmers' Role in Conservation of Genetic Resources**
17:00-18:00	**Evening Lecture**	Biodiversity, Food, and the Future

Day Three: 8th November, 2016 NASC, Pusa

09:00-10:40	**Plenary Session 3**	**Agrobiodiversity for Livelihood Security and Ecosystem Services**			
11:00-13:15	**Technical Session 4**	**Science-led Innovation**			
	Concurrent Sessions (5) **Plant Genetic Resources**				
	4-A Trait Discovery and Enhanced Use of PGR	**4-B** PGR and Genomics	**4-C** PGR Informatics	**4-D** Animal and Aquatic GR	**4-E** Microbe and Insect GR
14:15-16:40	**Technical Session 5**	**Quarantine, Biosafety and Biosecurity Issues**			
14:15-16:40	**Satellite Session 3**	**Climate Change as an Opportunity for Agrobiodiversity Management** *(Organized by GIZ)*			
14:15-16:40	**Round Table Dialogue**	**Genebank Management: Challenges and Opportunities**			
17:00-18:30	**Public Forum**	**Role of Stakeholders in Agrobiodiversity Management**			

Day Four: 9th November, 2016 NASC, Pusa

09:00-10:40	**Plenary Session 4**	**Access and Benefit Sharing (ABS) in the Context of Regulatory Systems**
11:00-13:15	**Technical Session 6**	**IPRs, ABS and Farmers' Rights**
11:00-13:15	**Technical Session 7**	**Partnership, Networks and Capacity Building**
11:00-13:15	**Satellite Session 4**	**Crop Wild Relatives: Back to the Wild to Save the Future** *(Organized by Bioversity International and University of Birmingham)*
14:15-16:40	**Concluding Session**	**Theme-wise Reports and Delhi Declaration**

NOTE:

- Technical Sessions 3, 5, 6 and 7 will run as *common sessions* across commodities
- Technical Sessions 6 and 7 will run simultaneously
- *Satellite sessions* will run parallel to the Technical Sessions
- Posters are displayed throughout on 7th, 8th and the forenoon of 9th of November. However, dedicated time for Poster Session, including discussion, will be between 18.30-19.30 on 7th and 8th of November.

SESSION-WISE DETAILS OF PROGRAM

6th November, 2016 at Plenary Hall, Vigyan Bhawan

INAUGURAL SESSION

10:30-11:30	**Inauguration by the Prime Minister of India**	
11:30-12:00	***Tea/Coffee Break***	

PLENARY SESSION 1

12:00-13:30	**Agrobiodiversity for Sustainable Development Goals (Sdgs)**	
	Co-Chairs : M.S. Swaminathan, MSSRF and **Martin Kropff,** CIMMYT **Convener : R.K. Tyagi,** NBPGR **Rapporteurs : Anjula Pandey,** NBPGR; **B. Sarath Babu,** NBPGR	
12:10-12:40	**Plenary Lecture** We Manage What We Measure: an Agrobiodiversity Index to Help Deliver the Sustainable Development Goals	**M. Ann Tutwiler,** Bioversity International
12:40-13:10	**Plenary Lecture** Managing Agrobiodiversity through Use: Changing Paradigms	**R.S. Paroda,** ISPGR & TAAS
13:10-13:30	Discussion and Concluding Remarks	
13:30-14:30	***Lunch***	

TECHNICAL SESSION 1-A
Food, Nutrition and Environmental Security

14:30-17:30	**Concurrent Session: Plant Genetic Resources**	
	Co-Chairs : David Bergvinson, ICRISAT and **Nikolay Dzyubenko,** VIR **Convener : Prem Mathur,** Bioversity International **Rapporteurs : Kalyani Srinivasan,** NBPGR; **Kamala Venkateswaran,** NBPGR	
14:30-14:40	Introduction	
14:40-15:05	Why We Need Effective Partnerships and Agrobiodiversity to Feed 9-Billion People?	**Martin Kropff,** CIMMYT
15:05-15:30	Indian Agrobiodiversity Management System	**Trilochan Mohapatra,** ICAR
15:30-15:55	Reducing Mineral and Vitamin Deficiencies through Biofortification: Progress under HarvestPlus	**Howarth Bouis,** HarvestPlus
15:55-16:20	From Industrial Agriculture to Diversified Agroecological Systems	**Emile Frison,** IPES-Food

16:20-17:00	**Rapid Presentations (From Abstracts)** **I.S. Bisht,** NBPGR, India Traditional land and food systems: a case of Uttarakhand state in North-western Indian Himalayas (#54) **Masatoshi Funabashi,** Sony Computer Science Laboratories, Inc., Japan Synecological farming for mainstreaming biodiversity in smallholding farms and foods: Experiments in Japan and Burkina Faso (#1391) **W.L.G. Samarasinghe,** Plant Genetic Resources Center, Sri Lanka Strategies for conservation and sustainable use of biodiversity for food and nutrition in Sri Lanka (#1468) **Mani Vetriventhan,** ICRISAT, India Little millet, *Panicum sumatrense*, an under-utilized multipurpose crop (#1448)
17:00-17:30	Discussion and Concluding Remarks
17:30-18:00	***Tea/Coffee Break***

TECHNICAL SESSION 1-B
Food, Nutrition and Environmental Security

14:30-17:30	**Concurrent Session: Animal, Aquatic, Insect and Microbial Genetic Resources**	
	Co-Chairs : J.K. Jena, ICAR and **Purvi Mehta,** BMGF	
	Convener : Anil Kumar Saxena, NBAIM	
	Rapporteurs : Monica Sodhi, NBAGR; **S. Renu;** NBAIM	
14:30-14:40	Introduction	
14:40-15:05	Animal Genetic Resources (AnGR) for Food Security	**Olivier Hanotte,** ILRI
15:05-15:30	Insect Biodiversity, Ecosystem Services and Sustainable Agriculture	**N.K. Krishna Kumar,** Bioversity International
15:30-15:55	Conservation and Management Approaches of Fish Genetic Resources in India: Present Status and Future Outlook	**J.K. Jena,** ICAR
15:55-16:20	Microbial Diversity of Extreme Regions: An Unseen Heritage and Wealth	**Anil Kumar Saxena,** NBAIM
16:20-17:00	**Rapid Presentations (From Abstracts)** **C. Lavina Vincent,** Central Marine Fisheries Research Institute, India Partial gene characterization of candidate functional gene MSTN encoding growth and muscle development in *Trachinotus mookalee* and *Trachinotus blochii* (#1659) **Sijun Zheng,** Yunnan Academy of Agricultural Sciences, China Innovative integrated systems for intensification of banana, pig and cattle production in Yunnan province of southwest China (#825) **K. Vinod,** ICAR-CMFRI, India Conservation and Sustainable Management of Seahorses in the Gulf of Mannar and Palk Bay, South-East Coast of India (#1761)	

	Rajesh Kumar Vaid, National Centre for Veterinary Type Cultures Collection, India Role of Veterinary Type Culture Collection in capturing equine microbial biodiversity (#852)	
17:00-17:30	Discussion and Concluding Remarks	
17:30-18:00	***Tea/Coffee Break***	

EVENING LECTURE

18:00-19:00	**Evening lecture**	
	Co-Chairs : Ann Tutwiler, Bioversity International and **S. Rajaram,** RSM **Convener : Anuradha Agrawal,** NBPGR **Rapporteurs : D.B. Parakh,** NBPGR; **Chithra Devi Pandey,** NBPGR	
18:00-18:10	Introduction	
18:10-18:50	Agrobiodiversity and Achieving the Zero Hunger Challenge	**M.S. Swaminathan,** MSSRF
18:50-19:00	Concluding Remarks	
19:30-21:30	***Congress Dinner at Podium Lawns, NASC Complex, Pusa***	

7th November, 2016 at AP Shinde Hall

PLENARY SESSION 2

09:00-10:40	**Conservation through Use**	
	Co-Chairs : R.S. Paroda, ISPGR & TAAS and **Cristian Samper,** Bioversity International **Convener : Kuldeep Singh,** NBPGR **Rapporteurs : Radhamani J.,** NBPGR; **Rakesh Bhardwaj,** NBPGR	
09:00-09:10	Introduction	
09:10-09:35	**Plenary Lecture** Agrobiodiversity Use for Food Security	**Gurdev S. Khush,** University of California
09:35-10:00	**Plenary Lecture** Exploring the Benefits of a Systems Based Approach to PGR Conservation	**Toby Hodgkin,** Platform for Agrobiodiversity Research
10:00-10:40	Panel Discussion **Panelists : S. Rajaram,** RSM; **Marie Haga,** Crop Trust; **Calvin Qualset,** University of California; **Usha Zehr,** Mahyco	
10:40-11:00	***Tea/Coffee Break***	

TECHNICAL SESSION 2-A
Conservation Strategies and Methodologies

11:00-13:15	**Concurrent Session: Seed Genebanks**	
	Co-Chairs : B.S. Dhillon, PAU and **R.S. Hamilton,** IRRI	
	Convener : Hari D. Upadhyaya, ICRISAT	
	Rapporteurs : Sherry Jacob, NBPGR; **Veena Gupta,** NBPGR	
11:00-11:05	Introduction	
11:05-11:25	Building a Global System for the *Ex situ* Conservation of Crop Diversity	**Marie Haga,** Crop Trust
11:25-11:45	Germplasm Management for Enhanced Genetic Gains	**Hari D. Upadhyaya,** ICRISAT
11:45-12:00	ICARDA Efforts to Promote *In Situ*/On-Farm Conservation of Dryland Agrobiodiversity	**Mariana Yazbek,** ICARDA
12:00-12:15	Genebanks: Management of Genetic Erosion in *Ex Situ* Collections	**N. Murthy Anishetty,** Ex-FAO
12:15-12:30	Conservation of PGR for Effective Utilization: New Initiatives at NBPGR	**Rishi K. Tyagi,** NBPGR
12:30-12:45	**Rapid Presentations (From Abstracts)** **Arnab Gupta,** Bioversity International, India Low Carbon footprint seed conservation technique: The Desiccated-Ambient storage system using Zeolite beads (#1623) **Manisha Thapliyal,** Forest Research Institute, India Conservation of Forest Genetic Resources: Need and Challenges (#1835) **Teswang Rinchen,** DIHAR, DRDO, India Phytodiversity and its conservation strategies in permafrost conditions at extreme altitude of trans-Himalaya in Leh-Ladakh (#1845)	
12:45-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 2-B
Conservation Strategies and Methodologies

11:00-13:15	**Concurrent Session: *In Situ* and On-farm Conservation**	
	Co-Chairs : Stephan Weise, Bioversity International and **H.S. Gupta,** Ex-BISA	
	Convener : Shailendra Rajan, CISH	
	Rapporteurs : Joseph John K., NBPGR; **A.K. Misra,** NBPGR	
11:00-11:10	Introduction	
11:10-11:30	Agrobiodiversity: Key to Agricultural Productivity	**Calvin Qualset,** University of California

11:30-11:50	How Informal and Formal Seed Systems Can Work Together for the Conservation and Use of Agrobiodiversity?	**Coosje Hoogendoorn,** Royal Tropical Institute
11:50-12:10	Impacts of Changing Climate on Conservation Priorities for CWRs	**Nigel Maxted,** University of Birmingham
12:10-12:30	On-farm/*In Situ* Conservation of Tropical Fruit Tree Diversity: Emerging Concepts and Practices	**V. Ramanatha Rao,** GRSV
12:30-12:45	Conservation Dynamics of Root and Tuber Crops under On-Farm Management	**Stefan De Haan,** CIAT
12:45-13:00	**Rapid Presentations (From Abstracts)** **Nelli Hovhannisyan,** Yerevan State University, Armenia The role of Monastic gardens in sustainable conservation of grape (*Vitis vinifera* L.) genetic diversity in Armenia (#1477) **Shailendra Rajan,** CISH, India On-farm Conservation of Mango Diversity through Community Based Organization: A Case Study (#1819) **S.R. Maneesha,** CCARI, India 'Kulagar' – A Potential System to Conserve the Crop Diversity (#1786) **S.D. Kumbhar,** MPKV, India Farmers' Participatory Conservation of Rice Landrace Champakali (#148) **Yun-Yue Wang,** Yunnan Agricultural University,Yunnan, China Innovative Biodiversity Management and Community Development: Yunnan Yuanyang Hani Rice Terraces Case (#1929)	
13:00-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 2-C
Conservation Strategies and Methodologies

11:00-13:15	**Concurrent Session: *In Vitro*, Cryo, and DNA Banking**	
	Co-Chairs : P.L. Gautam, Ex-NBA and PPV&FRA and **Emile Frison,** IPES-Food	
	Convener : Neelam Sharma, NBPGR	
	Rapporteurs : P. Rajasekharan, IIHR; **Sandhya Gupta,** NBPGR	
11:00-11:10	Introduction	
11:10-11:30	Priority Science for the Preservation of Priority Crops	**Hugh Pritchard,** RBG
11:30-11:50	Plant DNA Resources in RIKEN BRC to Bridge the Gap between Gene Function and Phenotype	**Hiroshi Abe,** RIKEN
11:50-12:10	Securing Plant Genetic Resources for Perpetuity through Cryopreservation	**Bart Panis,** Bioversity International
12:10-12:25	Expanding Applications of Cryobanking for Genetic Resources Conservation	**Rekha Chaudhary,** NBPGR
12:25-12:40	*In Vitro* Propagation and Conservation of Tropical RTBs	**Badara Gueye,** IITA

12:40-13:00	**Rapid Presentations (From Abstracts)** **R. P. Kaur,** Central Potato Research Station, India Pollen cryopreservation in aid to conservation of potato genetic resources (#298) **Neelam Sharma,** NBPGR, India Application of *In vitro* techniques for Conservation of Indian Medicinal Plants – A Case Study (#1285) **S. Uma,** ICAR-NRC for Banana, India Success story of rejuvenation of near extinct fragrant banana, cv. Manoranjitham through inter-institutional and public-private partnership (#1305)
13:00-13:15	Discussion and Concluding Remarks
13:15-14:15	***Lunch***

TECHNICAL SESSION 2-D
Conservation Strategies and Methodologies

11:00-13:15	**Concurrent Session: Animal and Aquatic Genetic Resources**	
	Co-Chairs : M. Vijay Gupta, Ex-World Fish and **H. Rahman,** ICAR	
	Convener : Arjava Sharma, NBAGR	
	Rapporteurs : R. S. Kataria, NBAGR; **V.S. Basheer,** NBFGR	
11:00-11:10	Introduction	
11:10-11:25	Complementary Strategies for AnGR Conservation and for Global Innovation Challenges	**S.J. Hiemstra,** CGN
11:25-11:40	Farm Animal Genetic Resources: Evaluation and Conservation in India	**Arjava Sharma,** NBAGR
11:40-11:55	Experiences on Conservation of Indian Dairy Animal Biodiversity	**S.B. Gokhale,** BAIF
11:55-12:10	Conservation and Responsible Fisheries and Fisheries Technology	**C.N. Ravishankar,** CIFT
12:10-12:25	Aquatic Genetic Resources and Technologies for Food and Environmental Security	**K.K. Lal,** NBFGR
12:25-13:00	**Rapid Presentations (From Abstracts)** **S.K. Singh,** CIRG, India Impact of structured breed improvement programmes on genetic improvement and conservation of Indian goat (#39) **A.K. Thiruvenkadan,** VCRI, India Options and strategies for the conservation of sheep and goat genetic resources in India (#1890) **S.K. Majhi,** NBFGR, India Germ cell transplantation into adult recipient fish for speedy propagation of endangered germlines (#675)	
13:00-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 2-E
Conservation Strategies and Methodologies

11:00-13:15	**Concurrent Session: Microbial and Insect Genetic Resources**	
	Co-Chairs : **N.K. Krishna Kumar**, Bioversity International and **B. Venkateswarlu,** VNMKV	
	Convener : **Sushil K. Sharma,** NBAIM	
	Rapporteurs : **Ram Nageena Singh,** IARI; **Ankita Gupta,** NBAIR	
11:00-11:10	Introduction	
11:10-11:30	Biodiversity of Fleshy Fungi, their Conservation and Applications for Human Welfare	**R.C. Upadhyay,** DMR
11:30-11:50	Microbial Conservation Strategies and Methodologies: Status and Challenges	**Sushil K. Sharma,** NBAIM
11:50-12:10	Birds and Insectivory: Agrobiodiversity Implications in Sustainable Agriculture	**A. Verghese,** GPSIAM
12:10-12:30	Conservation of Pollinator Biodiversity in the Era of Neonicotinoids	**V.V. Belvadi,** UASB
12:30-13:00	**Rapid Presentations (From Abstracts)** **Pradeep Mehta,** Earthwatch Institute, India Reviving Traditional Bee Keeping Practices and Restoration of Landscape for Sustainable Agriculture in Indian Himalaya (#700)	
13:00-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 3

14:15-16:40	**Adaptation and Mitigation to Climate Change**	
	Co-Chairs : **J.S. Sandhu,** ICAR and **Ravinder Kaur,** IARI	
	Convener : **J.C. Rana,** NBPGR	
	Rapporteurs : **K. Pradheep,** NBPGR; **T. V. Prasad,** NBPGR	
14:15-14:25	Introduction	
14:25-15:00	Fighting Climate Stress with Orphan Legumes	**Ed Southern,** Kirk House Trust
15:00-15:15	Climate Change and Agricultural Biodiversity: Rethinking the Role of Science	**Jacob van Etten,** Bioversity International
15:15-15:30	Use of Agrobiodievrsity in Adapting to Climate Change	**J.C. Rana,** NBPGR
15:30-15:40	Post-disaster Revival of Local Seed System for Climate Change Adaptation	**Devendra Gauchan,** Bioversity International

15:40-16:25	**Rapid Presentations (From Abstracts)** **D.C. Putri Hendrawan,** ICRAF, Indonesia Increasing Resilience to Climate Change in Rural Livelihoods: to Diversify or Not? (#1434) **B.K. Joshi,** Bioversity International, Nepal Policy framework for adaptation to climate change (#1846) **B.N. Motagi, ICRISAT,** Nigeria Germplasm Enhancement for Increasing Groundnut Productivity and Production in West and Central Africa (#1055) **Ganga Rao N.V.P.R.,** ICRISAT, Kenya Effective Utilization of Local Genetic Diversity of pigeonpea, sorghum and finger millet in Eastern and Southern Africa: Impacts and Prospects (#1641) **M.P. Paulton,** CMFRI, India Indian edible oyster, a promising bivalve for aquaculture amidst the challenges of climate change as revealed through thermos-tolerance studies (#1720) **Hamidou Falalou,** ICRISAT, Niger Abiotic stresses tolerance and nutrients contents in groundnut, pearl millet and sorghum mini core collections for food and nutrition security (#1742) **Manyasa E.O.,** ICRISAT, Kenya Exploiting genetic diversity for adaptation and mitigation of climate change: A case of finger millet in East Africa (#1773)
16:25-16:40	Discussion and Concluding Remarks
16:40-17:00	***Tea/Coffee Break***

SATELLITE SESSION 1

14:15-16:40	**Harnessing Biodiversity for Food Security and Sustainable Development (CIMMYT)**	
	Chair : Martin Kropff, CIMMYT **Panel Chair : B.S. Dhillon,** PAU **Convener : Sukhwinder Singh,** CIMMYT **Rapporteurs : Prashant Vikram,** CIMMYT	
14:15-14:25	Opening remarks: Harnessing Biodiversity for Food Security and Sustainable Development	**Martin Kropff**
14:25-14:45	The Seeds of Discovery Initiative: A Learning Model Towards Effective and Equitable Use of Genetic Resources (#1938)	**Kevin Pixley**
14:45-14:55	Global Challenges and Urgency for Partnerships to Apply Genetic Resources	**Sukhwinder Singh**
14:55-15:05	Impact of SeeD Project in Mexico	**Gilberto Salinas**
15:05-15:20	What you did, Why, Main Result, Personal Statement about the Value of this Project (#1936)	**Prashant Vikram**
15:20-15:30	Present and Future Opportunities for Using Biodiversity for Wheat Improvement	**Anthony Hall**

15:30-15:40	Linking and Leveraging SeeD Resources in Indian Wheat Breeding Program-Prospects and Future (#1937)	**SeeD Project Partners**
15:40-16:10	Panel Discussion: How to enhance the value of SeeD and like-minded initiatives; How to secure funding for such critical, long-term, but often considered 'non-urgent' research	**B.S. Dhillon, PAU; N.N. Singh, TAAS; R.K. Singh, IRRI; S. Visscher, Lisa Wilson, USAID; P.K. Agrawal, ICAR; Kuldeep Singh, NBPGR; Ravi Singh, CIMMYT; Gurdev Khush, USA; Sanjay Rajaram, RSH; N.K. Singh, NRCPB**
16:10-16:30	Words of Wisdom: G.S. Khush, S. Rajaram and R.S. Paroda	
16:30-16:40	Concluding Remarks and Vote of thanks by Session Chair	
16:40-17:00	***Tea/Coffee Break***	

SATELLITE SESSION 2

14:15-16:40	**Agrobiodiversity for Nutrition and Health (Bioversity International and NIN)**	
	Chair : Soumya Swaminathan, ICMR **Convenors : Gina Kennedy,** Bioversity International; **T. Longvah,** NIN; **M.S. Suneetha,** UNU	
14:15-14:20	Introduction	
14:20-14:40	Rediscovering our future: How neglected and Underutilized Biodiverse Foods Can Nourish the Planet	**Gina Kennedy,** Bioversity International
14:40-14:55	Agrobiodiversity and Wild Foods for Improving Nutrition, Health and Well Being	**T. Longvah,** National Institute of Nutrition
14:55-15:10	Harnessing Traditional Foods for Nutrition and Health	**S. Muranaka,** JIRCAS
15:10-15:25	Utilizing Agrobiodiversity to Scale Up Nutrition: The Kenyan Experience (#1930)	**Gladys Mugambi,** Ministry of Health, Kenya
15:25-15:40	Medicinal Plant Diversity for Health, Wellness and Livelihood in Indian Perspective	**Jitendra Kumar,** DMAPR
15:40-15:55	Community Health and Nutrition: A Practitioner's Perspective	**S. Subhanandhan,** TPSVMS
15:55-16:25	**Rapid Presentations (From Abstracts)** **Veena Gupta,** ICAR-National Bureau of Plant Genetic Resources, India Curative Agro-biodiversity and Indigenous Knowledge Case Studies on conservation through farming communities (#551) **V.K. Vikas,** ICAR-IARI Regional Station, Wellington, India *Triticum dicoccum*: A low GI food for the diabetics (#221) **A.R. Mohd Nazri,** Faculty of Food Science and Nutrition, Universiti Malaysia Sabah, Malaysia Nutritional composition and antioxidant capacity of peels, pulp and arils of spiny gourd (*Momordica Cochinchinensis*) fruits grown in Malaysia (#944)	

	Julia Boedecker, Bioversity International, Kenya Participatory approach to improve dietary diversity in Vihiga County, Western Kenya (#1186)
	T.R. Suma, MS Swaminathan Research Foundation, India Micro level politics of land use impacts agro-biodiversity and rural food and nutritional security: A case study from Wayanad, Kerala (#1287) **K.T. Hoang,** HealthBridge Foundation of Canada, Vietnam Linkage Between Child Nutrition and Agrobiodiversity, Gender Role in Home Gardening in North West of Vietnam (#1457)
16:25-16:40	Discussion and Concluding Remarks
16:40-17:00	***Tea/Coffee Break***

FARMERS' FORUM

14:15-16:40	**Farmers' Role in Conservation of Genetic Resources**
	Moderators : R.R. Hanchinal, PPV&FRA; **A.K. Singh,** ICAR and **Vipin Kumar,** NIF **Convener : R.C. Agrawal,** PPV&FRA **Repporteur : Satya Singh,** NIF
14:15-14:30	Objectives and Expectations
14:30-15:50	**Farmers' representing various Biodiversity Hotspots** Gopal Sahgwan, IRA; Kamalbhai Ambalal Patel, Biofertilizer Indus.; Smt. Anjamma; Mr. Sanjay Patil; Sh. Biharilal Sharma; Prabhat Kumar, IARI; Mr. P. Narayan Unny; Mr. Sharma, Sh. Potshangbam Devakanta, Shri Prakash Singh Raghuvansi; Hariman Sharma, HP; Pandurang Lokhande, MP
15:50-16:15	Open Forum
16:15-16:40	Concluding Remarks
16:40-17:00	***Tea/Coffee Break***

EVENING LECTURE

17:00-18:00	**Evening Lecture**
	Co-Chairs : M.S. Swaminathan, MSSRF and **Ronnie Coffman,** Cornell University **Convener : G.J. Randhawa,** NBPGR **Rapporteurs : Sunil Neelam,** IIMR; **Anitha Pedapati,** NBPGR
17:00-17:10	Introduction
17:10-17:50	Biodiversity, Food, and the Future **Peter Raven,** MBG
17:50-18:00	Concluding Remarks

POSTER SESSION

18:00-19:30	**Poster Session and Visit to Exhibitions**
19:30-21:30	**CIMMYT50 Celebration: Reception Dinner**

8th November, 2016 at AP Shinde Hall

PLENARY SESSION 3

09:00-10:40	**Agrobiodiversity for Livelihood Security and Ecosystem Services**	
	Chair : T. Mohapatra, ICAR and DARE **Convener : Kavita Gupta,** NBPGR **Rapporteurs : K.C. Bhatt,** NBPGR	
09:00-09:10	Introduction	
09:10-09:35	**Plenary Lecture** Agrobiodiversity, Livelihoods and Climate Change	**Kamal Bawa,** University of Massachusetts
09:35-10:00	**Plenary Lecture** Grassroots Innovations for Market Mediated Livelihoods and Value Chain Development	**Anil Gupta,** NIF and IIMA
10:00-10:40	**Panel Discussion** **Panelists : Gerry Jayawardena,** DoA; **Coojse Hoogendoorn,** KIT; **Nikolay Dzyubenko,** VIR; **M.S. Swaminathan,** MSSRF	
10:40-11:00	***Tea/Coffee Break***	

TECHNICAL SESSION 4-A
Science-led Innovation

11:00-13:15	**Concurrent Session: Trait Discovery and Enhanced Use of PGR**	
	Co-Chairs : G.S. Kush, University of California and **Calvin Qualset,** University of California **Convener : M. K. Rana,** NBPGR **Rapporteurs : M. Elangovan,** IIMR; **V. Vikas,** IARI	
11:00-11:05	Introduction	
11:05-11:25	Utilizing Genetic Diversity in CIMMYT Global Wheat Breeding Program	**Ravi Singh,** CIMMYT
11:25-11:45	Challenges and Opportunities for Value Capture from Plant Genetic Resources	**Andreas Graner,** IPK
11:45-12:05	Indian Wild Rice- Diversity, Population Structure, Trait Value and Relation with Cultivated Rice	**N.K. Singh,** NRCPB
12:05-12:25	Introgression of Yield Component Traits and Biotic Stress Resistance Genes in Rice Following Interspecific Hybridization	**Kuldeep Singh,** NBPGR
12:25-12:45	Rapid Presentations (From Abstracts) **Zhang Zongwen,** Bioversity International, China Managing the biodiversity of neglected and utilized crops in China (#1941)	

	S. Gopala Krishnan, IARI, India Genetic enhancement of rice (*Oryza sativa* L.) through inter-specific crosses involving *Oryza rufipogon* and their potential in improving heterosis (#1694) **Sundeep Kumar,** ICAR-National Bureau of Plant Genetic Resources, India Identification of stable heat tolerant wheat germplasm lines under extreme late sown condition (#1123)	
12:45-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 4-B
Science-led Innovation

11:00-13:15	**Concurrent Session: PGR and Genomics**	
	Co-Chairs : Ed Southern, Kirk House Trust and **Akhilesh Tyagi,** University of Delhi **Convener : Rakesh Singh,** NBPGR **Rapporteurs : Lalit Arya,** NBPGR; **Manjusha Verma,** NBPGR	
11:00-11:10	Introduction	
11:10-11:30	Application of Genomics to Enhanced Utilization of Plant Genetic Resources	**Robert Henry,** QAAFI
11:30-11:50	Sears to Sequencing: Deciphering the Potential of Wheat for Hunger-Free World	**Bikram Gill,** Kansas State University
11:50-12:10	Genome Sequencing to Unlock the Potential of African Indigenous Tree Species	**Alice Muchugi,** ICRAF
12:10-12:25	Genome Analysis of Rice Genetic Resources for the Identification of Novel Genes and Alleles for Biotic Stress Resistance	**T.R. Sharma,** NRCPB
12:25-12:45	**Rapid Presentations (From Abstracts)** **Rakesh Singh,** NBPGR, India SNP marker based genetic diversity study in rice germplasm of Arunachal Pradesh (#1166) **Tilak Sharma,** CSK Himachal Pradesh Agricultural University, India Population genetic structure and phylogenetic relationships in lentil species as revealed by morphological and SSR markers (#509) **N. Anuradha,** IARI, India Molecular Diversity in Pearl millet Association Mapping Panel revealed by Genomic and EST SSR Markers (#1783)	
12:45-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 4-C
Science-led Innovation

11:00-13:15	**Concurrent Session: PGR Informatics**	
	Co-Chairs : Stefano Diulgheroff, FAO and **Bhag Mal,** APAARI **Convener : Sunil Archak,** NBPGR **Rapporteurs : D. P. Semwal,** NBPGR; **Rajeev Gambhir,** NBPGR	
11:00-11:10	Introduction	
11:10-11:30	Towards the Third Global Assessment on the State of PGRFA Conservation and Use	**Stefano Diulgheroff,** FAO
11:30-11:50	Digital Technologies to Modernize Effective and Efficient Use of Plant Genetic Resources	**Eric Huttner,** ACIAR
11:50-12:45	**Rapid Presentations (From Abstracts)** **Sunil Archak,** NBPGR India as a Crucible to Develop Integrated Information Systems (#202) **R.S.S. Ratnayake,** National GEF Secretrait, Ministry of Mahaweli, Sri Lanka Modelling Distribution of Neglected and Underutilize Fruit Species in Sri Lanka for Sustainable Utilization (#1182) **V. Girish Naik,** Central Sericultural Research and Training Institute, India Mulberry Genome Network: an interactive web platform for Morus specific genetic and genomic resources (#600)	
12:45-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 4-D
Science-led Innovation

11:00-13:15	**Concurrent Session: Animal and Aquatic Genetic Resources**	
	Co-Chairs : Olivier Hanotte, ILRI and **J.K. Jena,** ICAR **Convener : Kuldeep K. Lal,** NBFGR **Rapporteurs : Rajeev K. Singh,** NBFGR; **Rekha Sharma,** NBAGR	
11:00-11:10	Introduction	
11:10-11:30	Genetic Improvement of Production and Adaptive Traits in Livestock	**J.M. Reecy,** Iowa State University
11:30-11:50	Genomic Resource Development for Aquaculture Species in India	**Vindhya Mohindra,** NBFGR
11:50-12:10	Advanced Reproductive Biotechnologies for Animal Multiplication, Genetic Improvement and Conservation	**A.K. Srivastava,** NDRI
12:10-12:30	Molecular Traceability of Spatial Genetic Diversity for sustainability of Fish Genetic Resources	**Kuldeep K. Lal,** NBFGR

12:30-12:50	**Rapid Presentations (From Abstracts)** **Atul K. Singh,** ICAR-Directorate of Coldwater Fisheries Research, India Status, potential and challenges to the important fish germplasm *vis-a-vis* aquaculture and fishery management in cold water regions of India (#288) **M.M. Chanda,** NIVEDI, India Habitat mapping of Deccani breed of sheep using remote sensing variables: Implications for breed conservation and disease resistance (#604) **Ravinder Singh,** NBAGR, India Cytogenetic and mitochondrial D-loop sequence based characterization of buffaloes of Odisha state in India (#845) **Grinson George,** Central Marine Fisheries Research Institute, India Biodiversity *vis-a-vis* Oceanography: few case studies indicate ecosystem responses as a major factor governing fish distribution in space and time (#1626)
12:50-13:15	Discussion and Concluding Remarks
13:15-14:15	***Lunch***

TECHNICAL SESSION 4-E
Science-led Innovation

11:00-13:15	**Concurrent Session: Insects and Microbial Genetic Resources**	
	Co-Chairs : S.N. Puri, Ex-CAU and **Anupam Verma,** NAAS **Convener : Chandish Ballal,** NBAIR **Rapporteurs : Sanjay Gupta,** NBAIM; **Richa Varshney,** NBAIR	
11:00-11:10	Introduction	
11:10-11:30	Insect Genetic Resources - Innovation for Utilization	**Chandish Ballal,** NBAIR
11:30-11:50	Exploiting the Essence of the Microbial Diversity of the Rann of Kutch for Devising Strategies for Salinity and Drought Tolerance	**K.K. Pal,** DGR
11:50-12:10	Innovations in Insect Pest Management: Interventions Using Insect Derived Volatiles	**K. Subahran,** NBAIR
12:10-12:30	Insights from Genome and Genome Based Informatics of Agriculturally Important Microorganisms	**Alok Srivastava,** NBAIM
12:30-12:50	**Rapid Presentations (From Abstracts)** **Ruchira Kodithuwakku,** Department of Export Agriculture, Sri Lanka A Preliminary Study on Abundance of Selected Soil Organisms in Prominent Landuse Systems at Mid Country of Sri Lanka (#759) **Sanjay Kumar Gupta,** ICAR-NBAIM, India Soil Metaproteomics: A novel tool for deciphering functional diversity from environmental samples (#1491)	
	Ram Nageena Singh, ICAR-Indian Agricultural Research Institute, India Draft Genome and mining of genes from a phosphate solubilizing bacterium *Burkholderia cenocepacia* PS27 (#1688)	
12:50-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 5

14:15-16:40	**Quarantine, Biosafety and Biosecurity Issues**	
	Co-Chairs : Kenja Le Mentec, STDF; and **A.K. Srivastava,** NDRI	
	Convener : Ravi Khetrapal, CABI	
	Rapporteurs : Celia Chalam, NBPGR; **Bharat Gawde,** NBPGR	
14:15-14:20	Introduction	
14:20-14:40	Converging Provisions of CBD and WTO to Ensure Biosecurity	**Ravi Khetrapal,** CABI
14:40-15:00	Invasive species and International Trade	**Kenza Le Mentec,** STDF (WTO)
15:00-15:15	Biosecurity Issues in Germplasm Exchange: African Experience	**P. Lava Kumar,** IITA, Nigera
15:15-15:45	**Panel Discussion** **Biosecurity and Biosafety provisions *vis-à-vis* Agrobiodiversity**	
	Moderator : J.L. Karihaloo, APAARI	
	Panelists: S. R. Rao, DBT; **Gurinder J. Randhawa,** NBPGR; **Vibha Ahuja,** BCIL, **Neeraj Sood,** NBFGR	
15:45-16:20	**Rapid Presentations (From Abstracts)** **Shashi Bhalla,** NBPGR, India Biosecuring import of transgenic crops germplasm into India under quarantine umbrella (#1451) **V. Celia Chalam,** NBPGR, India Role of viral diagnostics in quarantine for plant genetic resources and preparedness (#1515) **M. Mohan,** NBAIR, India *Tuta absoluta*: A new invasive alien insect pest of Solanaceous crops in India threat assessment and management options (#1219) **Kavita Gupta,** NBPGR, India Biosecurity policies influencing international exchange of PGR (#1218) **C. S. Kariyawasam,** Ministry of Environment, Sri Lanka Comparative study of the reproductive biology of gorse (*Ulex europaeus*) in the mount lofty ranges of South Australia and Central highlands of Sri Lanka (#1527) **Pravata K. Pradhan,** NBFGR, India Cyprinid herpesvirus-2: Widespread occurrence in goldfish populations in India (#1767)	
16:20-16:40	Discussion and Concluding Remarks	
16:40-17:00	***Tea/Coffee Break***	

SATELLITE SESSION 3

14:15-16:40	**Climate Change as an Opportunity for Agrobiodiversity Management (GIZ and NEHU)**	
14:15-14:20	Introduction	
14:20-14:30	Setting the Scene: Climate Change Winners and Losers	**Uwe Scholz and Indrani Phukan,** GIZ CCA NER Project
14:30-14:50	Climate Change: Major Winners and Losers in Respect to Agriculture Production and Crops Migration	**N. H. Ravindranath,** IISC
14:50-15:10	Changes in Agrobiodiversity and Arising Opportunities in the North Eastern Region of India (#1934)	**S. K. Barik,** NEHU
15:10-15:30	GIZ Agrobiodiversity Portfolio (#1933)	**Friederike Kraemer and L Wald Miller,** GIZ
15:30-15:45	Importance and new utilization opportunities for Bamboo in northeast India under the angle of climate change and inclusive agro-economic development (#1932)	**Werner Kosemund,** INBAR
15:45-16:00	Traditional Knowledge of Tribal People of Meghalaya in Adaptation to Climate Change: Integrating Traditional Knowledge of the Indigenous People with the Computer Model Output in Vulnerability Assessment and Adaptation Actions (#1931)	**S. Ashutosh,** Government of Meghalaya
16:00-16:15	Advocating for Shifting Cultivation in the context for Climate Change in the Eastern Himalayas - Lessons and Issues (#1935)	**Amba Jamir,** Sustainable Development Forum Network
16:15-16:40	*Discussion and Concluding Remarks* How can opportunities arising due to Climate Change be optimally tapped by rural communities?	
16:40-17:00	***Tea/Coffee Break***	

ROUND TABLE DISCUSSION

14:15-16:40	**Genebank Management: Challenges and Opportunities**	
	Co-Chairs : Marie Haga, Crop Trust and **Kuldeep Singh,** NBPGR **Moderators : H.D. Upadhyaya,** ICRISAT and **R.K. Tyagi,** NBPGR	
14:15-14:25	Objectives and Expectations	
14:25-14:40	Background and Highlighting the Issues	**Prem Mathur,** Bioversity International
14:40-16:30	Round Table Discussion	**Representatives of National and CGIAR Genebanks**
16:30-16:40	Concluding Remarks	
16:40-17:00	***Tea/Coffee Break***	

PUBLIC FORUM

17:00-18:30	**Role of Stakeholders in Agrobiodiversity Management**
	Co-Chairs : **M.S. Swaminathan,** MSSRF and **R.S. Paroda,** ISPGR & TAAS
17:00-17:20	Objectives and Expectations
17:20-18:00	**Panel Discussion** **Panelists :** **Adel El-Beltagy,** IDDC; **Anil Gupta,** NIF; **Ajay Jakhar,** BKS; **Sunita Sreedharan,** SKS Law
18:00-18:20	**Open Forum**
18:20-18:30	Concluding Remarks

POSTER SESSION

18:30-19:30	Poster Session and Visit to Exhibitions
19:30-20:15	**Cultural Program**
20:15-21:30	***Dinner at Podium Lawns, NASC Complex, Pusa***

9th November, 2016 at AP Shinde Hall

Plenary Session 4

09:00-10:40	**ABS in the Context of Regulatory Systems**	
	Co-Chairs : **Adel El-Beltagy,** IDDC and **B. Meena Kumari,** NBA **Convener :** **Pratibha Brahmi,** ICAR **Rapporteurs :** **Shashi Bhalla,** NBPGR; **Vandana Tyagi,** NBPGR	
09:00-09:10	Introduction	
09:10-09:35	**Plenary Lecture** Rust, Risk, and Germplasm Exchange: The Borlaug Global Rust Initiative	**Ronnie Coffman,** Cornell University
09:35-10:00	**Plenary Lecture** Regulating Access to Genetic Resources and Benefit Sharing: International Treaties and Indian Experience	**Rai S. Rana,** NBA and Ex-NBPGR
10:00-10:40	**Panel Discussion** **Panelists :** **R.S. Hamilton,** IRRI; **Sudhir Kochhar,** Ex-ICAR; **Neeti Wilson,** Anand and Anand	
10:40-11:00	***Tea/Coffee Break***	

TECHNICAL SESSION 6

11:00-13:15	**IPRs, ABS and Farmers' Rights**	
	Co-Chairs : R.B. Singh, Central Agricultural University and **Lim Eng Siang,** ITPGRFA **Convener : Pratibha Brahmi,** NBPGR **Rapporteurs : Poonam J. Singh,** NBFGR; **Shakti Khera,** NBPGR	
11:00-11:10	Introduction	
11:10-11:30	Indian Initiatives on Farmers' Rights	**R.R. Hanchinal,** PPV&FRA
11:30-11:50	The Role of ITPGRFA in Agrobiodiversity Management: Future Strategies and Actions	**Lim Engsiang,** ITPGRFA
11:50-12:10	Access and Benefit-Sharing of Animal Genetic Resources	**Ilse Köhler-Rollefson,** League for Pastoral Peoples
12:10-12:55	**Rapid Presentations (From Abstracts)** **Pratibha Brahmi,** NBPGR, India Alternative options for benefit sharing under ITPGRFA (#33) **C. Thomson Jacob,** National Biodiversity Authority, India Mainstreaming biodiversity into the agricultural sector (#756) **Sherry Rachel Jacob,** NBPGR, India The global conservation status of Indian germplasm and its implications (#732) **Prabha S. Nair,** National Biodiversity Authority, India Germplasm exchange from India under the multilateral system *vis-a-vis* the Biological Diversity Act, 2002: A critical appraisal (#1580)	
12:55-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

TECHNICAL SESSION 7

11:00-13:15	**Partnership, Networks and Capacity Building**	
	Co-Chairs : Gurbachan Singh, ASRB and **H. S. Dhaliwal,** Eternal University **Convener : S. P. Ahlawat,** NBPGR **Rapporteurs : S. K. Yadav,** NBPGR; **Anurag Khanujia,** NISCAIR	
11:00-11:10	Introduction	
11:10-11:30	International PGR networks on commodity crops – Lessons learned and success stories	**Stephan Weise,** Bioversity International
11:30-11:45	Capacity Building in Application of Biotechnology for Germplasm Enhancement	**Darshan Brar,** PAU
11:45-12:00	Implementation of SUWON Declaration	**Raghunath Ghodake,** APAARI
12:00-12:15	Transforming Indian Agriculture for National and Global Environmental Benefits and Biodiversity Conservation	**Shyam Khadka,** FAO

12:15-12:30	Post-disaster Revival of the Local Seed System and Climate Change Adaptation	**Devendra Gauchan,** Bioversity International,Nepal
12:30-12:45	A Resource Box for Resilient Seed Systems	**Paul Quek,** Bioversity International
12:45-12:55	Plant Diversity to Improve Food Security and Livelihoods of Local Communities	**Tiziana Ulian,** Royal Botanic Gardens
12:55-13:15	Discussion and Concluding Remarks	
13:15-14:15	***Lunch***	

SATELLITE SESSION 4

11:00-13:15	**Crop Wild Relatives: Back to the Wild to Save the Future (Bioversity International and University of Birmingham)**	
11:00-11:05	**Introductory remarks by Co-Chairs :** **Ehsan Dulloo,** Bioversity International and **Bikram Gill,** Kansas State University	
11:05 -11:20	Utilization of Crop Wild Relatives in the Indian Breeding Programs: Progress, Impact and Challenges	**J.S. Sandhu,** ICAR
11:20-11:35	Conservation Planning for Crop Wild Relative Diversity in the SADC Region (#645)	**Joana Magos Brehm**
11:35-11:45	A strategic approach to crop wild relative conservation in mega-diverse Mexico (#286)	Aremi Contreras Toledo
11:45-11:55	Identification and collection of priority crop wild relatives in three provinces of South Africa (#1002)	**Nkat Lettie Maluleke**
11:55-12:05	Re-collection to assess temporal variation in wild barley diversity in Jordan (#988)	**Imke Thormann**
12:05-12:15	Conservation planning and climate change mitigation of Global CWR Diversity	**Nora Patricia Castañeda Álvarez**
12:15-12:25	Spatial analyses of CWR occurrence data as tools for selection of sites for conservation of priority CWR in Zambia (#921)	**Dickson Ng'uni**
12:25-12:35	Exploring the wilds: Harnessing genetic potential for crop improvement (#1096)	**N.C. Gupta**
12:35-12:45	Genetic variability for nutritional traits among wild relatives of pearl millet conserved at ICRISAT Genebank (#1059)	**Santosh K. Pattanashetti**
12:45-13:15	Impacts of a changing climate on natural conservation priorities for CWR	**J. Phillips**
13:15-13:30	Horizon scanning exercise for global CWR action for the shoot, medium and long term future	**Nigel Maxted,** Univ. of Birmingham - facilitator
13:30-14:15	***Lunch***	

CONCLUDING SESSION

14:15-16:40	**Concluding Session**
14:15-14:25	Introductory Remarks
14:25-15:25	Presentation of Congress Recommendations
15:25-15:45	Delhi Declaration on Agrobiodiversity Management
15:45-16:00	Discussion on IAC2020
16:00-16:40	Concluding Remarks by the Organizers/Co-Chairs


OFFICE BLOCK


अन्तर्राष्ट्रीय कृषि-जैवविविधत
विज्ञान, तकनीकी, नीति एवं साझेदारी
6-9, 2016, नई दिल्ली


IAC 2016
प्रथम अन्तर्राष्ट्रीय कृषि-जैवविविधता काँग्रेस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E-H
A-D
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RAMESH CHAND
GLIMPSES OF AGRO-BIODIVERSITY