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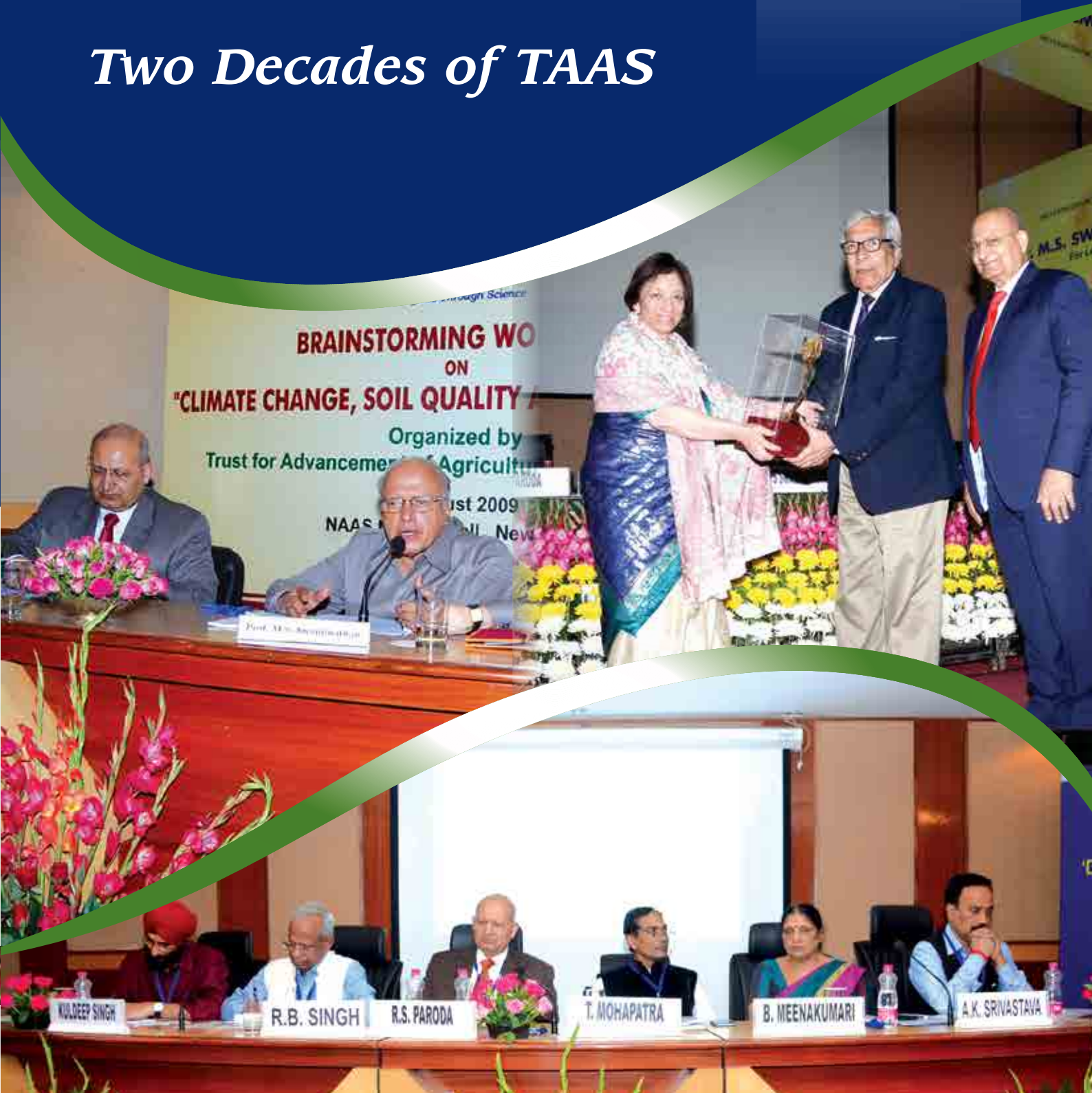
Progress Through Science

Accelerating Science-Led Growth in Agriculture:

Two Decades of TAAS



About Founding Chairman of TAAS

Dr Raj S. Paroda is the founding Chairman of TAAS. Dr.Paroda has made valuable contributions in the field of agriculture both as a researcher and an able administrator. His contributions in the field of plant breeding and genetic resource management are globally recognized. During the period 1994-2001, Dr.Paroda spearheaded and modernized the national agricultural research system (NARS) as Director General, Indian Council of Agricultural Research (ICAR) and Secretary, Department of Agricultural Research and Education (DARE), Government of India. He modernized Indian National Agricultural Research System (NARS) and created more than 30 new institutions including the National Gene Bank. International Crop Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru and the Agriculture Research Institute of Kazakhstan have named their Gene Banks after Dr Raj Paroda in recognition of his notable contributions in the field of genetic resource management. The prestigious National Agriculture Technology Project (NATP) to reorient agricultural research, education and extension system of India was designed and negotiated with World Bank for US $ 250 million in 1998 under his dynamic leadership.

He was General President of Indian Science Congress (2001) and the National Academy of Agricultural Sciences. Among international recognitions, he was elected as Fellow of Agricultural Academies of Russia, Georgia, Armenia, Tajikistan and the Third World Academy of Sciences (TWAS). He also served as President of more than a dozen Agricultural Scientific Societies in India. He was instrumental in establishing Asia Pacific Association of Agricultural Research Institutions (APAARI), at FAO, Bangkok and served with great distinction as Executive Secretary for over two decades. He was elected Founder Chairman, Global Forum on Agricultural Research (GFAR), Chairman, ICRISAT Board of Trustees. Twenty (20) universities have awarded him D.Sc. degree (*Honoris Causa*), including Ohio State University. He is Honorary Fellow of American Society of Crop Science and American Society of Agronomy, besides fellow of TWAS and Agricultural Academies of Russia, Armenia, Georgia, Tajikistan and Kazakhstan. He is recipient of many national and international awards, including Padma Bhushan. Other awards included Rafi Ahmed Kidwai Memorial Prize, ICAR Team Research Award, FICCI Award, Om Prakash Bhasin Award, APSA Special Award, Life Time Award by Association of Agricultural Scientists in America, Dr Harbhajan Singh Memorial Award, Dr BP Pal Memorial Award, Borlaug Award, 'US Awasthi IFFCO Award', and Dr MS. Swaminathan Award for Environment Protection 2020. Currently, he is Chairman, Trust for Advancement of Agricultural Science, New Delhi.

For the overall benefit of farmers, lately Dr Paroda served as Chairman, Farmers' Commission of Haryana, Chairman of Working Group on Agriculture and Member of Rajasthan Planning Board. As Chairmen of the Trust for Advancement of Agricultural Sciences (TAAS), his goal during last two decades is to harness potential of agricultural sciences by linking science to society through policy advocacy and public awareness.

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Two Decades of TAAS

Compiled and Edited by

Raj Paroda, Bhag Mal and Umesh Srivastava

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Progress Through Science

Foreword

I have observed the significant progress made by the Trust for Advancement of Agricultural Sciences (TAAS). In a span of two decades, TAAS has emerged to be a vibrant national 'Think Tank' under the visionary leadership of Dr Raj S. Paroda. It has executed several activities aiming at faster agricultural growth by linking science to society, mainly through policy advocacy and public awareness on thematic issues of national importance. Its special focus on technology transfer through knowledge sharing without dissemination loss, capacity building, especially of youth (including women) and required networking of institutions and stakeholders to address both current and emerging challenges in Indian agriculture is indeed praiseworthy. TAAS is known to have catalyzed diverse stakeholders to strengthen agricultural research, education and extension related activities aiming at higher production as well as consumption while ensuring sustainability and household food and nutritional security.

It is quite impressive that TAAS has organized more than 41 national/international conferences/workshops, six policy dialogues, and 11 Foundation Day Lectures. I am impressed with the proceedings and recommendations brought out well in time and in most impressive manner. These publications have also influenced many policy decisions for accelerating growth of Indian agriculture. It has also honoured 11 eminent scientists of international repute with Dr M S Swaminathan Award for Leadership in Agriculture. Besides, TAAS has brought out 20 strategy papers on subjects of great national relevance. TAAS has also awarded Life Membership to more than 100 eminent agricultural scientists.

The publication entitled "Accelerating Science-Led Growth in Agriculture: Two Decades of TAAS" provides an impressive account of various achievements of TAAS over the past 20 years. I commend the efforts of Dr Raj Paroda, Dr Bhag Mal and Dr Umesh Srivastava for bringing out this comprehensive publication. I am confident that this publication will be of immense use to researchers, science managers, policy planners, students, farmers and the representatives of the private sector.

M S Swaminathan

Dr. R.S. Paroda

General President, 88th Session of Indian Science Congress &
Founder Chairman TAAS till date

Preface

The Trust for Advancement of Agricultural Sciences (TAAS) was established as a consequence of vision statement made by the then Hon'ble Prime Minister, Shri Atal Bihari Vajpayee while inaugurating the 88th Session of the Indian Science Congress in 2001. He had exhorted the scientists to interact with people to create required scientific temper in the society so as to stimulate a positive change for faster agricultural growth. To achieve this objective, the organising committee of the congress decided to form a neutral platform to ensure timely interface among agricultural scientists-stakeholders-policy makers to debate on issues of national importance. Thus, the Trust for Advancement of Agricultural Sciences (TAAS) was formed soon after the Indian Science Congress that I happened to preside with active support of its founder Vice-President Dr. Anupam Varma, Secretary late Dr. N.N. Singh and members, especially Dr Narendra Gupta and late Dr. S. Nagarajan.

The primary objective of TAAS is to act as a 'Think Tank' to deliberate on thematic issues around agricultural research and innovation for development (ARI4D) and catalyze the policy makers for implementation of important recommendations. In the last two decades, TAAS has organized a series of national, regional and international conferences, symposia, workshops, seminars, brainstorming sessions and stakeholders' dialogues. Besides, it has organised lectures of eminent agricultural scientists, and brought out number of strategy papers and success stories on topics of national interest. It has also conferred Dr MS Swaminathan Award for Leadership in Agriculture on eminent scientists in recognition of their outstanding contributions in the field of agriculture .

The recommendations emerging out of various events organised by TAAS have sensitised the policy makers to ensure needed diversification in agriculture, improve both productivity and sustainability, and create the much needed awareness among farmers for judicious use of natural resources, especially the land and water. It has brought out number of important publications, which have been well received by the researchers, policy makers, development personnel, students and especially the farmers. While TAAS has made outstanding contributions for the welfare of the society, it continues to strive for diversified activities, with greater emphasis on scaling innovations for impact on smallholder farmers to improve their production and profitability.

This publication entitled **"Accelerating Science-Led Growth in Agriculture: Two Decades of TAAS"** provides a comprehensive account of various achievements of TAAS during the past 20 years of its existence. I appreciate and acknowledge the contributions of all colleagues and friends from the TAAS family in India and abroad who have actively participated and contributed towards making the journey of TAAS highly productive and fruitful. I also wish to thank especially Dr Bhag Mal and Dr Umesh Srivastava for their sincere efforts in compiling and editing the manuscript and Ms Simmi Dogra for her secretarial assistance.

It is my expectation that the readers will find this compilation both informative and useful.

R.S. Paroda,
Chairman, TAAS

Progress Through Science

Acknowledgements

The Trust for Advancement of Agricultural Sciences (TAAS) owes its establishment to the vision of Padma Bhushan Dr. R.S. Paroda, former Secretary, Department of Agricultural Research and Education (DARE) and Director General, Indian Council of Agricultural Research (ICAR) and the General President of the 88th Session of the Indian Science Congress held in January, 2001 at the Indian Agricultural Research Institute (IARI) Campus, New Delhi. He conceptualized the idea, and established a platform to link science with society through a Think Tank process for deliberating on important national issues relating to agricultural research for innovation and development, and in the process to sensitize the policy makers. The impact made by TAAS on different policy making agencies is a testimony of the dynamic leadership provided by Dr. Paroda, and the able Trustees of TAAS.

Establishment of TAAS was made possible mainly due to support of Dr. S. Nagarajan, former Director, IARI who provided an office space on the campus of prestigious Indian Agricultural Research Institute (IARI), popularly known as 'Pusa Institute' in December, 2002. The subsequent Directors, Dr. S.A. Patil, Dr. H.S. Gupta, Dr. Trilochan Mohapatra, Dr. A.K. Singh and now Dr. Ashok Kumar Singh extended their full support to TAAS and its activities which is highly appreciated. Currently, Dr. Trilochan Mohapatra, Secretary, DARE and Diretor General, ICAR and Dr. Ashok Kumar Singh, Director, IARI are closely associated with TAAS as trustees. TAAS gratefully acknowledges their esteemed support.

Some corporate houses and organizations like Mahyco Foundation, Sehgal Foundation, Venkateshwara Hatcheries, Monsanto, Nuziveedu Seeds Pvt. Ltd., National Seed Association of India (NSAI), Rasi Seeds, Asia-Pacific Association of Agricultural Research Institutions (APAARI), National Academy of Agricultural Sciences (NAAS), and a few State Agricultural Universities (SAUs) have provided their support to TAAS activities, which is duly acknowledged. Mahyco's continued support for the prestigious Dr. M.S. Swaminathan Award since its inception is very much appreciated. The valuable help provided by late Dr. R.K. Arora, late Dr. N.N. Singh and Dr. P.L. Gautam and Dr. Narendra Gupta is highly appreciated.

This publication entitled **"Accelerating Science-Led Growth in Agriculture: Two Decades of TAAS"** summarizes the highlights of two decades (2001-2021) of TAAS journey. Under the able guidance of Dr. R.S. Paroda, I along with Dr. Umesh Srivastava have updated this publication by adding the achievements and contributions of TAAS during the past five years (2016 -2020/21) to the previous publication 'Building Trust: The Journey of TAAS (2001-2015)', thoroughly reviewed, abridged and edited the manuscript to make it more crisp. Ms. Simmi Dogra has provided secretarial assistance which is very much appreciated and acknowledged.

Bhag Mal
Secretary, TAAS

Progress Through Science

Acronyms and Abbreviations

AAEA	American Applied Economics Association
ABS	Access & Benefit Sharing
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AI	Artificial Insemination / Artificial Intelligence
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APCoAB	Asia-Pacific Consortium on Agricultural Biotechnology
APEDA	Agricultural & Processed Foods Export Development Authority
APMC	Agricultural Produce Marketing Committee
AR4D	Agricultural Research for Development
ARI	Agricultural Research Institutions
ARI4D	Agricultural Research & Innovation for Development
ARYA	Attracting and Retaining Youth in Agriculture
ASSOCHEM	Associated Chambers of Commerce and Industry of India
ATARI	Agricultural Technology Application Research Institute
ATIC	Agricultural Technology Information Centre
ATMA	Agricultural Technology Management Agency
AVRDC	Asian Vegetable Research and Development Center
AZRAI	Arid Zone Research Association of India
BAR	Bureau of Agricultural Research
BAU	Bihar Agricultural University / Birsa Agricultural University
BCM	Billion Cubic Meter
BDA	Biodiversity Authority
BI	Bioversity International
BISA	Borlaug Institute for South Asia
BMGF	Bill & Melinda Gates Foundation
BPD	Business Planning & Development
BRAI	Biotechnology Regulatory Authority of India
CA	Conservation Agriculture
CABI	Centre for Agriculture and Bioscience International
CACP	Commission for Agricultural Cost & Prices
CAGR	Compound Annual Growth Rate
CASI	Conservation Agriculture based Sustainable Intensification
CAZRI	Central Arid Zone Research Institute
CBD	Convention on Biological Diversity
CCAFS	Climate Change Agriculture & Food Security
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CDRI	Central Drug Research Institute
CFF	Crops for the Future
CGIAR	Consultative Group on International Agricultural Research

CIAE	Central Institute of Agricultural Engineering
CIB&RC	Central Insecticides Board & Registration Committee
CIBA	Central Institute of Brackishwater Aquaculture
CIFA	Central Institute of Freshwater Aquaculture
CIFT	Central Institute of Fisheries Technology
CII	Confederation of Indian Industry
CIMMYT	International Maize and Wheat Improvement Center
CM	Cubic Meter
CSA	Climate Smart Agriculture
CSIR	Council of Scientific & Industrial Research
CSISA	Cereal Systems Initiative for South Asia
CSO	Civil Society Organization
CSR	Corporate Social Responsibility
CWANA	Central and West Asia & North Africa
CWR	Crop Wild Relatives
DAC/DoAC	Department of Agriculture and Cooperation
DAD-IS	Domestic Animal Diversity Information System
DARE	Department of Agriculture Research and Education
DBT	Department of Biotechnology
DFI	Doubling Farmers' Income
DH	Double Haploid
DIPP	Department of Industrial Policy & Promotion
DMAPR	Directorate of Medicinal & Aromatic Plants Research
DoA	Department of Agriculture
DoAHD&F/DAHD&F	Department of Animal Husbandry Dairying & Fisheries
DSS	Development Support System
DST	Department of Science and Technology
DUs	Deemed Universities
DUS	Distinctness, Uniformity and Stability
EDP	Executive Development Programme
EEI	Extension Education Institute
EPA	Environmental Protection Agency
ESI	Entomological Society of India
FAO	Food and Agricultural Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FCO	Fertilizer Control Order
FDI	Foreign Direct Investment
FICCI	Federation of India Chambers of Commerce and Industry
FIPB	Farmers' Innovation Promotion Board
FLD	Front Line Demonstration
FO	Farmers' Organization
FRI	Forest Research Institute
FSHG	Farmers' Self Help Groups
FSSAI	Food Safety Standards Authority of India
GAP	Gender in Agricultural Partnership / Good Agricultural Practices
GCARD	Global Conference on Agricultural Research for Development
GCWA	Global Conference on Women in Agriculture
GDP	Gross Domestic Product
GEAC	Genetic Engineering Appraisal Committee

GFAR	Global Forum on Agricultural Research
GHGs	Green House Gases
GI	Geographical Indications
GIS	Geographical Information System
GLP	Good Laboratory Practices
GM	Genetic Modification/Genetically Modified
GMO	Genetically Modified Organism
GO	Government Order
GOT	Grow Out Test
GPS	Global Positioning System
GR	Green Revolution
GURT	Genetic Use Restriction Technology
HPC	High Powered Committee
HRD	Human Resource Development
HYV	High Yielding Variety
IAAE	International Association of Agricultural Economists
IAC	International Agrobiodiversity Congress
IARC	International Agricultural Research Center
IARI	Indian Agricultural Research Institute
IASRI	Indian Agricultural Statistics Research Institute
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agriculture Research in the Dry Areas
ICDD	International Conference on Dryland Development
ICDS	International Child Development Scheme
ICRAF	World Agroforestry Centre
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information Communication Technology
IFAD	International Fund for Agricultural Development
IFFCO	Indian Farmers' Fertilizer Co-operative
IFPRI	International Food Policy Research Institute
IIHR	Indian Institute of Horticultural Research
IIT	Indian Institute of Technology
IITA	International Institute for Tropical Agriculture
ILRI	International Livestock Research Institute
IMOD	Inclusive Market Oriented Development
INDC	Intended Nationally Determined Contributions
INM	Integrated Nutrient Management
INSPIRE	Innovation in Science Pursuit for Inspired Research
IoT	Internet of Things
IPM	Integrated Pests Management
IPNI	International Plant Nutrition Institute
IPNS	Integrated Plant Nutrient System
IPO	Agricultural Products Industry / Initial Public Offering
IPR	Intellectual Property Right(s)
IPRS	In-Pond Raceway System
IPS	Indian Phytopathological Society
IRRI	International Rice Research Institute
ISAF	Indian Society of Agroforestry
ISAS	Indian Society of Agricultural Statistics

ISC	Indian Science Congress
ISCA	Indian Science Congress Association
ISGPB	Indian Society of Genetics & Plant Breeding
ISPRD	Indian Society of Pulses Research and Development
ISST	Indian Society of Seed Technology
ITDS	International Technology Dissemination System
ITK	Indigenous Technical Knowledge
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
IVLP	Institute Village Linkage Program
IVRI	Indian Veterinary Research Institute
JIRCAS	Japan International Center for Agriculture Sciences
KRIBHCO	Krishak Bharat Cooperative
KT	Knowledge Transfer
KVK	*Krishi Vigyan Kendra*
LFM	Linking Farmers to Market
LLRUVAS	Lala Lajpat Rai University of Veterinary and Animal Sciences
MANAGE	National Institute of Agricultural Extension Management
MAS	Marker Assisted Selection
MAYA	Motivating and Attracting Youth in Agriculture
MDG	Millennium Development Goals
MDP	Management Development Programme
MGMG	*Mera Gaon Mera Gaurav*
MGNREGA	Mahatma Gandhi National Rural Employment Guarantee Act
MIDH	Mission for Integrated Development of Horticulture
MoA&FW	Ministry of Agriculture & Farmers' Welfare
MoEF&CC	Ministry of Environment, Forest & Climate Change
MOET	Multiple Ovulation and Embryo Transfer
MoFPI	Ministry of Food Processing Industries
MoS&T	Minister of Science & Technology
MSP	Minimum Support Price
MSSRF	MS Swaminathan Research Foundation
MTA	Material Transfer Agreement
N_2O	Nitrous Oxide
NAARM	National Academy of Agricultural Research Management
NAAS	National Academy of Agricultural Sciences
NABARD	National Bank for Agriculture and Rural Development
NABL	National Accreditation Board for Testing & Calibration Laboratories
NACA	Network of Aquaculture Centers in Asia-Pacific
NACD	National Council on Agricultural Development
NAD&FWC	National Agricultural Development & Farmers' Welfare Council
NAEEP	National Agricultural Education & Extension Project
NAIS	National Agricultural Information System
NARES	National Agricultural Research & Education System
NARS	National Agricultural Research System
NASC	National Agricultural Science Complex
NASF	National Agricultural Science Fund
NASI	National Academy Sciences, India
NBA	National Biodiversity Authority
NBPGR	National Bureau of Plant Genetic Resources

NBS	Nutrient Based Subsidies
NDDB	National Dairy Development Board
NEK	Non-Exchangeable K (Potassium)
NFDB	National Fisheries Development Board
NFSM	National Food Security Mission
NGDA	National Grossland Development Authority
NGO	Non-Governmental Organization
NHEC	National Higher Education Commission
NIAP	National Institute of Agricultural Economics and Policy Research
NIC	National Informatics Centre
NICRA	National Initiative on Climate Resilience Agriculture
NIF	National Innovation Fund, National Innovation Foundation
NIN	National Institute of Nutrition
NIP	New Investment Policy
NIPB	National Institute of Plant Biotechnology
NITI	National Institution for Transforming India
NLM	National Livestock Mission
NOC	Network Operation Centre
NOPT	Nutrient Omission Plot Technique
NPABS	Nagoya Protocol on Access and Benefit Sharing
NPBBD	National Program for Bovine Breeding Dairy Development
NRAA	National Rainfed Area Authority
NRBMP	National Resource Best Management Practices
NRCPB	National Research Centre for Plant Biotechnology
NRDC	National Research Development Council
NRM	National Resource Management
NSAI	National Seed Association of India
NSR&EP	National Seed Registration & Export Promotion Council
NSSO	National Sample Survey Office
NUS	Neglected & Underutilized Species
ODA	Overseas Development Agency
OPV	Open Pollinated Variety
OSU	Ohio State University
PAU	Punjab Agricultural University
PCAARRD	Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development
PCARRD	Philippines Council of Agriculture, Forestry and Natural Resources Research & Development
PCO	Pest Control Operator
PDS	Public Distribution System
PHT	Post-Harvest Technology
PJTSAU	Professor Jayashankar Telangana State Agricultural University
PMB	Pesticides Management Bill
PPP	Public-Private Partnership
PPV&FRA	Protection of Plant Varieties & Farmers' Rights Authority
PRD	Protecting Regulatory Data
QPM	Quality Protein Maize
R&D	Research and Development
RAAI	Rainfed Area Authority of India
RAC	Research Advisory Committee
RAP	Regional office for Asia & Pacific (FAO)

RDNA	Recombinant DNA
RKVY	*Rashtriya Krishi Vikas Yojana*
RPS	Retention Pricing Scheme
RRS	Regional Research Station
RWC	Rice-Wheat Consortium
SABC	South Asia Biotechnology Centre
SAHD	State Animal Husbandry Department
SAR	Synthetic Aperture Radar
SAU	State Agricultural University
SDA	State Department of Agriculture
SDAH	State Department of Animal Husbandry
SDIP	Sustainable Development Investment Portfolia
SHG	Self-Help Group
SITARE	Students Innovation for Advancement of Research Explorations
SMS	Straw Management System
SMTA	Standard Material Transfer Agreement
SOC	Soil Organic Carbon
SPAD	Soil Plant Analysis Development
SPS	Society of Pesticide Science, India
SRC	Staff Research Council
SRFSI	Sustainable & Resilient Farming Systems Intensification
SRR	Seed Replacement Rate
SSC	State Seed Corporation
STCR	Soil Test Crop Response
TAMNET	Tropical Asian Maize Network
TFL	Truthfully Labelled
TFP	Total Factor Productivity
TIFAC	Technology Information Forecasting and Assessment Council
TM	Trade Mark
TMOP	Technology Mission on Oilseeds and Pulses
TOR	Team of Reference
TP	Technology Parks
UIN	Unique Identification Number
UNCCD	United Nations Convention to Combat Desertification
UNEP	United National Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNICEF	United Nations Children's Fund
UPOV	International Union for Protection of New Varieties of Plants
USAID	United States Agency for International Development
UUC	Under Utilized Crops
VCU	Value for Cultivation and Use
WTO	World Trade Organization
YPARD	Young Professionals for Agricultural Development
ZTM	Zonal Technology Management

1 Genesis of TAAS

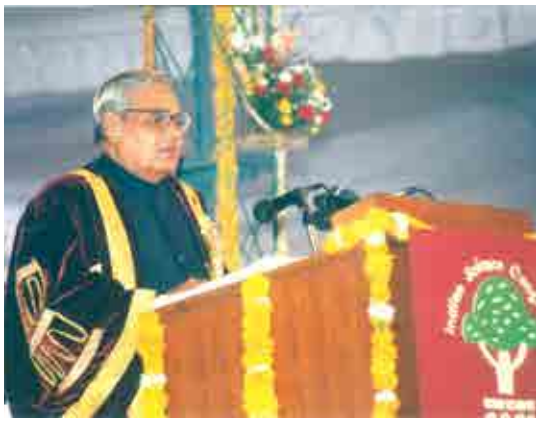
Background

The Trust for Advancement of Agricultural Sciences (TAAS) is a non-profit organization formed in response to a vision statement (Annexure-1) prepared jointly by all the Science Academies of India and released by the then Hon'ble Prime Minister, Shri Atal Bihari Vajpayee, while inaugurating the 88th Session of the Indian Science Congress (88th ISC) at the Indian Agricultural Research Institute (IARI), New Delhi on January 3, 2001. He had observed in his inaugural speech that science and technology will perhaps be the most potent among the many forces that will shape human history in the new millennium. He exclaimed that "Our goal to make India a leading nation in the world in the new century hinges critically on how successfully we take science to the people and create a strong scientific temper in our society".

The 88th ISC left a deep impression of the Indian leadership on all generations of Indian scientists and the budding scholars pursuing various streams of science as they turned past the millennium. They also realized the importance of food, nutrition and environmental security. This was a good beginning but the much more was required to be done in agriculture sector as a follow up. Dr. R.S. Paroda, General President of the 88thsession while reviewing the details of this overwhelming success with the National Organizing Committee also brought out two critical follow up points to their attention. First, the agricultural sciences need further systematic nurturing and promotion through research to contribute to sustainable economic development. Second, the 88th ISC should not be concluded as a singular event but it should be a beginning of a new movement of harnessing science, particularly agricultural sciences, for the welfare of people and the national economy. The idea was spontaneous but capable of writing a new chapter to drive scientific pursuits for development in farm sector. Eventually, Dr. R.S. Paroda built a consensus and decided to form a Trust by the name of "Trust for Advancement of Agricultural Sciences (TAAS)", dedicated to the cause of agriculture, farmers, enterprises/industry and humanity. The Trust was formally registered vide document No. 4700, in Book No. IV, Volume No. 3075 on pages 23 to 30 on 17 October, 2002 in the office of the Sub-Registrar, Sub-Distt. No. III, New Delhi with its Headquarters at the Indian Agricultural Research Institute (IARI), New Delhi.

Genesis

The Indian Science Congress Association (established in 1914) has been into the service to the nation to advance and promote the cause of science in India for more than a century now. The 88th Session of the Indian Science Congress was held in New Delhi from 3-6 January 2001. It was organized on the campus of country's premier national institute, the Indian Agricultural Research Institute (IARI), New Delhi. Dr. R.S. Paroda, the then Secretary, Department of Agricultural Research and Education (DARE), Government of India and Director General, Indian Council of Agricultural Research (ICAR) was elected as the General President for this Session, and he had been actively leading the preparations as President Elect since the conclusion of the 87th session held in January 2000. The 88th Session of ISC being the



Hon'ble Prime Minister, Shri Atal Bihari Vajpai Inaugurating 88th Session of Indian Science Congress, 2001

Release of Vision Document by Hon'ble Prime Minister

first one of the new millennium, and keeping in view the United Nations Millennium Development Goals (MDGs) proclaimed in 2000, the theme of the science congress was specially chosen to address: "Food, Nutrition and Environmental Security".

Agriculture is the source of perpetual creations on which civilization depends. The Millennium Summit of the United Nations in 2000 had adopted of the United Nations Millennium Declaration and established eight international development goals, commonly known as the Millennium Development Goals. The world had already recognized the importance of sustainable development at the Earth Summit in 1992 and then set these MDGs in various sectors at the turn of the century; to be achieved by 2015. Thus, the role of agricultural sciences became even more prominent as they were poised to make potential contribution to the eradication of extreme poverty and hunger, provide nutrition to improve maternal and child health, and contribute to ensuring environmental sustainability.

The inaugural speech (Annexure 1) by the then Hon'ble Prime Minister, Shri Atal Bihari Vajpayee was full of motivation. He exclaimed, "Of the many forces that will shape human history in the new millennium, science and technology will perhaps be the most potent". We know how science and technology have changed the complexion of the world in the last couple of centuries of the last millennium. But this is just the beginning of a long and exciting voyage. All the discoveries of science and all the inventions of technology so far amount to the arrival of just a couple of stars in a sky of countless stars that are yet to appear. On thematic area of the 88th ISC, the Hon'ble Prime Minister observed, "Having achieved food sufficiency, our aim now is to achieve food security for all our citizens. The percentage of our population living below the poverty line has come down, and we have overcome starvation. Our objective now is to overcome malnutrition. The new century will be the Century of Knowledge and the Century of Mind. However, if the brain does not develop properly in nearly one-third of our children who are undernourished, how will we be able to create those young minds that are essential to build India of our dreams in the 21st century? More than 50 per cent of the pregnant women and children are anemic. Vitamin and protein deficiencies are rampant. These realities overshadow our achievements and burden our national conscience. ... "I urge the participating scientists to come up with comprehensive and useful recommendations to deal effectively with all the issues relating to food, nutrition, and environmental security. Accomplishing this task requires massive efforts in many areas. ..."

During the inaugural function, the Hon'ble Prime Minister also released an important 'Vision Statement' (Annexure 2) brought out jointly by all the National Scientific Academies. It stated:

"... By 2020, India will be free of poverty, hunger and malnutrition, and become an environmentally safe country. This, we believe, will be possible to achieve through accelerated social and economic development by harnessing the advances in science, and blending them with our indigenous knowledge, wisdom and unique socio-cultural ethos. We believe India can banish poverty and emerge as a developed nation by promoting growth through efficient and sustainable use of our human, natural and other resources. ..."

The Vision Statement concluded by stating: "Hunger free India is an idea whose time has come. Let us launch a science-based crusade for the elimination of hidden hunger and malnutrition".

The 88th ISC came out with a series of recommendations and way forward (Annexure 3) to give a fresh impetus for actions aimed at sustainable development as well as nutritional and food security. Government of India, Ministry of Agriculture has a separate department to administer the activities related to agricultural research and education, and the country has an elaborate national agricultural research system comprising of ICAR institutions and state agricultural universities. Many professional societies and the academy of agricultural sciences provide supplementary scientific and academic back-ups. Some NGO and private sector led R&D establishments are also prominent besides many international agricultural research centres having their regional or country offices in India. They perform their mandate based activities. A new realization came with the 88th ISC that much more was needed to be done to carry out the Hon'ble Prime Minister's 'agricultural science based crusade for

Inauguration of TAAS office

the elimination of hidden hunger and malnutrition'. A High Level Think Tank could have been a relevant complementary mechanism to assess, deliberate and recommend researchable and policy issues of highest esteem. In view of this, TAAS got established to act as a 'Think Tank' to deliberate on thematic issues of national importance and provide a neutral platform to all stakeholders associated with agricultural research for development (AR4D) in India. Significant events pertaining to the establishment of TAAS are given in the Box 1.

Box 1 : Important Dates and Events leading to establishment of TAAS

3 January 2001

Inaugural speech by the Hon'ble Prime Minister in the 88th ISC stressing the need for creating scientific temper and reaching the society

7 January 2001

Decision to form a Trust under the Chairmanship of Dr. R.S. Paroda, General President of the Indian Science Congress

24 August 2002

First Meeting of TAAS Trustees

17 October 2002

Registration of the Trust as TAAS

14 December 2002

Opening of TAAS office on IARI Campus

2 Vision, Mission, Strategy, Objectives & Governance of TAAS

Vision

India becomes a prosperous agricultural country through science-based crusade for elimination of poverty, hidden hunger and malnutrition

Goal

Harnessing the potential of agricultural science for the welfare of people

Mission

Promoting growth and advancement of agriculture through scientific interactions and partnerships

Strategy

The TAAS acts a neutral and vibrant Think Tank for strengthening agricultural research and innovation for development (ARI4D). It executes its programs and activities through collaboration and innovative partnerships with other national, regional and international organizations and networks. Its major strategic thrusts are: policy advocacy, technology transfer, information dissemination/knowledge sharing, human resource development/capacity building.

Objectives

- To act as a Think Tank to deliberate on key issues relating to agricultural research for development (AR4D) and influence policy decisions.
- To organize workshops, conferences, brainstorming sessions, seminars, policy dialogues and special lectures on emerging issues and new developments in agricultural sciences.
- To disseminate knowledge among stakeholders through publication of proceedings and policy papers.
- To confer national awards for the outstanding contributions to Indian agriculture by the scientists of Indian and foreign origin
- To facilitate the scientific interactions and partnership building of non-resident Indian agricultural scientists with Indian scientists

Current activities

- Expert Consultations/ Brainstorming Sessions/ Symposia/Conferences/ Workshops/ Dialogues/ Seminars on Important Themes
- Strategy Papers/ Policy Briefs/ Success Stories
- Foundation Day Lectures/ Special Lectures
- Dr. M.S. Swaminathan Award for Leadership in Agriculture

Governance of TAAS

The activities of TAAS are managed by a Board of Trustees comprising: Chairman, Vice-Chairman, Secretary, Treasurer and eight member Trustees. New members are periodically inducted in place of outgoing Trustees. The Board meets once in every quarter, reviews progress of activities and formulates future programs depending upon the prevailing needs of the society. The Board also identifies the collaborating organizations to be involved in implementing its programs/activities. The finances of the Trust are audited annually by an authorized auditor appointed by the Board. The composition of the current Board of Trustees is given in Box 2, whereas the composition of the previous Board of Trustees since 2002 onwards is given in Annexure 4

Box 2 : Board of Trustees (2016-2020)

Chairman	Dr. R.S. Paroda
Vice-Chairman	Dr. Gurbachan Singh
Secretary	Dr N.N. Singh (January 2016 - May 2020) - deceased
	Dr. Bhag Mal (w.e.f. 27 June, 2020)
Treasurer	Dr Narendra Gupta (15 April, 2017 – 15 October 2019)
	Dr. J.L. Karihaloo (15 October 2019)
Trustees	Dr. T. Mohapatra
	Dr. K.L. Chadha
	Dr. A.K. Srivastava
	Dr. (Mrs.) Rita Sharma
	Dr. A.K. Singh
	Mr. Raju Barwale
	Dr. J.L. Karihaloo (15 April, 2017 – 14 October, 2019) and
	Dr. Narendra Gupta (wef 15 October, 2019)

3 Activities of TAAS

The TAAS mobilizes various players and stakeholders, and organizes number of activities to achieve its objectives. These include the following:

I. National/International Consultations/Brainstorming Sessions/Symposia/Seminars/Dialogues/Workshops on topics of contemporary importance in collaboration with national, regional and international organizations

II. Foundation Day/Special Lectures by the leading scientists/social workers, with established record of scientific and agro-social achievements\

III. Bringing out publications on policy/strategy papers/ success stories on thematic areas of national importance.

IV. Dr. M.S. Swaminathan Award for Leadership in Agriculture instituted in recognition of immense service rendered by Dr. M.S. Swaminathan, a great visionary and the father of Green Revolution in India, as also acknowledged in Hon'ble Prime Minister's speech at the 88th Indian Science Congress (ISC), is conferred annually for the excellence in agricultural science, as demonstrated by evident large scale impact on society.

V. Conferring specific Awards to encourage young scientists in different fields of agricultural science.

VI. Recognition of innovative practices developed by the farmers that have led to improved farming practices/ higher yields and farmers' income/ resource conservation/ environmental protection, etc.

Box 3 : TAAS as A Think Tank

Issues of National Importance

1. Genetic Resource Conservation through Use
2. Regulatory Mechanisms for GM crops
3. Increasing Farm Productivity
4. Outscaling Conservation Agriculture
5. Promoting Farmer-led Innovations
6. Linking Farmers to Markets
7. Promoting Public-Private Partnerships
8. Soybean and QPM Maize for Nutritional Security
9. Linking Research with Development
10. Role of Women in Agriculture
11. Promoting Agricultural Innovations and Value Chains
12. Retaining Youth in Agriculture
13. Building Leadership in Agriculture
14. Agricultural Knowledge Management and Sharing
15. Managing Climate Change and Soil Health
16. Policy Advocacy for Creating Enabling Environment for Good Agricultural Practices and Resilience in Agriculture
17. Regional and Sub-regional Partnerships for ARI4D
18. Discussion on National Issues, such as, New Seed Bill/Pesticide Management Bill, Weed Management, etc. among several others

4 National and International Consultations/ Conferences/ Symposia/Workshops/ Dialogues/ Brainstorming Sessions

Preamble

The TAAS has so far organized 41 national/ international consultations/symposia/seminars/ dialogues/workshops/ brainstorming sessions (Annexure V) on topics of thematic importance. These meetings have been attended by subject matter specialists and other concerned stakeholders who discussed specific issues rather critically and came out with specific recommendations. Subsequently, all important recommendations have been sent to the concerned researchers, science managers and policy makers for required follow up/action. A brief account of these initiatives is given below:

1. Enabling Regulatory Mechanisms for Release of Transgenic Crops

(A Brainstorming Session: October 18, 2003)

Background

Biotechnology offers novel ways to genetically modify crop plants with improved quality or productivity, thus ensuring better income to the resource poor farmers. The varieties of crops developed through techniques of genetic engineering are known as genetically modified or GM crops. As expected with any new technology, concerns have been raised about safety of the cultivation of GM crops and products derived from them. Thus, in order to keep pace with the development taking place worldwide, it is essential to evolve precise mechanisms and protocols of introducing transgenes and to assess biosafety of GM corps. The process has to be fast. To address these concerns at all levels, a neutral platform comprising all stakeholders, viz., scientists, representatives of Non-Governmental Organizations (NGOs) and policy makers is required.

A brainstorming session on 'Enabling Mechanisms for Release of Transgenic Crops' was organized on 18 October, 2003 at ICAR-IARI, Pusa Campus, New Delhi to discuss relevant issues. About 100 participants from different institutions, including Drs. H.K. Jain, R.P. Sharma, Manju Sharma, NGOs and private sector deliberated upon issues concerning biosafety of GM crops and other related issues, and came out with following recommendations:

Dr. R.S. Paroda chairing the Brainstorming Session

Recommendations

Status on Agricultural Biotechnology in India

- India's approach for the development of transgenic crops has largely depended on individual initiatives without the formulation of a composite product-oriented, integrated approach. While this has helped the nation in the generation of competent human resources, time has come to evolve a national policy, which would promote required collaboration and coordination at different inter-institutional levels, including the ICAR institutes, State Agricultural Universities (SAUs), academic institutions and the private sector so as to ensure delivery of products to end users. Large-scale development and commercial release of transgenic crop varieties would not be possible in the absence of such collaborative approach. Hence, it is critical at this juncture to build the required partnerships.
- Development and commercial release of transgenic varieties should be attempted in two phases: (i) in the first phase, molecular biologists and biotechnologists

should have the primary responsibility and play an important role. However, it would be unrealistic to believe that they can also take the responsibility for the field-testing and evaluation of newly developed transgenic varieties for biosafety and other regulatory requirements, and (ii) in the second phase, there should be much closer collaboration with scientists from relevant disciplines, including plant breeders, and also with the private sector, in order to ensure timely seed production and commercialization of transgenic varieties.

- While India has made significant progress in the field of molecular biology and biotechnology, critical gaps in R&D efforts still remain. Increased investments and intensified efforts are, therefore, necessary at this stage to create additional research capacity in areas such as gene and promoter isolation, vector constructs, and cloning and transformation protocols relevant to important Indian crops. India must embark upon a major research program in the area of functional genomics, especially in crops of considerable economic value.
- A national facility needs to be created to assist the biotechnologists through facilitated access to agronomical and economically important genes and promoters.
- India needs to generate a critical mass of highly trained molecular biologists and biotechnologists to develop cutting edge technologies, which are becoming increasingly important. There is an urgent need to organize elaborate training programs in a number of institutions having well equipped laboratories and highly trained scientists. The training program should be of longer duration (at least 6 months), in order to develop required competence in the younger generation of scientists.

Need for Public-Private Partnership

- Mechanisms need to be developed to build a strong public-private partnership. The golden triangle of partnership between International Research Centers, ICAR institutes, SAUs, and the Private Sector can help in taking the transgenics from laboratory to the field at a much faster pace.
- Steps will have to be taken so that there is a swing from 'mistrust' to 'trust' between the public and private sector players, especially in terms of Intellectual Property Right (IPR) and benefit sharing related issues.
- Possibility of developing a consortium at the national level, of both public and private sector institutions in order to promote agricultural biotechnology needs to be explored.
- Steps should be taken to create general public awareness and appreciation towards importance of transgenics among the stakeholders.
- Economic concerns of the farmers/consumers in relation to transgenic varieties/hybrids need to be effectively addressed.

Enabling Regulatory Framework

- There is considerable overlap in the functions of the Monitoring-cum-Evaluation Committee under the Department of Biotechnology (DBT) and the agronomic evaluation of the transgenics undertaken by the ICAR. Harmonization of these functions could considerably reduce the time required for the evaluation and release of transgenic materials and also save resources.
- There is a distinct need for 'referral laboratories/ institutes ' for evaluating specific aspects of biosafety of transgenics, related to the human, animal, plant health and also the environmental safety.
- Prevention of distribution of spurious seeds in the name of transgenics; establishing minimum standards and criteria for the release of transgenics, revision of the Seed Act and Rules, procedures for litigation and dispute settlement, and speedy process of evaluation of the transgenics, are some of the major concerns in relation to the regulatory framework in India, which need to be addressed on priority for effectively reaping the benefits of biotechnology in agriculture.
- The significance of patents and other IPR in relation to the development, protection and commercialization of transgenics have to be clearly understood by the researchers/ institutions involved in this field. There are a number of intellectual property rights/ patent issues related to plant regeneration, plant transformation, gene sequences, promoters, vectors and screening techniques which need to be kept in mind while commercializing the transgenics. There is a need to develop appropriate mechanisms and approaches to overcome the intellectual property barriers for the successful commercialization of transgenics developed so that farmers are able to reap the benefits of biotechnological products.
- There are several complex legal issues related to the regulatory framework for the transgenics. It appears that the framework of the Environmental Protection Agency (EPA) of USA is not the most appropriate model to deal with the biotechnology related issues in India. Hence, there is an urgent need to formulate a separate legislation that would have no overlap with other legislations. A scheme of certification and internal regulatory procedures and committees should facilitate self-regulation as far as possible. Also, a formal system of Tribunals and Adjudicatory Bodies, having legal and technical experts, would help in quick dispute settlement. The bottom line is that unless transparent regulatory framework is put in place, the growth of biotechnology would continue to be hampered.
- The need was felt to have a brainstorming session to examine the pros and cons of setting up of a 'National Authority for Biosafety/Biosecurity' in order to have congruence of biotechnology, biodiversity, biosafety and biosecurity.
- For successful utilization of biotechnology in India, it is critical to devise a clear National Biotechnology

Policy, which covers the important elements of contract sociale, science-led impact and risk analysis, information empowerment and awareness, with proper R&D support.

2. Role of Science and Society towards Plant Genetic Resources Management – Emerging Issues

(A Brainstorming Session: January 7-8, 2005)

Background

Plant genetic resources (PGR) have played an important role in agricultural development. However, changes in land use pattern, increasing population and overexploitation of natural resources are threatening these genetic resources towards depletion to the point of extinction. Therefore, urgent measures are needed to ensure proper conservation and access to genetic resources and sharing of their benefits with farmers and communities contributing towards evolution and conservation of these resources.

Lighting of lamp during inauguration by Dr. M.S. Swaminathan

A two day brainstorming session was jointly organized by TAAS, National Academy of Agricultural Sciences (NAAS) and Indian Society of Plant Genetic Resources (ISPGR) on 7-8 January, 2005 at IARI, Pusa Campus, New Delhi to deliberate on these concerns and to see what specific role science and society can play to ensure conservation and use of the plant genetic resources. In all 80 participants representing ICAR, SAUs, Govt. Departments, representatives of Academies, NGOs, Private Sectors, farmers, representatives of international centers, and media participated in the brainstorming session.

The recommendations emerged out of the deliberations are summarized below:

Recommendations

Scientific Issues

- **Establishment of National Database on Plant Diversity:** The database on plant diversity may be integrated with corresponding data on indigenous knowledge for better decision making and help in conservation/protection of biodiversity rich areas, restoration of fragmented habitats of important species and economic prospecting. This would also facilitate in the identification of specific gaps in plant genetic resources conservation so that pointed collecting missions could be mounted on priority. This national database could also serve as a referral point for identification of stakeholders in diversity conservation and benefit sharing programs particularly in implementing various provisions of the Protection of Plant Variety and Farmers' Rights Act, 2001 and the Biodiversity Act, 2002.
- **Coordinated National Program for Enhancing Germplasm Evaluation and Utilization:** The ICAR-National Bureau for Plant Genetic Resources (ICAR-NBPGR) alone cannot characterize/ evaluate all the germplasm. This being a priority issue, it is recommended that a special All-India Coordinated Project on Germplasm Evaluation be initiated with ICAR-NBPGR providing the facilitation/ coordination role. There is an urgent need for development of a national information system on crop genetic resources with integration of information on passport, evaluation, conservation status, indigenous knowledge, etc., to facilitate both protection and rational use of the germplasm.
- **Developing New Conservation Strategies:** For conservation of perennials and vegetatively propagated materials, alternative methods, such as clonal repositories, *in vitro* conservation and cryopreservation need to be examined and adopted.

Social Issues

- ***In situ* Conservation and Community Participation:** *In situ*/on-farm conservation of landraces and traditional varieties need to be strengthened in partnership with farmers and the local community. In such areas, the on-going programs of tribal welfare should also take into consideration agrobiodiversity conservation as one of the important objectives. Various civil society groups working at the grass roots level for the welfare of these communities have also to be involved for on-farm conservation and sustainable management of agrobiodiversity.
- **Awareness Generation:** The present level of literacy about various international agreements and national legislations with regard to plant genetic resources is indeed very poor even among the scientific community. There is an urgent need to educate the policy makers, planners, science managers, scientists and the general public about the implications of major developments in this field.

Policy Issues

- **Strengthening NBPGR as Nodal Organization:** India can take legitimate pride in having established a single window system for plant genetic resources through ICAR-NBPGR. There is a strong need to

strengthen this institution including its regional stations and also networking with crop based institutes to fulfill its mandate effectively and efficiently.

- **Germplasm Exchange:** It is imperative that Indian scientists continue acquiring new germplasm accessions in unrestricted and fair manner. The Biological Diversity Act, 2002, which the country had enacted in the recent past, should facilitate this kind of access. The scope of the material to be designated under the multilateral system for exchange of germplasm of crops, of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), requires critical understanding in order to ensure that valuable national plant genetic resources are provided the agreed access; yet at the same time protected from patent regimes elsewhere.
- **Streamlining Policy Advisory Measures:** The issues concerning agrobiodiversity, particularly in the light of recent national and international developments, cut across the mandate of various ministries and departments. A national level Advisory Committee with representations of the concerned ministries and departments should be constituted to deliberate and provide directions for the development of national policy issues related to various aspects of agrobiodiversity.
- **Germplasm Access and Benefit Sharing:** India has enacted the Protection of Plant Variety and Farmers' Rights Act, 2001 and Biodiversity Act, 2002, which shall help us to protect, conserve and utilize the genetic resources in a sustainable manner. The efforts for *in situ* conservation can, however, be sustained only if accompanied by appropriate policies that provide commensurate monetary benefits as well as non-monetary incentives for individuals and communities. The proposed gene fund (under Protection of Plant Variety and Farmers' Rights Act, 2001) and biodiversity fund (under Biodiversity Act, 2002) could be used to provide such support to the farmers and communities.
- **Cooperation between Public and Private Sector:** There is a greater need to strengthen the laboratory and field infrastructure to undertake work relating to modem biotechnology both in ICAR/SAU system as well as in private sector.

3. Role of Information Communication Technology in Taking Scientific Knowledge/Technologies to the End Users

(A National Workshop: January 10-11, 2005)

Background

In a fast changing global environment, and globalization of agriculture economy, agriculture in developing countries including India, has to be more dynamic by harnessing the latest technologies and emerging opportunities. It is paramount that existing concern of "digital divide" and the future role of ICT in agriculture are well understood and recognized. In this context, the Trust for Advancement of Agricultural Sciences (TAAS) along with the National Academy of Agricultural Sciences (NAAS), the Indian Society of Agricultural Statistics (ISAS), and the Asia-Pacific Association of Agricultural Research Institutions (APAARI) jointly organized a National Workshop on "Role of Information Communication Technology in Taking Scientific Knowledge/Technologies to the End Users" on 10-11 January, 2005 at the Indian Agricultural Research Institute, New Delhi. Around 70 experts representing different stakeholders i.e. Public Institutions (ICAR, DoAC, NIC, DBT, etc.), NGOs, Foundations, Private Sector, Farmers' Commission, International Agricultural Research Centres, etc. had deliberated on all relevant issues by which ICT can become a catalyst of change in Indian agriculture.

The brainstorming sessions centered around current status, opportunities and constraints to make ICT a point of focus for making India a developed nation through

Dignitaries on the dais during Inaugural Session of the Workshop

progress in agriculture sector, especially by linking producers with consumers through extension. The major recommendations were:

Recommendations

Multi-dimensional ICT-based initiatives

ICT based initiatives for agricultural development, including farmers' prosperity, should be multi-dimensional in nature. These should be capable of addressing problems of rural communities in a holistic manner, touching all aspects of rural life including agriculture, human/animal/plant health, education, banking, governance, entertainment, etc. This can be achieved by setting up rural knowledge centres using broad band connectivity with multi-media interactive modules in problem solving mode by synergistic deployment and engagement of various stakeholders involved.

Knowledge Intensive Products and Services

Knowledge intensive products and services for empowerment of our farmers are urgently needed. This would require a well-coordinated system among government, public and private organizations. In this context, the Indian Council of Agricultural Research (ICAR) and the Department of Agriculture and Cooperation (DoAC) under the Ministry of Agriculture and Farmers' Welfare (MoA&FW) can play a leading role in having a National Agricultural Information System (NAIS) established. Suitable mechanisms need to be developed for the creation of location specific knowledge capsules in the form of CD-ROM, Portals, Kiosks, etc. through involvement of specialized institutions.

Networking of Knowledge Dissemination Agencies

The existing knowledge dissemination agencies in the country such as ICAR Institutes, SAUs, KVKs/ATICs, NIC, IFFCO, KRIBHCO, as well as other non-government and private sector institutions need to be networked rather than creating a new institution so that available information/knowledge is shared and transmitted freely to the end users. NAIS should work in a partnership mode using the complementary strengths of partners as the basis of subsidiary responsibilities being assigned to other partners. Affirmation of authorities for specific tasks, and contributory sharing of financial resources for the smooth implementation of joint projects should be decided jointly, and well in advance. Institutions such as ICAR-Indian Agricultural Research Institutes (ICAR-IARI) and ICAR-Indian Agricultural Statistical Research Institute (ICAR-IASRI) could jointly play the knowledge and technology coordination role under NAIS.

Capacity Building of Extension System/ Functionaries in ICT

Complexities in the second-generation agriculture would require greater role of emerging ICT tools and methods in complementing the existing extension system. This would require capacity building of extension functionaries for the transfer of knowledge without dissemination losses to the end users. At the district level, the KVKs could in future play an important role provided given specific ICT mandate with commensurate human resource.

- Village level ICT should be the ultimate goal for easy access to required knowledge by the farming community. This could be achieved through promotion of Rural Information Clinics or Rural Internet *Choupals* by the enthusiastic young entrepreneurs, well trained as ICT agents by the SAUs and ICAR institutions located throughout India. For access to knowledge at the farmers' door steps, the above goal must be met.
- There is also a need to reorient the agricultural extension curriculum so that extension workers in future are spatial and information specialists as well. The National Agricultural Research System (NARS) should be proactive in providing user-friendly, need-based and locally relevant trainings.
- There should also be an emphasis on gender equity by letting women have easy access to Knowledge Transfer (KT), ensuring gender oriented content and the increased women participation in the application of KT.
- There is a strong need to establish joint ventures with the Private Sector and NGOs to enrich KT resources in terms of both hardware and software and the relevant content creation.

Agricultural Knowledge Transfer Policy

To empower agricultural community with needed information and knowledge in the coming decade (by 2015), the Government should come out with an Agricultural KT Policy with a Mission-oriented strategy to implement the same in a time-bound manner. Only through such commitment at the highest level, we shall be able to address the concern of "Digital Divide" and empower our farmers to be well informed and competitive.

4. Farmer-led Innovations for Increased Productivity, Value Addition and Income Generation

(A Brainstorming Session: October 17, 2005)

Background

Farming has been the main occupation of Indians for over five millennia. Over the generations, farmers have come out with numerous innovations for meeting their food, nutrition, health, fibre, fuel wood, timer and other day-to-day needs; ensured their livelihood security and exclusive community-based socio-economics; besides farm-based monetary returns. They designed a number of need-based farm implements to increase the farming efficiency. Farmers also selected numerous varieties of crops having preferred traits, higher productivity, better cooking and/or keeping quality, etc. They also developed low cost technologies to package, store and preserve both seed for prolonged vigor and health, and farm produce for increased shelf-life and marketability.

Inaugural Session in progress. Seen on the dais are (L to R) Dr. S. Nagarajan, Prof. R.B. Singh and Dr. R.S. Paroda

However, intellectual property rights on such innovations have often been ignored. It is necessary that we duly recognize farmers' innovations and blend their traditional wisdom with scientific knowledge for ensuring sustainable agriculture. A brainstorming session was organized by TAAS at ICAR-IARI, Pusa Campus, New Delhi on 17 October, 2005 where about 40 participants from Research Institutes, NGOs and farmers critically discussed these issues and came out with following recommendations:

Recommendations

Documentation of Innovations and Traditional Knowledge

- It is essential to document innovations and traditional knowledge and disseminate them further through various organizations such as Indian Council of Agricultural Research (ICAR), National Academy of Agricultural Sciences (NAAS), Trust for Advancement of Agricultural Sciences (TAAS), National Innovation Foundation (NIF), etc. Also, regional and international organizations such as FAO, Global Forum on Agricultural Research (GFAR), APAARI could be involved to promote and popularize various successful innovations by the farmers to link them to markets for better income and livelihood opportunities.
- Innovative technologies identified in one region need to be popularized in similar eco-regions elsewhere, through publication, documentation and dissemination of "Success Stories".
- Marketing Opportunities for Traditional and Value Added Innovative Products Involvement of research institutions is quite critical to understand and blend the traditional innovations with scientific refinements for their large scale adoption and popularization.
- Risk management with focus on market opportunities through value addition is required. Farmers need to be protected from varying and often declining prices. Export potential has to be explored and procedures streamlined in order to take full advantage of globalization of agriculture.
- Aggressive programs for training of rural youth, especially farm women for post-harvest handling and value addition of the locally available agri-products, will help in linking rural communities to markets for better income opportunities.
- Setting up of a quality testing laboratory in each region to test and certify farm products (such as organic foods, medicinal plants etc.) produced by the local entrepreneurs is an essential requirement for which Government, Private Sector and NGOs' support is critical.

Plant Based Medicinal Products

It is necessary to develop processes for producing drugs from locally available medicinal plants especially to treat common ailments. Patenting and popularizing the inventive, value added products in the market will benefit both producers and consumers. In this context, the available valuable knowledge relating to medicinal uses of local herbal plants need to be gathered and documented through appropriate incentive and reward mechanisms developed before the traditional knowledge is lost forever or remains unacknowledged.

Agro-forestry and Horticulture

Concept of tree plantation as social activity has to be promoted, especially in dry, desert and hilly areas, which will help in the development of agro-forestry and horticulture in these regions and also ensure better returns for the resource poor communities, besides improvement in our environment.

Agro-tourism

Agro-tourism around farmers' innovative efforts would not only generate greater public awareness but would also help in revenue generation and greater community involvement in protecting our rich biodiversity.

Farmers' Innovation Promotion Board

Creation of a "Farmers' Innovation Promotion Board (FIPB)" by the Ministry of Agriculture and Farmers' Welfare (MoA&FW), Government of India would obviously accelerate the process of innovations in agriculture to link farmers to markets. Sooner it is done, better it will be in the national interest. The best example of this kind already exists in the dairy sector, namely the National Dairy Development Board (NDDB), which has not only helped in achieving "White Revolution" but has organized small and even landless dairy farmers to form rural cooperatives, thus, linking them to markets as well as consumers while ensuring regular income.

Scientist-Farmer Dialogue

A regular mechanism of scientist – farmer dialogue would certainly accelerate the process of agricultural innovations and hence, be put in place at the national level by the organization such as ICAR.

5. Farmer-led Innovations towards Plant Variety Improvement and Conservation: Protecting Farmers' Rights, Geographic Indications, Appellation of Origin, etc. in the National Context

(A National Dialogue: November 12-13, 2006)

Background

The farmer-led innovations, their art and science of growing and managing crop agriculture, design of farm implements to reduce drudgery and increase farm efficiency and their contributions to value addition in agricultural produce are important issues with regard to their appreciation value in the IPR and access and benefit sharing regimes. In this context, a specific focus is required on IPR related national Acts/laws, and also on the understanding of various dimensions of benefit-sharing requirements with the farmers to ensure continued innovations by the farming communities. A lack of understanding on protection of Farmers' Rights for their own varieties as well the requirement of programs to encourage other farmer-led innovations were some other important areas of concern, which called for a Dialogue.

A two-day national Dialogue on "Farmer-led Innovations towards Plant Variety Improvement and Conservation: Protecting Farmers' Rights, Geographic Indication, Appellation of Origin etc. in the National Context" was held on 12-13 November 2006 at the National Agricultural Science Centre Complex, New Delhi. It was jointly organized by the Trust for Advancement of Agricultural Sciences (TAAS) and Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA); and was co-sponsored by Agricultural and Processed Foods Export Development Authority (APEDA) and Asia-Pacific Association of Agricultural Research Institutions (APAARI). The participants were from Government/Public sector agencies, ICAR, SAUs, international organizations, and other stakeholders representing academies, attorney firms, NGOs, private sector and farmers.

The deliberations were held in three technical sessions. The session-wise details and their recommendations are presented here:

Recommendations

Need to Accelerate the Pace of National Seed Regulatory Reforms

- The uniqueness of Protection of Plant Varieties & Farmers Rights (PPV&FR) Act of India is that along with grant of IPR on plant varieties it also recognizes the rights of farmers, besides considering the issues of conservation and benefit sharing with respect to crop varieties. The PPV&FR Act, therefore, entrusts important multiple responsibilities on the Authority created for the purpose.
- The many functions of the Authority include the task of characterization and documentation of varieties registered under the Act; and also documentation, indexing and cataloguing of farmers' varieties. Therefore, detailed documentation of crop varieties, whether developed by scientist breeders or farmer breeders, would be desirable.
- The efforts should particularly aim for technically competent and efficient crop variety testing, validation and seed quality enforcement system that meets all necessary requirements. The efforts should particularly ensure that the additional tasks in no way lead to the dilution of the existing testing system but rather strengthen it further.

Importance of Extant Crop Varieties as a Vital National Resource

- Under Section 2(j) of the PPV&FR Act, 'extant variety' includes: i) varieties notified under the Seeds Act, 1966; ii) farmers' variety; iii) varieties about which there is common knowledge; and iv) any other variety which is under public domain. Under Section 2 (i) of the PPV&FR Act, 'essentially derived variety' is defined with respect to the 'initial variety'. In conjunction with other provisions referring to 'extant variety' and 'essentially derived variety' in the Act, The 'extant' varieties are crucial for augmenting crop productivity and production in the country and with regard to implementing the provisions in the Act on "Farmers' Rights" and "Benefit Sharing".
- Awareness about the provisions and implementation of the PPV&FR Act among all key players in the private seed sector, which could be a key user of 'extant varieties' as 'initial varieties' was considered equally important. It emerged that improved crop varieties from the private seed sector, that are in cultivation but have not been notified under the Seeds Act, 1966 can also be considered for registration as 'extant' varieties under the category of 'varieties in public domain' or 'varieties of common knowledge', as per definition of 'extant variety' in the PPV&FR Act, and subject to availability of legally verifiable evidence.

A National Program on Farmers' Varieties and Innovations Needed

- Establishment of a national program for the recognition (identification) of farmers' varieties, including data verification may be desirable, along with appropriate rules for access and benefit sharing for the realization of farmers' rights. To verify the true expression of characteristics of farmers' varieties, their testing and validation may need to be done in the native area of their cultivation.
- Farmers' varieties generally possess preferred and economically important traits, which are also relevant to their trade value. A proposed directive on "conservation of varieties" under consideration by the European Commission has similarities with the case of farmers' varieties in the Indian PPV&FR Act. Accordingly, the concern was that there is no program, policy or window of opportunity for the

enormous crop variety diversity at the farmers' level. Therefore, an institutional mechanism should be evolved for characterization, data generation and diffusion mechanism for the farmers' crop varieties as well as safe storage of seeds of these varieties in the National Gene Bank.

- In order to encourage farmer-led innovations, it was suggested that the PPV&FR Authority should institute special awards to recognize farmers, including women farmers, for their valuable contributions.

Establishment/Accreditation of Laboratories and Institutions for Crop Variety Testing

- Establishment of new or accredited institutions for field testing for Distinctness, Uniformity and Stability (DUS) of new varieties, to be registered under the PPV&FR Act, need to be given a priority. The testing system being envisaged must be critically viewed for its competence and effectiveness and should build on existing system with required efficiency and reforms.
- The provision of 'Essentially Derived Varieties' in the PPV&FR Act necessitates testing of new varieties at the biochemical and molecular level. Thus, there will be need for establishing accredited laboratories for this purpose as well.

A System for Quality Saplings, Planting Materials and Organic Agriculture Neede:

- Currently, the importance of both 'seed' and 'rights' necessitates emphasis on availability of quality saplings and planting materials of horticultural crops, as also for other tissue-culture materials. Accordingly, there is need for enforcement of the quality standards of seedlings and registration of nurseries and other agencies dealing with planting materials. Likewise, standards and appropriate testing system of organic agriculture was felt necessary for promotion of organic farming. Thus, in national interest, notified laboratories were needed for quality testing of organic produce under both public and private domain.

Innovative Use of Various Legal IPR Tools for Economic Gains

- Presentations by farmers on their innovations and new initiatives were appreciated by all the participants. It was quite clear that the farmers need advisory services as well as other technical and financial support for recognition of their innovative efforts to logical conclusions.
- Each IPR-related Act recognizes and provides protection in a specific form. To effectively harness commercial value of extant varieties and other farmer' innovations, provisions of different IPR Acts should be appropriately made use of. Thus, agriculture commodities/goods which have international trade value and may qualify as geographical indications, should be got protected under the provisions of the Geographical Indications (Registration and Protected) Act. Of course, dual protection is also possible, if it is also protected as extant variety. Likewise, the trade mark protection can be sought for brand building of specific indigenous agricultural commodities in demand.
- The IPR and benefit sharing tools can be of great use to local and indigenous communities for conserving their agricultural biological diversity, and sustainably using their biological resources along with traditional knowledge. The innovative use of these tools and documentation system can bring the farmers due economic benefits from the traditional knowledge and genetic resource base. It can also help in preventing the unauthorized commercial use by others.
- NGOs and Farmers' Cooperatives have important role to play for value-addition and acknowledgement of farmer-led innovations. There is need to develop a national strategy for greater involvement of genuine NGOs and farmers' groups so that they are able to play a constructive role in the development of agriculture and allied activities in the country, and the rights of farmers are duly protected.

Need for Continued Germplasm Exchange

- Indian agriculture has gained tremendously by the exchange of germplam and the varieties of different crops with different countries all over the world in the past. Germplasm exchange (both import and export) will continue to remain the core basis for unhindered crop improvement work in future. The participants felt concerned about the difficulties in germplasm supply and receipt with the arrival of IPR and related Acts. It was felt necessary that concerned organizations, viz., the Biodiversity Authority (BDA), the PPV&FR Authority, the Ministry of Environment and Forests, the Ministry of Agriculture and the Indian Council of Agricultural Research must jointly address this important issue and work out appropriate and efficient coordination mechanisms. In this context, the advisory and functional role of the National Bureau of Plant Genetic Resources was felt necessary, especially after the ratification of the legally-binding International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), and endorsement of the Standard Material Transfer Agreement (SMTA) by the Governing Board of the Treaty under overall umbrella of FAO.

Inter-Departmental Coordination Required for Reforms in the Indian Seed Sector

- It was general consensus that we need to address on priority some of the tasks that require gearing up of the Indian seed sector. These included; i) futuristic variety testing research; ii) services to international bodies like International Union for Protection of New Varieties of Plants (UPOV); iii) advisory services to other developing countries, iv) interface with Trade Mark (TM), Geographical Indications (GI) and Patent offices; v) interface with Value for Commercial Use (VCU) testing system; vi) service towards honoring

the farmers' rights; vii) decisions on benefit sharing and compulsory licensing; viii) publication of plant varieties journal; ix) human resource development for scientific and technical aspects. Accordingly, it is critical that all relevant Departments should come together for a concrete action plan with deliverables to eliminate the difficulties of the Indian seed sector, such as, long drawn and much awaited revision of Indian Seed Act.

6. Models of Public-Private Partnership in Agricultural Biotechnology

(A Brainstorming Session: April 7, 2007)

Background

India experienced unprecedented success with cultivation of Bt Cotton. This success has its foundation in partnership between public institutions, private entrepreneurs and farmers. Over the years, similar partnerships have developed among different sectors; the examples are golden rice and fruit borer resistant brinjal. It is expected that more such partnerships will emerge to overcome impediment in agricultural development.

Recognizing the need to initiate a dialogue on public-private partnership involving all the concerned stakeholders, APCoAB along with APAARI and TAAS organized a "Brainstorming Session on Public-Private Partnership in Agricultural Biotechnology" in 14 March, 2005. The session was attended by experts on crop biotechnology, crop breeding, IPR, policy and planning, representing NARS, government science and technology departments, CGIAR Centers, private sector and NGOs. One of the recommendations of the Brainstorming Session was to define specific models of partnerships that could be considered by the policy makers for starting negotiations and taking decisions. The "Brainstorming Session on Models of Public-Private Partnership in Agricultural Biotechnology" held by TAAS on 7 April 2007 is a follow-up of this recommendation. It was attended by 46 participants including policy planners and scientists from government departments, Indian Council of Agricultural Research (ICAR), private sector, CGIAR centres and non-government organizations (NGOs). The group deliberated on the emerging issues and came out with following recommendations:

Recommendations

Models of PPP

In view of the highly diverse nature of agricultural biotechnology projects operating successfully in partnership mode, no single model can be the most appropriate one at large. However, recommendation emerged for some basic requirements that are essential for making a public-private partnership (PPP) successful, as follows:

- The partnership should be based on common goals of the partners to achieve objectives of mutual interest that are also aimed at addressing national challenges in agricultural growth and farmers' incomes.
- The partners should have matching resources which also complement mutual strengths.
- The partnership should be built on mutual trust and commitment to create a dynamic and result oriented working environment.
- The output of the partnership should be more than the potential of individual partners.
- The existing PPP models should be analyzed to develop appropriate guidelines for entering into

Participants attending the Brainstorming Session

future partnerships and for negotiating terms of benefit sharing.

- PPPs need to consider partnering seed industry, including seed associations, to enable expeditious multiplication and distribution of the seed to farmers.
- All projects should be analyzed for freedom to operate from IPR perspective before these are implemented.

Policy

- A Senior Level Working Group comprising ICAR/DBT/DST/IITs/Universities should be constituted to frequently review the technological developments in the public sector and identify the appropriate ones which are fit to be commercialized in a partnership mode. Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB) could facilitate identification of potential partners in a network.
- All partners must ensure that the project at any stage does not adversely impact ecology and biodiversity.
- With changing perceptions of partnership in a globalized world, multinational companies may be considered at the same level as Indian national companies for entering into partnerships with public sector.
- Private sector needs to make long-term investment in basic and strategic research in molecular aided selection, genomics and bioinformatics, and enter into partnerships with public sector right from project inception stage.

Capacity Building

- There is a need for building comprehensive infrastructure and human resource in public sector for biosafety and transgene testing.
- Human resource development in public sector institutions on technical and legal aspects of IPRs is essential to build capacities and forge partnerships.

7. Farmer-Led Innovations for Sustainable Agriculture

(A Symposium: December 14-15, 2007)

Background

Innovations made by farmers have contributed tremendously to the advancement of agriculture. They have traditionally conserved indigenous genetic diversity, selected new genotypes, developed innovative farming techniques to mitigate oncoming challenges and developed new tools to help in overcoming day-to-day operational drudgery. This knowledge has, by and large, remained undocumented and unrecognized.

A symposium on Farmer-Led Innovations for Sustainable Agriculture was organized at the Birsa Agricultural University, Ranchi, on 14-15 December, 2007 in collaboration with TAAS and NAAS. It was also co-sponsored by the PPV&FRA, Govt. of India and the National Rainfed Area Authority (NRAA). The symposium was attended by a large number of innovative farmers, officers and the scientists from Birsa Agricultural University, Ranchi, ICAR Institutes and the representatives of PPV&FRA, TAAS, NRAA, and NAAS. The recommendations emerging out of the discussion held are as follows:

Recommendations

Participatory Development and Institutional Support:

- Farmer-led innovations are both realistic and more imaginative to address location specific problems. These are also aimed at sustainable agriculture. Despite, in many cases, lacking the scientific explanations, farmers' practices are invariably practical and sound. Therefore, we need to document and disseminate such innovations for wider adoption.
- Indigenous technical knowledge (ITK) has to be blended with scientific innovations through participatory research approach. This would require concerted efforts for research reorientation and change in the mindset of scientists. Also, institutional support for scientific documentation of ITKs would be needed as a matter of priority.
- Farmer-led innovations would often require validation and refinement for which State Agricultural Universities (SAUs) and ICAR Research Institutions could provide laboratory equipment and facilities through establishment of Technology Parks (TPs). Benefits of such refined/improved technologies could be shared among the farmer entrepreneurs and the concerned scientists/institutions through commercialization.
- Organic farming offers greater opportunities for higher income to producers and better health to the consumers. Production and marketing of products of organic farming would require effective quality control and assurance to the consumers. For this, there is an urgent need to establish quality control laboratories for testing various farm products.

Inauguration of the Symposium

- Protection of IPRs would be a pre-requisite for facilitating assured access as well as benefit sharing. Hence, creation of IPR cells in all institutions/SAUs and their strengthening would be required, if not already created.

Linking Farmers to Markets

For enhanced income and due share in the price of farm produce, it is imperative to link farmers to the markets (LFM). For LFM, it is necessary to have value addition through adoption of low cost, rural based post-harvest technologies (PHT) with appropriate storage/marketing facilities. Besides, market intelligence through effective use of information and communication technology (ICT) would enable proper decision making. All these initiatives would also help in generating employment for the rural youth, besides additional income to the farming community.

Policy

- Currently, a top-down mechanism of research prioritization is being practiced, whereas a bottom up approach involving farmers, private sector and NGOs, is needed to make it more relevant. In addition, this process will also help in better ownership and participation of all stakeholders as well as identifying specific research gaps that need to be addressed on priority.
- For adoption of new innovations, initiatives such as Institute-Village Linkage Program (IVLP) has to be expanded to cover different agro-climatic regions of the country. This is important since most of the extension systems for technology transfer, operative in the past, are either non-existent or non-effective in the present context.
- For required awareness among young generation, it is necessary that history of Indian agriculture is taught both at the school and college levels, as is being done for the science subjects. Knowledge of agriculture is, indeed, essential being an important sector of our National economy.
- Farmers' role for protecting the germplasm, such as the landraces and varieties of different crops including the underutilized, medicinal and aromatic plants, has to be recognized and the Farmers' Rights need to be protected. Also, mechanisms are needed for streamlining access and benefit sharing, besides registration and protection of valuable germplasm materials.
- The national seed regulatory reforms need to be accelerated for the promotion of seed industry and much needed benefits to those engaged in varietal improvement, maintenance, and conservation and seed development activities.
- In order to enhance the farmer-scientist interface, a non-political Forum/Body has to be established at the national level for required facilitation. Hence, there is an obvious need for the creation of an Organization/Agency/Board/Authority at the National level for the authentic documentation and promotion of farmers' innovations in order to accelerate new innovations in agriculture.

8. Quality Protein Maize (QPM) for Human Nutritional Security and Development of Poultry Sector in India

(A National Symposium: May 3, 2008)

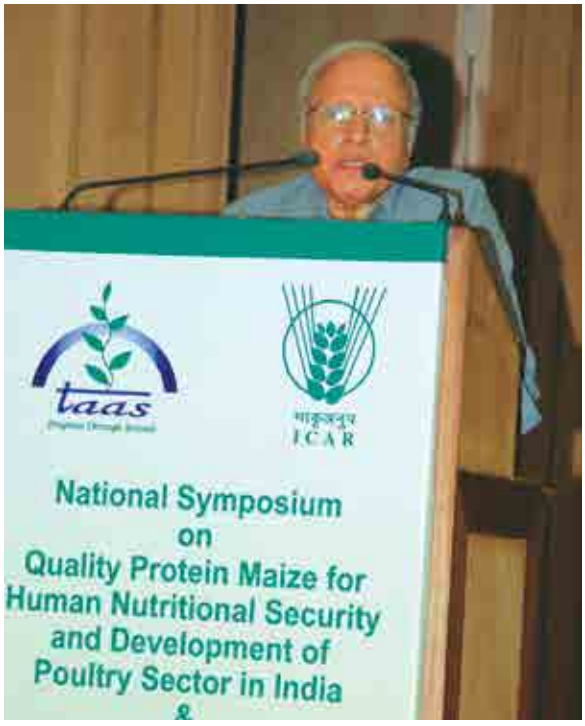
Background

Maize has enormous potential for providing nutritional security to the under nourished globally. Endowed with high content of carbohydrates, fats, proteins, important vitamins and minerals, maize has acquired the reputation of poor man's nutritious food. The recent development of maize with nutritious protein, quality protein maize (QPM), assumes special significance. However, there are some issues which need to be addressed before fully exploiting the potential of QPM. The symposium was organized by TAAS and Directorate of Maize Research (now ICAR-IIMR) on 3 May, 2008 at NASC Complex, DPS Marg, New Delhi to discuss this subject of considerable importance. This symposium was attended by over 150 delegates. The important recommendations made by the experts are given below:

Recommendations

Policy

- Maize should be included in the National Food Security Mission (NFSM), in addition to the existing thrust on wheat, rice and pulses. It is because of the potential of maize not only in meeting the food and nutritional security, but also the influence it



Dr. M.S. Swaminathan inaugurating the National Symposium

will have on the growth of allied sectors, viz., and poultry and livestock production.

- There is an urgent need to bring about 80-90 per cent area under single cross hybrids, which at present is rather low. Since QPM hybrids are basically bred by the public sector institutions, and the public seed agencies are unable to meet the demand for seeds of these hybrids, a Public-Private Partnership model needs to be promoted to achieve the desired area coverage.
- Maize crop has a wide range of adaptability, beside great potential for adaptation to climatic change. In addition, maize has also demonstrated a very high growth rate (about 4.5% p.a.) during the last one decade. With emerging problems of water scarcity, rising temperature, etc., maize seemed to have good potential both for vertical and horizontal expansion. There is need to have diversification of rice-rice and rice-wheat cropping systems in the peninsular and eastern India, respectively.
- Currently, utilization of maize as food crop is only 25 per cent, whereas its use for animal and poultry feed is almost 60 per cent. Hence, increasing area under QPM could lead to improved human nutrition and availability of low-cost high quality feed for which internal demand is increasing at much faster pace. This would demand use of variable maize products and change in the food habit through popularization of various maize recipes. Also, QPM could be a cheaper source of protein for the children and can thus be used effectively as mid-day meal for which Bihar State has already taken good lead. It also has relevance for inclusion in the Rural Employment Guarantee Scheme.
- Maize has also demonstrated its adaptation ability in areas where the *rabi* temperatures rise suddenly rather than gradually, as being the case in the eastern states including West Bengal. 'Single cross hybrids' of maize can play a significant role in these areas.
- Utilizing maize as nutritious animal feed would demand faster growth of bio-and organic fertilizers like poultry droppings. This will help in improving the health status of our soils.
- Poultry sector has enormous growth potential (about 15% p.a.) as compared to the present level of 11-12 per cent. Poultry industry would raise further the demand for QPM. Besides, maize has tremendous export potential in the region, especially South East Asia.

Incentives and Resource Allocation

- Maize being the best quality feed for poultry, it is necessary to provide incentives to those farmers who produce QPM. Government could consider giving a premium price to the QPM growers so as to accelerate its production in the country. In this context, State Department of Agriculture, Govt. of West Bengal has already taken major initiatives for seed production of the QPM hybrids through public-private partnership.
- The fast growth of maize wet as well as dry processing industry demands that it is included in the 'identified' schedule crops of the food processing industry. This would ensure stable prices for maize processed products in the market and would benefit both the producers and consumers.
- More thrust is needed now both on research and development of QPM maize, for which additional resources need to be allocated as a matter of priority.

9. Emerging Challenges before Indian Agriculture – The Way Forward

(A Brainstorming Workshop: March 6, 2009)

Background

India has made great strides in increasing food grain production. In the recent past, particularly significant progress has been made in achieving increased growth rates in horticulture, livestock and fishery. Nevertheless, declining total factor productivity, diminishing natural resources and stagnating farm incomes have caused serious concerns.

This workshop was organized by TAAS in collaboration with IFPRI on 6 March, 2009 at NASC Complex, New Delhi for an in-depth discussion on the emerging challenges that constrain agricultural growth and finding ways of overcoming these. The workshop was attended by 44 participants. The recommendations emerging out of the workshop are given below:

Recommendations

Policy

- Increasing agricultural productivity is a key challenge for ensuring national food security. To increase production, exploiting the potential of existing yield gaps offers a tremendous opportunity. Hence, a Mission Mode Program on "Bridging the Productivity Gap" with real missionary zeal and effective monitoring is required to be launched with meticulous planning as a matter of priority. For this, greater attention to agriculture in the national policy is needed, and the existing technology dissemination and input supply system needs to be revitalized and tuned to meet the emerging needs of farmers. Special emphasis on seed sector, input use efficiency, financial and insurance institutions and a paradigm shift in technology transfer mechanisms involving both the private sector and NGOs would be critical in achieving the desired goals.
- Rainfed areas have a huge potential to raise production and increase farm income. These grey areas can soon be made green to harness a second green revolution. Role of technologies, policies and infrastructure would be very important in realizing the potential of rainfed agriculture. In this context, it has to be ensured that public policies and technologies have appropriate synergies to move

forward. The initiative of the Government of India to establish the 'Rainfed Area Authority of India' is a welcome step. However, this Authority needs a proper policy framework, legal and funding supports as well as empowerment for effective coordination and monitoring of all rainfed related programs run by various Ministries/Departments. The sooner it is ensured, the better it would be in the national interest as time is otherwise running out.

- Linking farmers to markets is a pre-requisite for augmenting farm production and farmers' income. Role of innovative institutions would be critical in this context to reap the benefits of emerging opportunities. A silent revolution of innovative institutions is already taking place in the Indian agricultural production and marketing system (farm to plate continuum) encompassing effective functioning of value chains and marketing efficiencies. The current need is to replicate such 'best practices' through formation of producers' associations and self-help groups or cooperatives so as to harness fair and efficient contract opportunities through value addition by organizing the farmers. *Krishi Vigyan Kendras* (KVKs), constituting an existing institutional mechanism at the district level, could play a very important role in the entire supply chain through access to best practices in production to marketing continuum. Information and communication technology offers new opportunities in support of this.
- There is a dire need to significantly expand the capital investment in agriculture by both public and private institutions in the non-green revolution regions, particularly in the eastern and north-eastern India, where there is a great potential for agricultural growth. Hence, investment priorities must now be oriented towards realistic accelerated growth of agriculture for meeting the growing needs of the population. Therefore, public policies should be such that these trigger the much needed private sector investments for infrastructure development.
- Agriculture is confronted with new forms of risks and uncertainties. These are related to natural calamities, global climate change, use of food for biofuels, uncertainty over prices, etc. Role of knowledge system and institutional mechanisms for input supply, credit, crop and livestock insurance, etc., would, therefore, be important in reducing both risks and uncertainties in order to attain the much needed resilience in Indian agriculture. At the same time, less dependence on the use of chemical fertilizers and pesticides, and efficient use of water, energy and other inputs, including timely farm operations with major emphasis on small farm mechanization and bioenergy (solar and wind), would help achieve faster growth in agriculture.
- Water will be the most critical natural resource for the future growth of agriculture. Currently, the water sector for irrigation is invariably neglected both at the central and state levels. High inefficiencies in water delivery, distribution and on-farm use are adversely affecting our agricultural production. Irrigated area can be expanded considerably with improved efficiency in water use. Innovations in governance and pricing of surface and ground water for the desired water use efficiency, through an integrated approach among irrigation department, private sector, and farmers' water user associations are urgent issues for coordinated action by all stakeholders.
- Climate change has added a new dimension to future agricultural growth, which is a major concern. The worst affected would be small farm holders located in the marginal and under-privileged areas. Therefore, investment options for both adaptation and mitigation, and policies which can help in reducing the impact of climate change, are urgently needed at this stage, especially to provide incentives to the small farm holders for the adoption of technologies and practices such as conservation agriculture, carbon sequestration, etc., that can mitigate the impact of climate change.
- There is an urgent need for agricultural diversification by identifying the key crops/commodities which can help small farm holders to raise their income. Incremental gains in income through diversification will help capital formation which will be instrumental in attaining higher productivity and profitability. In this context, agro-ecological zone-wise planning, adoption of new area, new crops approach using geographical information system (GIS) and land use planning, and effective district level implementation of the strategy by involving grass root organizations and the stakeholders would be the best option to move forward.
- Food processing and distribution sector needs to be strengthened by evolving policies for greater private sector participation in the entire value chain. Incentives through appropriate tax structure should be such that agro-processing, especially in the rural areas, becomes a lucrative option both for the farmers and the private sector. Current post-harvest losses are also to be minimized for which construction of modern silos is a matter of national priority.
- Globalization of agriculture offers immense opportunities for enhanced agricultural export of a number of products. This can be harnessed only through increased efficiency in our production systems, improved quality of produce, value addition, market intelligence and long- term well targeted export policies and planning, supported fully well by an enabling environment both within and outside the country. An institutional mechanism, with emphasis on a single window system, would catalyze the whole process of agricultural exports from India, for which tremendous opportunities exist but have not been tapped presently.

10. Strategy for Conservation of Farm Animal Genetic Resources

(A Brainstorming Workshop: April 10-12, 2009)

Background

India is a rich repository of flora and fauna. It has 132 registered farm animal breeds. These breeds have evolved under domestication and over numerous cycles of natural selection. They have special attributes of remarkable adaptability to tropical environment and genetic resistance to many diseases. However, recent human interventions have led to over exploitation of these genetic resources and threatened the existence of some of the precious genetic diversity. Today, faced with the needs of growing population and to meet challenges of climate change there is urgent need to conserve our valuable indigenous genetic resources for sustainable use of their 'resilience' traits.

In order to discuss National and International issues pertaining to management of animal genetic resource, a brainstorming workshop was organized by TAAS and BAU Ranchi on 10-12 April, 2009 at BAU Ranchi to review the current status and develop strategies to conserve our animal wealth.

The group of participating experts, representing various stakeholders from national and international organizations, recommended and then unanimously adopted on 12th April, 2009 the following declaration, to be referred henceforth as "Ranchi Declaration".

Ranchi Declaration

- We assert that India, without waiting for the stipulated time frame of 2011, should immediately prepare a National Plan of Action on management and conservation of farm animal genetic resources for its speedy implementation.
- Currently, the five livestock and poultry species, viz., cattle, buffalo, goat, sheep and chicken (poultry) are at the top priority in terms of population, diversity and contribution to the national food, environment and livelihood security. Therefore, we propose that these species be immediately declared as BIG FIVE of India.
- We recognize the enormous contribution of farm animal genetic resources to the national gross domestic product (GDP). During 2006-07, the contribution of livestock and fisheries sectors was estimated to be Rs. 2,508 billion which is about 5.26 per cent of total national GDP and around 31.7 per cent of our agricultural GDP. Hence, it is urged that current resources be doubled for the livestock R&D sector on priority, and a specific policy directive given in favor of farm animal genetic resources that are so critical for the national food and nutrition security as well a sustainable livelihood of our resource poor farmers.
- We are convinced that maintenance of diverse animal genetic resources for food and agriculture is essential (especially for the farmers, pastoralists and animal breeders) to meet the current and future challenges arising out of climate change, increased press due to diseases, overexploitation of grazing lands and the changing consumer demand for animal products. Hence, maintenance and further improvement of pure breeds retaining their valuable characteristics, including those related to adaption to climate change, becomes a national priority.
- The role of farm men, women, pastoralists and rural communities in evolving different breeds of livestock and poultry, adapted to specific ecological niches, is fully recognized since, these breeds possess unique traits developed over many years of selection. In this context, we are convinced that a strong legal instrument is urgently needed to deal with the registration of livestock breeds, protection of animal keepers' rights and related issues for effective management and conservation of farm animal genetic resources, on a pattern similar to that of Protection of Plant Varieties & Farmers' Rights Act (2001).

Group photograph with Governor during the Brainstorming Workshop

- We especially recognize the need for capacity building of civil society organizations (NGOs and local livestock community/farmers) for managing Indian breeds of livestock and poultry and retaining their valuable characteristics and purity. In this context, the currently engaged staff at the Government Livestock Farms and some specialized *Gaushalas* be properly trained.
- It is acknowledged that major gaps/weaknesses exist in our national and state capacities to inventorise, monitor, characterize, sustainably use, develop and conserve animal genetic resources. These need to be bridged as a matter of priority through a mission mode program, and by developing the much needed population database for animals, their population trends and risks associated with them in order to establish country based early warning and response systems. Hence, there is an urgency to initiate appropriate action to conserve our valuable livestock and poultry breeds that are currently at risk.
- Considering available institutional strength and competent human resources, India could serve as a regional focal point for the management and conservation of farm animal genetic resources for South Asia. It would, therefore, be worth exploring this option through regional fora/ organizations such as South Asian Association for Regional Cooperation (SAARC), Asia-Pacific Association of Agricultural research Institutions (APAARI), etc.
- We recognize the need to strengthen research aimed at scientific management, genetic enhancement, sustainable use and conservation of farm animal genetic resources. This has to be accomplished through effective coordination linkage mechanisms among various ministries/ departments and the partnership with regional and international organizations/institutions such as FAO and International Livestock Research Institute (ILRI).

11. Climate Change, Soil Quality and Food Security

(A Brainstorming Workshop: August 11, 2009)

Background

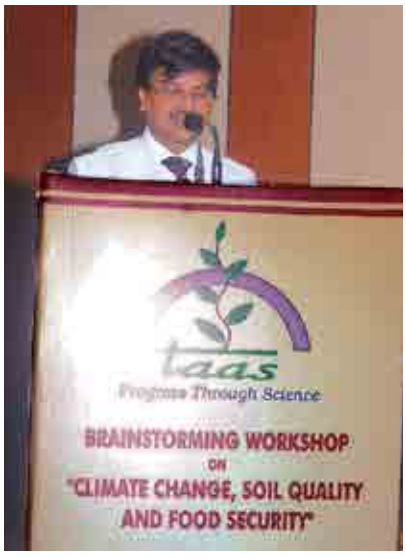
The major challenges to sustaining food productivity attained as a result of the Green Revolution of 1970s include feeding rapidly growing population, shrinking natural resources and risks associated with climate change which are impacting agriculture in many ways. Unforeseen changes in temperature and precipitation call for the measures for mitigation and adaptation in our agriculture, including cultivation of appropriate varieties and adoption of better agronomic practices.

In order to discuss these issues, a workshop was organized by TAAS on 11 August, 2009 at NASC Complex, DPS Marg, New Delhi attended by 51 participants. The participants comprising leading agricultural experts from national and international organizations, policy makers, scientists, leaders of corporate organizations and civil society discussed these issues intensively and came out with following recommendations:

Recommendations

Policy

- Per capita availability of land in India is likely to decrease substantially (around 0.09 ha by 2050) with the current growth in population. This coupled with the challenge of rising food demand necessitates an urgent need to double the resource allocation for agricultural R&D to focus on increased irrigated area, improved efficiency of water and fertilizer use, and improvement in the health of our degraded land. Immediate action on these R&D aspects is needed to address the emerging threats in the context of climate change and food security.



Dr. H.S. Gupta, then Director, ICAR-IARI presenting welcome remarks

Dr. M.S. Swaminathan chairing the Plenary Session

- Increasing weather aberrations and consequent risks are likely to impact adversely on Indian agriculture. Severity of these risks will get compounded with climate change or especially in terms of increasing temperature, erratic rainfall and rising sea level. It is estimated that cereal productivity may decrease anywhere between 10 and 40 per cent by 2100 if no corrective measures are taken in time. Hence, adaptation to climate change must receive high priority by all stakeholders.
- The role of R&D, especially in conserving natural resources like land and water, assumes significance for adoption of a strategy aimed at mitigation and adaptation to climate change. Conservation agriculture ensuring minimum disturbance of soil, increased vegetative cover, and diversification of crop sequences which has a lot of potential. However, adoption of new innovations would require proper policy, funding and institutional support.
- Achievement of the Millennium Development Goals (MDGs) in the event of climate change is likely to become more difficult, especially in South Asia where high incidence of poverty and malnourishment is rampant. In such a scenario, the achievement of MDGs would obviously require global/regional research partnerships, and sharing of information and experiences. In this context, organizations such as Asia-Pacific Association of Agricultural Research Institutions (APAARI), Global Forum on Agricultural Research (GFAR), CGIAR Centers, Food and Agriculture Organization of the United Nations (FAO) and some advanced research institutions (ARIs) like Japan International Research Center for Agricultural Sciences (JIRCAS) have to play an effective role in bringing all stakeholders together for research partnerships and capacity building.
- The Agricultural Research and Education System must be reoriented to respond effectively to the emerging challenges of natural resource degradation, and climate change. As stated before, there is an urgent need to double the agricultural R&D allocation to meet the new challenges being faced by Indian agriculture. The policy mismatch for different sectors of agriculture should also be looked in while making future R&D allocations.

Strategy

- To cope with climate change, the strategy should mainly entail adaptation to changing environment (new genotypes), and efficient use of resources (land, water, energy) as well as weather management services. Additionally, the long term mitigation strategy should aim to neutralize the factors such as greenhouse gases (GHGs) causing climate change.
- Adaptation and mitigation strategies would require strong R&D back up as well as proper financial and policy support. Diversity of agricultural systems, experiences of Green Revolution and new innovations are the keys to understand the processes that would accelerate both adaptation and mitigation. Mostly, these strategies should evolve around new plant types, appropriate land use planning, and efficient management of crops as well as available natural resources (biodiversity, land, water, energy, etc.).
- Crop improvement through traditional plant breeding, and biotechnology tools, should target better tolerance in crops to drought, heat, salinity, floods, etc. This could be done through breeding for earliness, adaptability to fragile ecosystems, improved plant architecture, and tolerance to pest dynamics. The strategy should also aim at the exploitation of alien genes as well as new genes for gene pyramiding, converting C3 plants to C4 plants, and building multiple resistance to both biotic and abiotic stresses, etc.
- Rainfed agriculture occupies nearly two-thirds of our agricultural land where water is the scarcest resource. Hence, increasing water- use efficiency through measures such as sprinkler irrigation, drip irrigation, use of plastic mulch and water harvesting (through bunding around small farm holdings) becomes an essential part of the proposed adaptation strategy. It is estimated that nearly 11-37 per cent runoff can be utilized by simple means like field bunding and land leveling, to successfully raise one crop in almost 25 mha of rainfed area. However, this will require proper technical backstopping through a responsive and efficient extension system, involving both public and private institutions, particularly NGOs active in rural areas.
- Improvement in soil fertility and productive capacity of ecosystem should evolve around the increasing carbon pools both in soil and vegetation. Trading of carbon, similar to other farm commodities prevalent in developed countries, can create another stream of income for farmers. However, special incentives to small and resource poor farmers for adopting resource conserving technologies/ environmental services need to be provided since these initiatives are in overall national interest. For this, we need to pursue the strategy of learning through change that will improve our soil and ecosystem, and bring in resilience in agriculture.
- Soil carbon sequestration is an effective strategy to improve soil health and raise crop yields. Somehow, available soil organic carbon (SOC), in most uplands in India, is only around 0.2-0.5 per cent, which is much below the threshold level (around 1.1%). Application of soil amendments such as crop residues and animal manure can enhance SOC pool significantly in rainfed areas, and hence be promoted. Burning of wheat and rice straw should be stopped/banned and farmers should be encouraged to adopt organic recycling to improve soil health and raise crop productivity.

12. Quality Seed for Food Security through Public-Private Partnership

(A National Seminar: April 13-14, 2010)

Background

In order to meet growing need of quality seed to ensure food security, public-private partnership is necessary. This will help in reducing the gaps in seed chain and developing buffer stocks of quality seed to meet urgent requirements during natural calamities. In order to discuss these issues, a 2-day seminar was organized jointly by the NSAI, TAAS and ICAR-IARI on 13-14 April, 2010 at ICAR-IARI, Pusa Campus, New Delhi. In all, 142 participants comprising private entrepreneurs, scientists and representatives of National Seed Association of India (NSAI) discussed various issues and came out with following recommendations:

Recommendations

- A Policy Paper needs to be brought out immediately based on crop-wise desired and current seed replacement rates (SRR), total seed requirements and availability, giving varietal shares and strategy to be followed to increase crop productivity by increasing the SRR. The ICAR should coordinate with the Department of Agriculture & Cooperation (DAC) and NSAI to bring out this paper to form the basis for strengthening of seed development program in the country.
- Increased availability of high yielding variety (HYV) seeds can fast bridge the yield gaps and thus, increase the national productivity and production. Hence, there is an urgent need for the ICAR to enhance the SRR of selected crops and vegetables, with emphasis on improved varieties of pulses and groundnut, where the SRR is still far from satisfactory. Wherever hybrids are successful, a special drive to increase the area under them would be desirable. For instance, in rice, the area under hybrids can be enhanced from the current 1.5 million hectares to at least 5 million hectares in the next Five Year Plan period. Similarly, in maize, the production can be doubled by increasing the area under single cross maize and QPM hybrids from the current 40-50 per cent to at least 70-80 per cent in the next 4 to 5 years.
- The success of partnership lies in trust, openness, and transparency. This can be built by regular interactions and dialogues, and appropriate policy framework to strengthen public-private partnerships. Therefore, a Standing Working Group in the Ministry of Agriculture (DAC/DARE-ICAR) may be constituted as a matter of priority under the leadership of an eminent scientist, comprising, in all, around 7 members representing DAC (2), ICAR (2) and seed industry (2). This could work as a "Think Tank" and play an oversight as well as honest brokers role in promoting public-private-partnership (PPP). The proposed Working Group could also review the existing guidelines for incentives and rewards and suggest ways for building new partnerships while taking care of access and benefit sharing (ABS) mechanisms.
- Good models and success stories on PPP existing in the NARS and the CGIAR system, such as that of ICAR-IARI, ICAR-NRCPB (now NIPB), ICAR-IIHR, ICRISAT, IRRI, etc., can be replicated or further refined, as needed, by other institutions/ universities. However, some of these institutions expressed concerns about the break in the continuity of Breeder Seed procurement by the commercial

Presidential address by Dr. R.S. Paroda

organizations, which has to be addressed to build partnership.

- For the access to new hybrids/varieties/genetic materials, the private sector may consider paying royalties between 3-7 per cent on sale proceeds – based on negotiations, on a case to case basis, and depending on exclusive/non-exclusive rights. The public sector seed corporations should also join hands with the research institutions in popularization and fast delivery of improved varieties, especially the hybrids. In view of the poor conversion of breeder seed to foundation and certified seed, the public sector should use PPP model to convert the maximum of breeder seed to certified seed. The public sector should, henceforth, pay a royalty on breeder seed on mutually agreed terms.
- There is an urgent need to build crop-based/ institution-based technology parks/ incubators so that scientists from both public research institutions and private seed sector could work together right from the beginning of the partnership in evaluating germplasm and breeding lines, and in developing, evaluating and commercializing varieties with the desired traits. This may encompass the development of transgenics, biosafety assessment, field evaluation, public awareness and release of the final product keeping in mind the national interest.
- Germplasm conservation through use can help in achieving both sustainable agricultural growth and development. Hence, it was emphasized that the national germplasm collection available at the NBPGR, being the national public goods, be made available more freely on request, to Indian scientists/institutions/seed companies engaged in crop improvement (R&D) programs. For this, the Standard Material Transfer Agreement (SMTA), as adopted recently by the FAO International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) for multilateral access, can be adopted for immediate implementation, with necessary safeguards as needed. All data on available germplasm must be documented / catalogued and placed on ICAR-NBPGR website.

Some of the policy related issues for consideration of the DAC are:

i) The DAC needs to harmonize, to the extent possible, seed related regulations both at the central and state levels. The New Seed Bill, currently under consideration of the Parliament, is expected to provide enabling environment for faster seed sector growth in the country.

ii) The quality seeds, whether certified or truthfully labeled, must qualify for seed subsidy. Subsidies need to be linked to promote area coverage under new HYVs and hybrids for increasing productivity, irrespective of whether produced by the public or private sector. This will benefit both farmers and the nation and avoid discrimination, which otherwise is counter productive.

iii) For accelerating hybrid seed production, the present system of receiving indents of the parental lines of notified hybrids by the public/private sector (through NSAI to DAC) and fixing one uniform price, irrespective of their commercial value, must be reviewed at the earliest in consultation with the ICAR and NSAI.

iv) For crisis management, it is essential to establish Regional Seed Banks as a contingency measure. There is an urgent need for establishing Seed Processing and Storage Facilities by the public / private sector for common use, on a fixed charge basis.

13. Building Leadership in Agricultural Research Management

(A National Dialogue: August 27-28, 2010)

Background

Agriculture sector is currently facing complex challenges including those in agricultural research. Funding crisis, declining scientific manpower, growing in-breeding in an era of complex problems as well as new opportunities in agriculture sector call for leaders who could become effective agents of change to effectively/ efficiently address these challenges.

Delegates attending the National Dialogue

A National Dialogue on "Building Leadership in Agricultural Research Management" was organized on 27-28 August, 2010 at ICAR-NAARM, Hyderabad to provide a forum to the leaders and stakeholders to discuss various issues and options for building effective leadership in order to revitalize the NARS. The conference was inaugurated by Dr. M.V. Rao, Chairman, Agri-biotechnology Foundation and Former Special Director General ICAR, and addressed by Dr. Mangala Rai, Director General, ICAR. Senior ICAR management staff, including 50 delegates from various organizations such as Centre for Organizational Research and Development, Administrative Staff College, Department of Biotechnology, CGIAR and some corporate houses participated in the dialogue.

Discussions in the National Dialogue focused on the leadership development strategies needed for the National Agricultural Research System (NARS). Some of the major recommendations that emerged during the Dialogue are given below:

Recommendations

Desirable Leadership Attributes

- The desirable attributes for leadership in agricultural research management must include: managing self, managing research for quality and development of science, facilitating partnerships and institutional linkage mechanisms, managing scientific teams and facilitating change in the organization. A leader must inspire, build confidence among colleagues, be consultative, should be able to manage conflict, delegate power with accountability, and should be accessible, honest and transparent in decision making.
- Emphasis need to be given on IQ (Intelligence Quotient) and also on EI (Emotional Intelligence), which is rather more important for a leader to be successful.

Building Leadership

- There is a need to create awareness and required competencies among prospective leaders for 'servant leadership'.
- There is a need to understand new challenges, and develop commensurate re-engineering exercises to identify clearly what kind of leadership is required to overcome these challenges.
- There is a need to develop a mechanism to monitor scientists, for their extra-ordinary performance and potential leadership qualities, and then to groom them for taking up leadership responsibilities.
- Decentralized structure and performance-based rational and transparent evaluation in a collective mode would provide proper platform for developing research management leadership.

Other Related Issues

- In-breeding in the institutes must be discouraged.
- Bright young students should be encouraged to take up agriculture as profession. There is an urgent need to attract good students in agriculture and agricultural research system.
- A formal training in management should be an essential qualification for Research Management Positions
- For best management practices, appropriate models for different institutes, as per their size and specific needs, must be evolved.
- Distinction between performers and non-performers be made more judiciously and in transparent manner.
- System wide mechanisms and incentives (both monetary and non-monetary) should be developed and put in place to attract talented scientists towards management cadre.
- Autonomy, freedom to experiment/play with ideas (at least 15% of the time), and 'freedom to fail' would encourage leadership potential.
- Necessary rules and guidelines should be developed/ put in place in the system to ensure quick decision-making.

14. Prospects of Producing 100 million tons of Wheat by 2015

(A Brainstorming Session: December 18, 2010)

Background

Demand for wheat will increase substantially due to increase in population and practically no option for horizontal expansion of cultivable land. Well thought measures are, therefore, needed to meet this challenge through vertical expansion i.e. by increasing the productivity of wheat to a substantial level.

A total of 91 wheat experts from India, CIMMYT and ICARDA represented by Dr. Sanjay Rajaram, (World Food Laureate) attended the Braining Storming Session on 18 December, 2010 at NASC Complex, DPS Marg, New Delhi. Based on detailed deliberations, the following recommendations emerged:

Recommendations

Policy

- Food security in India is synonymous to wheat production. Hence, consistent efforts would be necessary with adequate policy support to increase wheat production to meet our ever-increasing demand despite numerous challenges such as: factor productivity decline, high cost of inputs, poor soil health, low quantity and quality of water, and adverse impacts of climate change.
- Almost a decade ago, India had become number two in wheat production by surpassing the USA with almost same acreage. It must now aim to be number one by achieving higher production than China (currently 107 mt). In this context, there is no room for complacency. Concerted efforts are needed under national food security mission to coordinate AR4D initiatives, especially to accelerate wheat production

Dr. M.S. Swaminathan inaugurating the Brainstorming Session

efforts in eastern India, and in those States whose average wheat productivity is still lower than the national average.

Research and Technology

- Nutrient application in the form of fertilizers and pesticide use will become more expensive due to high energy costs. Similarly, water scarcity will be a major challenge. Hence, it is important to develop varieties that are both water and nutrient use efficient. This can be achieved through appropriate crop improvement and crop management strategies in an integrated manner. It would require intensified crop improvement efforts and more extensive use of germplasm, synthetic wheat breeding and use of biotechnology. In this context, wheat breeding efforts in the country must immediately be strengthened and capable human resource employed.
- The major focus of the researchers should now be on enhancing the yield, which has been stagnating for almost a decade. To overcome specifically this challenge, both breeding and biotechnological approaches for developing hybrid wheat appears to be a viable option. To address this, public-private partnership should be encouraged through much needed policy environment and support, especially to ensure quantum jump in wheat productivity.
- Marker assisted wheat breeding will play a pivotal role and there is need to develop efficient markers for traits such as yellow rust, stem rust, grain quality, etc. Transgenics in wheat should be developed, especially for abiotic stresses, like terminal heat, drought and other traits like herbicide resistance, grain quality improvement, tolerance to micronutrient deficiency, etc.
- Research on quality improvement has to be further strengthened as the country's consumer demand for improved quality wheat is increasing, since there is a need now for various end uses like flour, pasta, bakery, etc. Also, wheat quality will be a critical factor in case of future exports, if any.
- There is a need to lay more emphasis on breeding for yellow rust resistance which potentially will be the biggest threat to wheat production in near future. Keeping in view the impact of climate change, constant vigil and preparedness is required to deal with new threats like leaf blast, *Fusarium* head blight and Hessian fly. Similarly, incidence of leaf blight is now spreading, which needs to be addressed as a new threat.
- There is an urgent need to integrate both crop improvement and management strategies, especially to find solutions to improve soil health that has been constantly drained due to intensive rice-wheat cropping system in the Indo-Gangetic Plains. Organic matter content in the soil has to be improved and need based application of nutrients to be applied in future.
- Burning of crop residues is leading to environmental pollution, in addition to the loss of valuable organic matter needed to maintain soil health. We must promote surface retention or incorporation of crop residues for better soil health, which is so crucial for increasing productivity and profitability.
- In the scenario of decreasing availability of good quality irrigation water, there is an urgent need to adopt and promote water use efficient technologies like laser land leveling, raised bed planting, wheat sowing using zero till drill etc. for higher productivity and profitability to the farmers.

Packages of Cultivation Practices

- Unfortunately, considerable area is under late planting, especially in the eastern Gangetic plains. Through an aggressive campaign, timely sowing of

wheat for higher productivity has to be ensured, following the examples of Punjab and Haryana in the recent past.

- Substantial area in the eastern Gangetic plains is under rice-fallow. There is an urgent need to promote adoption of surface seeding and/or zero tillage to convert the single cropped area to double cropping for increased production of wheat. This option has to be pursued aggressively both by increasing area under wheat and cropping intensity in eastern India.
- Wheat can be grown as an intercrop with sugarcane by adopting bed planting technique or relay cropping with cotton. Therefore, future efforts be addressed towards farming system's research. Also, for increased system productivity, profitability and sustainability, summer mung in north western Gangetic plains must be promoted, since, excellent short duration, disease-resistant varieties of mung bean are now available.

Seed Systems

- Region-specific seed systems should be developed for ensured supply of quality seed of varieties suitable for different regions for achieving increased productivity. It was also felt that predominant variety must be phased out soon, since it has shown increased susceptibility to brown rust, whereas new resistant varieties are now available to replace it. This requires priority time bound action.

15. Stakeholders' Interface on GM Food Crops

(An Interface Dialogue: May 19, 2011)

Background

Despite Green Revolution and several innovations, the challenge of food and nutritional security still looms large. In order to meet the food requirements of the ever-increasing population, we would need to increase our food production from current 235 mt to at least 285 mt by 2020 from less cultivable land. GM technology provides powerful tools to meet this challenge. To discuss these issues, a dialogue was organized jointly by APCoAB, TAAS and ICAR on 19 May, 2011 at NASC Complex, DPS Marg, New Delhi.

Dr. (Mrs.) Manju Sharma presenting her views

Dr. S. Ayyappan and Dr. H.S. Gupta co-chairing a session

The recommendations given herein are a synthesis of the views of stakeholders emerged as a result of pragmatic in-depth discussions held. The meeting was attended by 45 experts representing a cross section of technical experts, scientists, policy makers, farmers and other stakeholders.

Recommendations

- There is a need for second Green Revolution in India especially for our nutrition security, since India has the maximum concentration of malnourished children and anemic pregnant women in the world. It is also extremely important to have good nutrition rather than food calories alone. For this, the use of GM technology is highly relevant in the present context. This technology offers new options to enhance nutrition security through designer cereal, oilseed, pulse, fruit and vegetable crops and to meet the challenges of biotic and abiotic stresses as well as those of global climate change. Moreover, the poverty of smallholder farmers can be overcome by providing them new technologies that can reduce cost on inputs, build resilience in farming and increase their income by linking to the markets. In this context, we do see a prominent role of biotechnology, which needs to be harnessed on priority.
- Development and adoption of appropriate GM technologies would need a mission mode approach for which a strong public research system needs to be built/strengthened. Along with public sector, the private sector investments on GM technologies have to be enhanced for which an enabling environment is a must. Appropriate protocols and IPR regimes need to be developed to encourage public- private partnership.
- There is an urgency now for the prioritization of crops in order to effectively use GM technologies for improving specific traits. To achieve this, a 'National

Mission on GM Food Crops' be initiated soon, being a national priority, jointly by DBT and lCAR. It should be a time targeted and well monitored program linked to specific outputs.

- It was strongly felt that the Biotechnology Regulatory Authority of India (BRAI) Bill, which is already in the Parliament, must be cleared soon and a strong message in this regard needs to be sent to all concerned policy makers and authorities since we have already lost valuable five years. The proposed BRAI is also recommended in order to ensure a single window system for testing, clearance and monitoring. At the same time, the regulatory system should not be too stringent to slow down the release process.
- The biosafety regulatory system, though well-defined and in place, needs to be made more efficient and fool proof so as to facilitate effective and safe application of biotechnology. We need a clear and well defined pathway and transparent system for which there is an urgent need to establish a few accredited laboratories in reputed public sector institutions like ICMR-NIN, ICAR-IVRI, CSIR-CDRI etc. having excellent infrastructure with modern equipments and well trained staff. Accreditation of some of these public sector laboratories is a must in order to build much needed public confidence. Also, a referral laboratory needs to be established so as to deal with any dispute arising on account of variations in results of different laboratories. There is no mechanism existing presently for the seed testing of GM crops. Hence, efforts are needed to establish accredited laboratories for this purpose.
- There is also an urgency to have proper post-release monitoring system, for which a suitable mechanism be put in place jointly by ICAR and DBT. Also, need for undertaking survey on farmers' fields is justified in order to assess the uptake and impact of GM technologies. Socioeconomic assessment should be an integral part of GM crops evaluation process. Also, opportunity costs of not adopting the technology should be a part of this assessment.
- Plant breeders and biotechnologists must join hands and work as one team to address specific research problems. Their efforts should be synergistic and not competitive. Similarly, strong public- private-partnership right from the beginning of the project, with needed understanding, mutual trust and defined roles for research and benefit sharing, be encouraged through enabling environment. This is a must for faster delivery to the end users of agricultural biotechnology.
- Public perceptions about GM technology are often not based on scientific facts. Information communication system, including public extension and awareness services, need to be considerably improved in order to effectively deliver correct and unbiased information to farmers and the general public. Also, there is an urgent need to properly inform and educate people at all levels, including policy makers and planners, farmers, consumers and other stakeholders on all aspects of agricultural biotechnology and biosafety. Required communication tools must be used for effective delivery of knowledge.
- Priority investments are needed on capacity building, especially in areas of biosafety research, regulatory systems (including legal aspects), communication tools and IPR issues since they are all critical for out-scaling innovations for greater impact.
- There must be a defined focus on agri-business and agri-biotechnology in the 12th Five Year Plan for which ICAR should take a major initiative and DBT must extend required funding support. Agri-business platforms and technology parks have to be established for building much needed public-private-partnership and for faster delivery of GM products to both the farmers and consumers.

16. Innovative Approaches for Agricultural Knowledge Management: Global Extension Experiences

(An International Conference: November 9-12, 2011)

Background

Globalization of economy, changing structure of rural economy and emerging issues such as climate change have opened up new avenues and challenges in agriculture and enhanced the need for timely and accurate information as one of the drivers of agricultural growth. This situation demands for a continuous search for new methods and approaches for generating, processing and sharing of agricultural knowledge communication by various stakeholders for augmenting agricultural production and productivity. Apart from innovativeness in methods, there is consistent effort to bring in innovativeness in increased level of partnership

Chief Guest Shri Harish Rawat, the then Hon'ble Union Minister, Food Processing Industries, and Parliamentary Affairs gracing the Valedictory Function

between public and private sectors in agricultural technology generation and sharing so as to improve efficiency of agricultural knowledge system.

In this context, an International Conference on "Innovative Approaches for Agricultural Knowledge Management: Global Extension Experiences" was organized from 9-12 November, 2011 by ICAR, International Society for Extension Education and TAAS in collaboration with Maharashtra Society of Extension Education, National Academy of Agricultural Sciences, Alcorn State University, USA, APAARI, FAO, GFAR, and Iowa State University, USA at the NASC Complex, DPS Marg, New Delhi.

The conference had 23 technical sessions and two special sessions. The conference was inaugurated by Smt. Pratibha Patil, the then Hon'ble President of India. It was also graced by the then Hon'ble Agriculture Minister Shri Sharad Pawar and attended by more than 250 national and international delegates.

The recommendations emerging out of the discussions held on above subject are given below:

Recommendations

- Research in extension education should be based on appropriate sampling, quasi-experimental designs and statistical tools. The extension research findings should be utilized for agricultural research and development. There is a need to tap the large reservoir of farmers' tacit knowledge to consider their perspective and it is blending with the scientific findings to develop applicable knowledge and appropriate technologies. The impact assessment of the technological interventions need to be analyzed and carried out with appropriate use of new tools focusing on profitability and livelihood security indicators rather than only yield data. Extension researcher should take care while making meaning of the results of adoption research so that effective communication and dissemination can be made. Future extension course curriculum should focus on comprehensive 'know how' and 'do how' of ICTs enabling future extension personnel to be e-ready. For all knowledge management initiatives, methodology for benchmark surveys and impact assessment are to be developed and standardized.
- In order to have appropriate convergence and integration of research, education and extension, the ICAR may specifically encourage SAUs and Deemed Universities (DUs) on this issue. The good extension models and best practices evolved and developed by various institutes and agricultural universities, which are found relevant in particular situations may be up-scaled by the main extension system responsible for large scale extension delivery. Integrated technology dissemination system (ITDS) combing all the available technologies from research institutes, extension organizations, input dealers, corporate R&D companies and marketing agencies need to be promoted for effective adoption of agriculture technologies and development of business models.
- The KVK- a unique intermediary institution created as part of NARS in India to assess, refine, demonstrate and function as knowledge and resource centre of agricultural technologies has emerged as a very successful model. This model may also be tried and tested in other developing countries as part of their NARS. Being the district level science based institution, KVK plays the role of knowledge and resource centre for better knowledge management, but expectations from KVK should be confined to mandated activities.
- All the extension/ KVK staff need to be provided with mobile phones and also there needs to be provision for funds for operational expenses. Mobile based advisory should be provided by district based institution (e.g.KVK/ATMA etc.). To enhance the uses of ICT in agriculture, there is a need of capacity building and training of users, KVK staff and farmers for exploiting the strength of ICT for extension purposes. The recommendations emerging from on-farm trials conducted through KVKs need to become part of package of practices of the district for smooth horizontal expansion of the technologies.
- Agricultural Technology Management Agency (ATMA) as a reform measure needs to be projected as an innovative institutional arrangement at district level and not as a scheme or project. Hence, regular interfaces with frontline systems are necessary to dispel any misconceptions about ATMA and its importance as mainstream extension interface at cutting edge level.
- Human resource development is critical to ensure transition of agricultural extension system for effective agricultural knowledge management. Hence, there has to be a serious re-look at the policy of restricted recruitments. This problem is alarmingly acute in allied sectors like animal husbandry, fisheries, horticulture, sericulture, etc. which have significant contribution to agricultural GDP. It is, therefore, strongly recommended for rigorous HRD, training and capacity building of all stakeholders.
- There is a need to promote transnational exchange of extension knowledge. When it comes to translate this imported knowledge into action, due care has to be exercised to test it for relevance, feasibility and profitability in terms of local conditions, and then adapt/adopt it. The implication is that one universal model fits all is not proper and we need to explore the 'best fit model' in terms of the local adaptability.
- Entrepreneurial success depends on personal factors and external support systems. Hence, there is a need to strengthen the entrepreneurial attributes of farmers by capacity building and providing facilitative measures like credit, technical backstopping, policy support and sustained cooperation till they independently manage their enterprises, besides promoting entrepreneurship in value chains of livestock, fisheries, horticulture, apiculture, sericulture, etc.

- Amongst various options of capacity building, awareness generation, frontline demonstrations, vocational education and training programs and training/ retraining of extension education functionaries are advocated. Frontline demonstrations, which emphasized on 'learning by doing' and 'seeing is believing' for effective technology application are to be strengthened. Focus should also be made in print and electronic media.
- Open and distance learning is considered as the most viable means for broadening education access, while improving the quality of education, advocating peer-to-peer collaboration and giving the learners, a greater sense of autonomy and responsibility for learning. The learning system needs to be adapted along the way, according to the situation and the adaptation required in that particular situation. Vocational training should also be imparted by the scientists on village and *panchayat* levels. Need based pre-service and in-service training programs, keeping in view their educational level need be incorporated as essential component of human resource development. Training needs to be promoted for increased knowledge of rural women to change their attitude to a significant level regarding value added products.
- In the context of climate change and other pressing agrarian challenges, ICT mediated knowledge management strategies should focus on improving the access to risk management knowledge products and advisory through mobile phones. It is recommended that extension systems have in place, capacity building of farmers and extension workers in optimum use of mobile networks. Most of the advisories being issued through mobile facility are text based. Text based advisory can be used only by literate farmers. The voice based SMS in vernacular language can be easily understood by illiterate farmers. There is a need for NARS to focus on application of sensor based networks for precision farming as there seems to be less focus in this direction. Low cost teleconferencing needs be encouraged to enhance the knowledge sharing and problem solving capabilities of extension personnel.
- Various content management tools used in different portals need to be adopted for extension systems. Knowledge Portals should be developed with vernacular language content to meet out local needs. There is a need to work on strategies for technologically empowering input dealers as that of MANAGE's initiative for agri-business. More focus should be given to farmers' success stories through print media and ICT tools. Market information systems should be integrated with KVK system so that knowledge is provided along with market information. Quality content creation at national level with active participation of concerned crop research institutions and experts (In-service and retired) needs to be done.
- Public/private partnership needs more emphasis in the process of agricultural knowledge management and the same should be a two-way process for accepting and sharing technologies. Extension through participatory approach needs to be holistic covering watershed development, technologies for higher productivity, increasing access to markets etc. Role of NGOs and cooperatives is significant in agricultural knowledge management and the same may be strengthened through effective convergence. Participatory irrigation management through group dynamics needs to be promoted at micro level. Concepts like village resource centre can be encouraged for agricultural knowledge sharing at grass root level. Strengthening of linkages between SHG's and different technical institutions and NGO's is important in the process of agricultural knowledge management.
- The successful networking approaches like *Krishi Mahotsava*, Community radio, *Krishak Samiti, Samaj Shilpi Dampatti* Model, Satellite approach and innovative mode of agro-advisory services need to be strengthened, process documented and up scaled. Participatory approach for managing the knowledge may be more effective if the primary stakeholders, viz., the farmers may be successfully persuaded to share their part in terms of labor, partial operational cost, land and other requirements. Moreover, support for establishment and sustaining the farmers' club by related institutions shall further add to the success of participatory approach. Endogenous tourism needs greater attention by all the related partners / stakeholders for maintaining eco-sustainability in hill agro-ecosystem.
- Climate change is a broad based multidimensional issue. Prioritization of short- term and long-term issues and goals for mitigation is necessary. There is urgent need for comprehensive study and systematizing the efforts in aggregating information on various aspects of climate change and its dissemination through development of a dedicated climate change portal. NRM and Extension Divisions of ICAR need to jointly organize a brainstorming session on climate change and agriculture. In view of climate change, the climate resilient technologies should be tested and refined with traditional knowledge systems for their dissemination. The technology modules being developed by *Krishi Vigyan Kendras* (KVKs) under National Initiative on Climate Resilience Agriculture (NICRA) should be replicated through convergence with line departments of State Governments.
- In order to conserve the natural resources, resource conservation technologies should be promoted on large scale focusing mainly the soil and water. For promotion of resource conservation technologies and also to save labor with economy, custom hiring

services for farm implements and machinery at *Panchayat* level should be made available to the farmers. For increasing input-use efficiency with the objective of increasing factor productivity and profitability, appropriate technologies related to water and nutrient management should be popularized on large scale. In view of shrinking size of holding of the farm families, there should be ban on converting agricultural land to other purposes. Simultaneously, massive program should be launched for converting the degraded and wasteland into cultivable lands.

- In order to increase the profitability in farming and ensuring sustainable livelihood security to the marginal and small farmers, secondary agriculture should be emphasized and appropriate technologies for post-harvest and value addition to the produce should be made available to the farmers.
- Land consolidation should be given rethinking for promotion of mechanization and precision farming technologies. Land records of the farmers should be updated and made online and each and every farm family should be provided a land possession card. Capacity building program for agricultural laborers should be carried out in the field of improved agricultural technologies. Prices of agricultural commodities should be fixed keeping in view the regional realities and a Composite Input Cell Produce Procurement Centre should be established at *Panchayat* level. In view of labor problem in agricultural activities, the provision of Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA) should be extended to the agricultural activities.
- In place of "Research for Development" the concept of "Extension for Research and Development" should be made operational to address various current agrarian issues and agricultural knowledge management particularly in respect of emerging new risks in rainfed agriculture.

17. Farmer-led Innovations

(A National Workshop: December 23-24, 2011)

Background

For centuries, farmers have been silently innovating and adopting various agricultural practices to make agriculture more efficient and cost effective. In particular, farm women have played a very important role in conservation of the germplasm and post-harvest management of crops. Somehow, most of these innovations by farmers have not been documented. Hence, they have remained un-noticed. This conference was specifically organized to assess the relevance of farmer-led innovations and the need for further validation and up-scaling of promising technologies for greater benefit to all stakeholders.

The workshop was organized by the *Haryana Kisan Ayog*, ICAR, TAAS, Chaudhary Charan Singh Haryana Agricultural University (CCSHAU), PPV&FRA and NIF and attended by 137 participants in which around 20 innovative farmers were specially invited. The discussions held during the workshop on 23-24 December, 2011 at CCSHAU, Hisar resulted in the following important recommendations:

Recommendations

- It is necessary to set up sanitary and phytosanitary and quality testing laboratories, preferably, in producing zone in each region to test and certify farm products (agri-products, organic foods, medicinal plants, dairy products, forest produce, etc.) produced by the local entrepreneurs for which Government, Private Sector and the NGOs support is critical and essential.
- The available valuable knowledge relating to medicinal uses of local herbal plants need to be gathered and documented through appropriate incentive and reward mechanisms before the same is lost forever or remains unknown/hidden. For further strengthening of this area, there is a

Inauguration of the National Workshop by the then Chief Minister of Haryana, Shri Bhupinder Singh Hooda

need to develop processing facilities for preparing primary products and drugs from locally available medicinal plants, especially to treat common ailments. Also, patenting and popularizing such value added products in the local markets will benefit both the producers and the consumers.

- The farmers' knowledge must be improved about non-traditional food crops having nutritional and medicinal values, such as *navara* rice, minor millets and other high value low volume crops. Government should help such farmers in their capacity building and marketing of value added products.
- Elite germplasm and varieties identified by the farmers should be registered with ICAR-NBPGR and PPV&FR Authority, respectively and required quantity of seeds may be deposited in the Gene Bank. The SAUs and ICAR must help the innovative farmers with the help of State Govt. in this endeavor.
- Farms of progressive farmers should be recognized as Centres of Excellence to facilitate the visits of other farmers. The services of farm innovators/ progressive farmers should be utilized as Professors, Experts, *Krishi Pracharaks* or *Krishi Mitras* by KVKs of ICAR and SAUs.
- The resource conservation technologies be demonstrated and refined at RRS/KVKs and at the site of progressive farmers. Weed management research and technologies related to DSR should be strengthened by ICAR research institutes and SAU's to help the rice growers.
- Good quality elite males of various indigenous breeds should be made available in the clusters of villages in order to establish profitable dairies/ goateries/piggeries.
- Scientific livestock/ poultry/fish farming, and animal production and health related technology transfer to farmers needs to be taken up on a massive scale for increasing livestock production and productivity in the State.
- The machinery/equipment required for small dairy farm mechanization, primary level milk processing and value addition should be identified, tested, multiplied and made available to needy farmers on subsidized rate.
- Currently, scattered extension and training programs are being organized by different government organizations and other agencies. There is need to establish workable linkage and centralized training complexes for women farmers and other entrepreneurs in each state. Extension approach needs to be strengthened and reoriented to make them more women friendly.
- Policy for establishment of viable units of integrated farming system by combining need based location specific components of crops, vegetables/flowers, tree crops, livestock, fisheries, poultry, mushroom cultivation, vermin-composting, biogas units, etc. to train students, youths, women and other farmers at the HQs, RRS and KVKs for developing required skill and entrepreneurship.
- Policy initiatives are needed to support and encourage small cooperative societies, SHGs, farmer companies for production and multiplication of quality seeds, planting material and establishing value addition, processing and marketing and storage units of horticulture, dairy, fishery and other produce at production sites to help the farmers.
- "Village Farming Schools" should be opened at least at *Panchayat* level in Haryana and other States.
- There is need to develop women friendly technologies and disseminating already developed technologies with defined strategy, need-based training and financial support. In this context, the educational tours of interested women farmers to show the units of value added agri-products and farms of progressive and innovative farmers should be arranged on regular basis to encourage and help them to adopt such technologies.
- A regular mechanism for holding such workshops frequently in each state for scientist-farmer dialogue would certainly accelerate the process of agricultural innovations and hence, be put in place at the national level by the relevant organizations such as Agricultural Extension Division of ICAR by involving SAUs, TAAS, NIF, Farmers' Commission in different States, etc.
- The innovations made by the farmers should also be protected for their intellectual property rights (IPR), for which SAUs/*Kisan Ayog*/Farmer Commissions should provide needed awareness, guidance, technical and financial inputs.
- Agro-tourism around farmers' innovative efforts would not only generate public awareness but will also help in revenue generation and greater community involvement in protecting our rich biodiversity.
- Scientists-farmers interaction may be enhanced through appropriate mechanism so as to get the feedback for research system about the field performance of the technology as well as upscale farmer led innovations.

18. Women in Agriculture

(A Global Conference: March 13-15, 2012)

Background

Empowerment of women is a pre-requisite for inclusive growth. Realizing this fact, the Global Conference on Agricultural Research for Development (GCARD) 2010 emphasized specifically on the need to empower women producers being central to agricultural research and rural development processes. It also urged all stakeholders to work jointly to reshape agricultural agenda so as to meet the needs of farm women for their increased efficiency and involvement in the farming operations as effective partners and decision makers.

Inauguration of the Global Conference by the then Hon'ble Chief Minister of Delhi, Smt. Sheila Dixit

To achieve these objectives, this conference was jointly organized by GFAR, APAARI, ICAR and TAAS from 13-15 March, 2012 at NASC Complex, DPS Marg, New Delhi. It was inaugurated by the then Chief Minister of Delhi Mrs. Shiela Dixit and the Plenary Session was attended by the then Hon'ble President of India Mrs. Pratibha Patil. The conference was well attended by 760 participants. A large number of women experts (around 150) from over 37 countries deliberated on the critical issues impacting women's involvement in agriculture and came out with the following recommendations:

Recommendations

- As a first step in empowering the gender role in agriculture, we urgently need to generate, document and share country specific gender disaggregated data on the contribution of farm women, existing gender disparities and the success of on-going development programs in addressing gender related concerns.
- There are strong linkages among agriculture, nutrition and empowerment of women, which need to be fully acknowledged while addressing the concerns of gender disparity. Control of women over household income is invariably linked with improved nutrition, health and education of children. Therefore, efforts are needed to harness the socioeconomic benefits. These should entail: (a) improving effectiveness of government investments by making them gender sensitive and through effective participation of rural women in prioritization and monitoring, (b) building capacity of women community groups for creating awareness, asserting their rights, articulating their needs and enhanced role in program planning, implementation, monitoring, and (c) enhanced role of scientific institutions in production of nutrition rich food and better post-harvest processing and value addition.
- Since nutritional insecurity is a complex issue and involves a multi-sectoral agenda, straight jacketed solutions may not always yield sustainable solutions. While it is important to define more comprehensive indicators for measuring household nutrition security, the organizations associated with nutrition and women empowerment should form a 'nutrition umbrella base,' which can help develop an integrated strategy for greater effectiveness. These efforts should be supplemented by those of micro-enterprises and women self-help groups for production and distribution of nutrition rich foods. The researchers should develop and use better methodology to generate required evidence and databases on the status of malnutrition and multiple pathways leading to nutritional security.
- In order to address such a complex issue as gender, individual and isolated line of action would not mean much. Hence, efforts should be made to build and strengthen coalitions by providing an enabling environment for the development of innovative networks (that breakdown silos between stakeholders, institutions, sectors and disciplines) and partnerships involving public and private sector, civil society, grassroots organizations, and bilateral and multilateral development organizations. Such networks can be developed at the regional, national and local levels, and can help generate credible evidence on economic and social impacts especially when role of women is not included in the development process.
- One of the most significant socioeconomic changes taking place in the developing countries during the last decade or so is the phenomenal growth of women SHGs that promise to play a pivotal role in the empowerment of women and transformation of rural areas. Hence, this is the time when we harness full potential of these SHGs by supporting fully the capacity building and leadership development initiatives. Channelizing agricultural

Shri Sharad Pawar, the then Agriculture Minister honouring H.E. The President of India

Innovation market place

Progressive women farmers with certificates given by Dr. Mark Holderness, GFAR

Display of products at market place

support services such as extension, information, credit, inputs, marketing through these SHGs and providing them adequate resources for entrepreneurship development, through vocational training would help raise income of farm women. A special fund, 'Women Empowerment Fund' must be created at the national level to support gender specific welfare associated programs.

- A 'must do now' for all is to ensure effective control of women on productive assets and income is securing property rights like land rights for women. This needs: (i) revisiting of laws on marriage and inheritance of property, and work on those which can be feasibly be amended and enforced; (ii) working with local and national governments to ensure secure land rights to women, (iii) recognition of customary systems, capacity building/education, and initiative of activities that lead scaling up (e.g., China's case for including women's names on ownership documents or inheritance through daughters as in the Philippines); and (iv) enforcement of laws to ensure women's access to and control over assets. These property rights should also be supplemented with building capacity and knowledge of women to take full benefits of these rights.
- Agricultural markets are also changing rapidly and women are at risk because of their limited access to markets and price volatility. The new business models focus more on financial viability and often ignore gender issues. As a result, women fail to take advantage of emerging market opportunities and remain mostly as wage earners or non-paid farm workers. Therefore, appropriate commodity based models such as "Mama Lus Frut Scheme" of New Papua Guinea should be promoted and women should be encouraged to become members of producers and marketing associations. These efforts should be backed by overall strategy to improve the Proceedings of Global Conference on Women in Agriculture market access through development of market infrastructure and better information flow by use of information communication technology (ICT).
- Agricultural research should be reoriented to make it more gender sensitive with emphasis on issues that lead to empowerment of farm women. Steps are required to induct more women scientists in the National Agricultural Research System (NARS) to enhance their role in policy, research planning and technology transfer. For this, there is a need to revisit agricultural education system and to revise course curricula to make it more gender sensitive. Also, emphasis on enhanced enrolment of girl students in agricultural universities will be desirable.

Dr. M.S. Swaminathan presenting a memento to Smt. Shobhana Narayan

Dr. R.S. Paroda was honoured for his contributions by a delegation from Central Asia

- AR4D systems have invariably come out with innovations which can increase work efficiency of women and reduce their drudgery in various farm operations. Some of these innovations must be out scaling for greater impact. Therefore, major efforts are needed for systematic documentation, dissemination, and adoption of relevant innovations. At the same time, efforts are needed to address safety, health and risk related issues concerning farm women so as to increase their efficiency.
- Climate change and weather related risks are likely to influence rural livelihoods and affect adversely the agricultural productivity. The strategy to deal with this challenge should also include assessing vulnerability of farm women to climate related risks, pathways to participate in the positive opportunities, if any, both for adaptation and mitigation options. Management of risk, access to technologies to make climate resilient agriculture, capacity building for anticipating the risk and its management through appropriate farm practices also deserve special attention. Climate change related policy such as REDD+ must have clear gender perspective and should encourage women participation both during planning and implementation stage. While providing compensation for environmental services, farm women should also be the beneficiary for their role.
- Gender issues are dynamic and so are both agricultural and socio-economic environment. This underscores the need for concerted efforts to understand diversity and severity of gender issues across the globe on a continuous basis. Researchers, policy makers, development agencies, regional and global fora, civil society organizations (CSOs) and women groups should come together to understand better the gender issues and share their experiences as to what works and what does not for the empowerment of women in agriculture. The global conference on women in agriculture (GCWA) has proved to be an important platform to meet these objectives. Therefore, this conference should henceforth be organized on regular basis once in every three years. Forum for Agricultural Research in Africa (FARA) readily agreed to host GCWA2 in Africa in 2015.
- Considering the urgency of addressing all gender related issues in agriculture across the world, a global partnership program called "Gender in Agriculture Partnership (GAP)" must be launched involving partnership of research and development organizations, national governments, regional and global fora, multilateral development agencies and donors. This platform should provide space for both policy research and policy advocacy on gender related issues in agriculture. GAP can also provide much needed technical backstopping and guide on future investments in programs relating to gender in agriculture. It will also facilitate effective networking and collaboration amongst active partners engaged in empowerment of farm women so as to attain desired inclusive growth in agriculture.

19. Foresight and Future Pathways of Agricultural Research through Youth

(A National Workshop: March 1-2. 2013)

Background

Nearly 35 per cent of Indian population is in the age groups of 20-35 years and among country's agricultural scientists 27 per cent are below the age of 40 years. Enhancing knowledge and skill of these scientists demands an integrated approach to research themes to produce competent professionals. The workshop focused on ways to engage young agricultural professionals into cutting edge goals set for agricultural development critical for our country. The workshop was organized by ICAR, APAARI and TAAS on 1-2 March, 2013 at NASC Complex, DPS Marg, and New Delhi. After in depth discussions on

Participants of the National Workshop

various aspects concerning involvement of youth in agriculture, the following recommendations were put forth by the participants:

Recommendations

Research

- There is an urgent need to reorient agricultural research towards farming systems' mode by ensuring inter-institutional and inter-disciplinary collaboration, and creating state-of-art research facilities
- For taking research to end users, greater emphasis is needed on joint research with the private sector through creation of excellent research infrastructure
- As a matter of institute level priority, there should be greater emphasis on collaborative research with advanced national/international research institutions
- To have a provision of a seed grant (Rs 10-15 lakhs) for each of the newly recruited scientists to encourage them to initiate research in a program mode rather than project mode
- Provision of a special project for young scientist to be made through competitive research at the national level by ICAR
- Encouraging young scientists for grant of patents and innovations
- Creating ICT facilities to discourage the repetitive research as well as for timely scientific accounting of the scientists

Development

- Short-to long-term trainings for young scientists at advanced research institutions at both national and international level
- Greater involvement of young scientists as members in decision making bodies at institute level such as RAC, SRC and academic council, etc
- Provision of training programs at NAARM for young and mid-carrier scientists for building scientific research leadership qualities
- Provision for institutional grant and administrative freedom to presentation of research work in International Conferences and its publication in referred journals

Policy

- Greater emphasis on human resource development through allocation of funds at institute level with more freedom and accountability
- Balancing the funding resources for basic, strategic, applied, and participatory research
- More scientific and administrative freedom for research pursuits by young researchers using a bottom up approach
- Creating centralized research facilities to encourage greater scientific collaboration with the private sector
- Incentives and rewards for innovation and out scaling for impacts
- National HRD strategy to address the concerns of smallholders through reorienting R&D efforts towards farming systems

20. Achieving Inclusive Growth by Linking Farmers to Markets

(A Brainstorming Session: June 24, 2013)

Background

More than 85 per cent of the farming population comprises smallholders who have less than 2 hectares land. The contributions of smallholder farmers towards agricultural production are very significant. Thus, improving the livelihood opportunities of these farmers is very important.

In order to address this issue, a brainstorming workshop was organized jointly by TAAS, ICAR and ICRISAT on 24 June, 2013 at ICAR-IARI, Pusa Campus, New Delhi. It was attended by 40 participants including Dr. William Dar, DG, ICRISAT, Prof. Abhijit Sen, Member, Planning Commission (now NITI Aayog), Dr. Ashok Gulati, Chairman, Agricultural Costs and Price Commission and many distinguished economists. During

Prof. Abhijit Sen and Dr. William Dar Co-chairing the Inaugural Session

workshop, based on intensive discussions following important recommendations emerged:

Recommendations

Policy

- There is considerable scope to improve market efficiencies, reduce price spread and raise producer share. This requires empowerment of farmers to harness market through policy reforms, institutional changes and knowledge sharing.
- Existing marketing regulations like Agricultural Produce Marketing Committee (APMC) act require changes to offer freedom and better choice to farmers for sale of his produce. However, this may not happen automatically and requires action on several fronts like new institutions of farmers, increased private sector role in marketing, better infrastructure and commitment of State Government to protect interaction of producers (farmers) and consumers.
- New mechanisms like producer companies, self-help groups (SHGs), contract farming etc. have shown promising and beneficial effects in some segments of agriculture and in some pockets. Their up-scaling and replication is a real challenge. This requires a relook into these models so as to make them more farmer friendly. Documentation of success stories at regional, national and global level and conditions for their success need to be ensured though supportive policy environment.
- Private sector can play an important role in scaling up and scaling out so as to have win-win models of linking farmers to markets. The partnership between public and private sector can take many forms, e.g. marketing cooperatives; development of cold storages, etc. For building public-private partnership, the government should provide incentives, higher investments and needed infrastructure, besides stable policies for faster development of agribusiness.
- At the grass-root level, the government with the help of either farmers or NGOs should facilitate growth of farmers' cooperatives or associations or producer companies through handholding of farmer-members in terms of empowering them in business skills, capital investment and risk management.
- Provision of credit, associated with development of warehouse receipts system, is an important mechanism that offers farmers, producer organizations and traders access to secured and reliable storage, which provide them with documentary title to their produce and thus enable them to obtain finance. This will avoid forced sales and help farmers realize better prices. The system may also minimize storage losses, and bring in efficiency in trade, while enabling small farmers to participate in markets while managing market risks. This practice should be given full policy support for bringing small holders in its fold.
- Role of women and rural youth in linking farmers to market (LFM) will be of great advantage. We need to design women and youth centric programs for their active role in agri-food value chain and support them through all means. FDI, contract farming rules/ regulations be reviewed to ensure protection of interests of both parties
- With regard to contract farming, there is an urgent need to have interface with the private sector and farmers so as to assess their needs and concerns to ensure an enabling environment for them to succeed.
- New and evolving market mechanism like virtual market should be tried on pilot basis in some areas and replicated based on success so achieved
- A policy dialogue on linking farmers to markets should take place at the national level involving policy makers, senior officials of concerned Ministries, scientists and representatives of private sector, farmers, NGOs and IARCs.

21. Outscaling Farm Innovation

(A National Workshop: September 3-5, 2013)

Background

Innovations made in different areas by farmers have contributed immensely to the development of

Dignitaries on the dais in the Inaugural Function

agriculture. Most of these innovations, however, remain confined to the areas of their origin and never reach to the community of farmers to benefit from. Moreover, many times, they do not reach to a productive stage just because of their scientific validation and further refinement.

It was for this reason that a full scale National Workshop was organized by TAAS, ICAR and APAARI on 3-5 September, 2013 at AP Shinde Auditorium, NASC Complex, New Delhi involving 267 participants comprising farmers, scientists, entrepreneurs, NGOs and bankers to discuss various aspects concerning out scaling farm innovations for larger impact. The recommendations emerging out of the workshop are given below:

Recommendations

Policy

- There is an urgent need for a paradigm shift in AR4D to address the needs of small farmers and place renewed emphasis on "FARMERS' First" through participatory approach, better knowledge sharing and enabling policy environment to ensure food and nutritional security on a sustainable basis.
- Out scaling of innovations based on their techno – economic feasibility, relevance and utility would be the key for inclusive growth of small farmers. Hence, identification of such innovations like happy seeder, laser leveler, zero-till drill, paddy transplanter, conservation agriculture, protected agriculture, new varieties/hybrids, etc. and their faster adoption or use will benefit considerably the small holder farmers.
- Mission mode programs on small farm mechanization, protected cultivation, low cost rural based agro-processing for value addition, livestock development, promotion of hybrid technology, micro-irrigation, etc. would go a long way in increasing both productivity and income of farmers. Hence, greater policy support for promotion of these innovations will be needed.
- Farmer-led innovations relating to new crops, new areas, and new on-farm/off-farm based secondary agriculture, etc. must be identified, tested, refined and advocated for large scale adoption for greater benefit to our farming community. Some examples are: *rabi* maize in Eastern India, spring maize in northern region, summer *mung* in rice – wheat cropping system, *boro* rice in West Bengal, direct seeded basmati rice, vegetable production in plastic tunnels, polyhouses, micro-irrigation, fertigation, organic farming, etc.
- Integrated farming systems involving high value crops and livestock should be developed and encouraged for different agro-ecosystems. This would help in increasing income of small farmers.
- Market reforms should be given high priority for promoting farmer-led innovations. Revision of Agricultural Produce Marketing Committee (APMC) Act especially to delink horticultural produce (vegetables and fruits), provision of *kisan bazars*/ huts, cool chain and credit linked trade/marketing options, and linking farmers to markets will be required to benefit both farmers and consumers.
- Convergence and connectivity of different institutions and development programs for out scaling of innovations and development of necessary social skills is necessary. The innovations in use of renewable sources of energy, like bioenergy and solar energy should be improvised and out scaled by convergence of programs and activities of different government departments and private sector.
- Market innovations should ensure greater share of farmers in the transparency in price discovery, better delivery of quality inputs, flow of market information and risk management.
- For open access knowledge sharing, there is a need for more effective and rather efficient extension mechanisms like ICT, smart phones, radio and television (dedicated channel exclusively on agriculture). Creation of a cadre of young technology agents for custom hire services in specialized areas will help in reducing dissemination losses while out-scaling farm innovations.
- Incentives and rewards to innovative farmers will be needed to promote useful technologies on farmers' fields. For this, central and state governments must create "Farm Innovation Fund" so as to ensure their sustained interest in creating and promoting new initiatives for enhanced productivity and income.
- Incentives and venture capital funds should also be provided to the entrepreneurs for up-scaling and out scaling farm innovations and technologies, which need substantial investment in producing material (planting material, machine, seed, feed, etc.) for out scaling the innovations.
- There is an urgent need to have institutional reforms especially for better coordination, convergence and efficiency. Linkage between KVK and ATMA, linking schemes under MGNREGA, RKVY, NFSM etc. without scaling of useful farm innovations, each KVK to act as an ATIC, promotion of self-help groups (SHGs), establishing cooperatives and farmers' company, etc. will help in having greater impact of new innovations. Also, successful public-private-partnership models will have to be replicated by creating enabling policy environment.
- Innovative farmers so identified must be rewarded and given incentives, as well as, recognition as "Farm Professors", so as to share their knowledge and experience, while imparting training to others for much needed capacity development. Farmer to farmer training will have much greater acceptability and generate confidence for out scaling new innovations.
- Availability of credit at low interest rates and provision of insurance schemes for promotion of activities by SHGs, cooperatives, farmers, companies, especially for processing, grading, storage and

primary value addition will encourage smallholder farmers in out scaling their innovations, since, such provisions will reduce risk factor and build much needed confidence to promote farm innovations.

- Farm innovations in livestock and other high value products are, rather, less documented and out scaled. There are many innovations relating to low cost medicinal and nutritional products in livestock sector. These need verification, improvement and out scaling.
- There is also a great need to provide adequate visibility to protection of farmers' innovations and sharing of benefits from their commercialization. These should go beyond plant varieties. Special programs must be supported to promote innovations in on-site conservation of genetic resources.

22. Strategy for Conservation and Productivity Enhancement of Farm Animal Genetic Resources

(A Brainstorming Workshop: January 10, 2014)

Background

Animal husbandry is an integral component of Indian agriculture supporting livelihood of more than two-third of the rural population. Milk and milk products, eggs and meat among the livestock and poultry products are key contributors to achieving nutritional security. Other contributions from the sub-sector are; drought power, fuel, wool, fibre, manure, hides & skin, etc. It also offers income-generating opportunities through self-employment. India has a rich genetic resource of farm animal, which includes 144 registered breeds of livestock and poultry (37 breeds of cattle, 13 of buffalo, 39 of sheep, 23 of goat, 6 of horse and ponies, 8 of camel, 2 of pig, 1 of donkey and 15 of poultry). In addition, there are many undescript/unregistered populations of other animal species like mule, *yak*, *mithun*, duck, quail, etc.

Small scale livestock keepers and pastoralists have developed locally suited, resilient animal populations over the centuries. These animals have been deeply integrated with their economy, cultural values and knowledge system. Further, evolution of intensive livestock production and market demand had promoted use of few specialized breeds with specific production traits. This process resulted into loss of genetic variability of native breeds. Declining livestock diversity has adversely affected our capacity to potentially mitigate the challenges posed by climate change as well as emerging diseases. Some programs have been initiated in last two decades to address the decline in indigenous livestock and poultry wealth. Still, there are wide gaps in terms of legislative, policy and administrative measures besides the required level of coordination among various agencies/stakeholders as well as proper execution of breed improvement and conservation programs.

Considering the importance of issues related to breeding strategies and conservation of Indian farm animal genetic resources, TAAS organized a brainstorming workshop jointly with the Indian Council of Agricultural Research (ICAR), and the Department of Animal Husbandry, Dairying & Fisheries (DAHD&F), Government of India in New Delhi on January 10, 2014. Participants included policy makers, researchers, senior officers from Central and State Animal Husbandry Departments, field officers, NGOs, livestock keepers and experts in the field of animal breeding and conservation. The following recommendations emerged from the workshop:

Recommendations

- Considering the urgency, a time bound National Action Plan must be finalized and put to action as a National priority for conservation and management of the existing rich diversity of valuable indigenous livestock genetic resources.
- To begin with, each State must at least identify and declare one livestock breed as "STATE BREED" in

Delegates of Brainstorming Workshop

order to initiate required conservation and genetic improvement activities on priority by creating the best possible facilities and to ensure participation of all stakeholders.

- A 'National Livestock Development Authority' be established by DAHD&F especially for the breed conservation and management programs. A possible composition of the National Authority could be :
  - Secretary, DAHD&F - Chairman
  - Deputy Director General (Animal Sciences), ICAR
  - Director, ICAR-NBAGR
  - A few (3-4) Directors/Chief Executive Officers of SAHDs
  - Two representatives from NGOs/*Goshalas*
  - Animal Husbandry Commissioner - Member Secretary
- In order to protect the rights of Livestock Keepers and to ensure proper access and benefit sharing (ABS) of AnGR, a legislation similar to the Protection of Plant Varieties and Farmers Rights Act (PPV&FRA), should be drafted and proposed jointly by ICAR-NBAGR/ ICAR and DAHD&F for speedy approval of its enactment.
- A 'National Gene Fund' linked to 'National Livestock Mission' should be created soon by the DAHD&F so as to ensure effective implementation of specific breed conservation programs. In this context, efforts be directed to implement "Ranchi Declaration" as a national priority.
- ICAR-NBAGR must accelerate the pace for characterization, documentation and registration of different livestock and poultry strains/breeds by further strengthening the 'Network Project on Animal Genetic Resources', involving all relevant institutions/organizations and by assigning breed specific responsibilities.
- An online Information System for management of data on animal genetic resources of the country should be developed at the National level and each state should identify a nodal officer responsible for regular updation of data, on a pattern similar to that of Domestic Animal Diversity Information System (DAD-IS) model of the FAO.
- ICAR-NBAGR, in collaboration with DAHD&F, should organize regular public awareness/ sensitization programs in various States for understanding of the importance and utility of our available animal genetic resources in the country.
- The State Animal Husbandry Departments (SAHDs) must ensure sufficient quantities of semen doses of superior germplasm/males to help implement a national breeding strategy.
- All SAHDs need to promote the establishment of animal breed societies and initiate performance recording of important indigenous breeds at field level in order to ensure effective bull evaluation.
- There is an urgent need to develop niche markets for breed specific value added products for conservation through improvement and use of indigenous farm animal breeds.
- Some *Goshalas* hold sizable population and infrastructure, which could be used for genetic improvement of indigenous breeds as well as their *in situ* conservation. For this, Government must provide the needed support, and technical backstopping be extended by the State Agricultural Universities (SAUs) and ICAR institutes.

23. Soybean for Household Food and Nutrition Security

(A Brainstorming Workshop: March 21-22, 2014)

Background

One of the major challenges of Indian agriculture currently is to ensure household nutritional security for the vast (40%) vegetarian population of India which depends largely on pulses for meeting its protein requirement. But, pulses are very costly as

Dr R.S. Paroda addressing the delegates

Dr R. Chidambaram at display of soya products

our indigenous production is too less and in order to meet our requirement large quantity of pulses have to be imported. Interestingly, protein from soybean is inexpensive and provides better protein than pulses. However, soybean is not very popular among masses.

This workshop was organized by TAAS, ICAR and NAAS on 21-22 March, 2014 at NASC Complex, DPS Marg, New Delhi. It was attended by 78 experts to explore possibilities of exploiting and promoting soybean as a food crop being an important source of protein to address the problem of malnourished children whose number is around 200 million currently in India. The main recommendations emerging from this interesting brainstorming workshop are given below:

Recommendations

General

- Soybean is a treasure trove of nutrients. Therefore, use of soybean as human food needs to be promoted through appropriate policy interventions and public awareness initiatives. A mission mode project in this regard is fully justified at the national level.
- Soybean is a crop of considerable importance to India. Its production has to be increased to ensure household nutritional security. Fortunately, India can double its soybean production in the next decade, provided area is increased under assured irrigation both in the north and north-eastern region. What is needed is varietal diversification and good agricultural practices, including higher seed replacement rate, effective weed management, on-farm mechanization, ridge furrow planting, supplemental irrigation (1-2) and intercropping.
- Use of full-fat-soy-flour in Indian diets at 10 per cent level is already an accepted policy. Hence, fortified flour and other soy-products need to be promoted further under food product category by the Food Safety and Standards Authority of India (FSSAI). Further, these soy-products be considered as essential food items and be kept out of taxation network as a national policy.
- Protein-rich soymeal also needs to be promoted for local consumption as feed for fish and livestock in order to increase their productivity and increased income of resource poor farmers, especially in arid areas. A brainstorming session in this regard could, hence, be organized involving all stakeholders to decide future road map.
- Public-Private Partnership (PPP) has to be strengthened to promote small scale entrepreneurship, contract farming, licensing of new innovations and soy product development etc.
- *Krishi Vigyan Kendra* (KVK) of ICAR, Home Science Colleges under SAUs, and some research institutions under CSIR, ICAR etc. are engaged in promoting use of various soy-products as human food. These initiatives need to be strengthened under the proposed Mission on Soybean.

Research

- Urgent initiative is needed to widen the genetic base of soybean, which is currently quite narrow. We need to exploit the untapped genetic potential, especially the wild and perennial gene pool, for higher productivity. Concerted efforts are, therefore, needed to introduce germplasm from China, South East Asian countries, USA, Brazil, Argentina as well as from IITA, AVRDC, University of Illinois, etc.
- Research efforts need to be concentrated to develop soybean hybrids with wide adaptability and enhanced productivity. Similarly, research efforts need to be intensified in the field of genomics, Marker assisted selection (MAS) and also GM soybean, especially for ensuring effective weed management, abiotic and biotic stresses as well as to attain higher yields.
- Development and dissemination of rural based, low cost soybean processing technologies need to be promoted and popularized.
- To intensify research in soybean, a Centre of Excellence must be created immediately by the ICAR at ICAR-Central Institute of Agricultural Engineering (ICAR-CIAE), especially to develop the new products and to provide training to small scale entrepreneurs.

Policy

- For ensuring required coordination and addressing the problems of soybean growers, processors and consumers, a single window system through establishment of a regulatory board, namely, "Soybean Development Board" needs to be ensured on priority by the Government.
- Invariably, the existing trade and pricing policies are not favorable to soybean producers in India. Hence, there is a strong case to raise tariff on import of crude soybean oil from present 2.5 to around 10.0 per cent. Similarly, minimum support price (MSP) of soybean be raised to a level that is comparable to the market price and its procurement be ensured especially in new areas as northern and eastern India. Also, while introducing soybean in rice-wheat production system, linkage with processing industry be established.
- Tax incentives as well as tax holiday be given to soy-based industries, especially for establishing and expanding its use in non-conventional soybean growing areas. At the same time, a separate food product category by the Food Safety and Standard Authority of India (FSSAI) for all soy-based products be established. Also, soybean must be exempted from all central and state level taxes and duties, in order to make it abundantly available to the consumers to combat existing protein malnutrition in India.
- Though soybean is currently a rainfed (90%) crop in India, it offers good opportunities for doubling the production through productivity enhancement provided one or two supplemental irrigations are ensured. Hence, the rainfed tag on soybean has

to be removed and it be popularized also in the irrigated areas, especially, for the diversification of rice-wheat production system in the Indo-Gangetic Plains. Soybean can favorably compete with rice if its productivity can be ensured around 2.5-3.0 t/ha, which is technically feasible.

- Soybean and processed soy-products (full-fat, defatted soy-flour, dal analogue, textured soy chunks etc.) need to be included in the nutrition intervention programs of the Central and State Governments such as mid-day meals, ICDS, military, para military, jails, Govt hospitals etc. so as to provide low cost, high quality protein to the resource poor consumers. Also, the soy-fortified wheat flour be made available through PDS and open markets to promote its use for household nutrition security.
- India is exporting currently around 5.5 mt of protein-rich high quality soymeal annually @ Rs 70/kg protein while importing pulses @ Rs 360/ kg protein. Therefore, to fight protein-calorie-malnutrition, which is predominantly high in India, the export of soymeal be rationalized to maintain a balance between internal demand and existing export potential, for which though there is good scope as soymeal from India is all non-GMO.
- A compensation package, such as, nutrient subsidy equivalent for its high protein content and the nitrogen fixation in the soil be made available to the soybean growers. This along with high MSP, linked with procurement, both by Government and private sector, would accelerate higher growth of soybean production in India, for which there exists good scope.
- More investment for soybean R&D (at least three times) is needed urgently to harness full benefits by soybean growers as well as consumers. Also, higher investments on human resource development, involving all stakeholders, would go a long way, in addressing household nutritional security through use of soybean as a food crop in India.

24. Upscaling Quality Protein Maize for Nutrition Security

(A Brainstorming Workshop: May 20-21, 2015)

Background

The Brainstorming Workshop on "Upscaling Quality Protein Maize (QPM) for Nutritional Security" was organized jointly by the Trust for Advancement of Agricultural Sciences (TAAS), Indian Council of Agricultural Research (ICAR), ICAR-Indian Institute of Maize Research (ICAR-IIMR), National Academy of Agricultural Sciences (NAAS), International Maize and Wheat Improvement Center (CIMMYT), Borlaug Institute for South Asia (BISA), and the Indian Society of Genetics and Plant Breeding (ISGPB), at New Delhi on 20-21 May, 2015.

The goal of the Workshop was to review the progress and identify opportunities for enhancing nutritional security in India using Quality Protein Maize (QPM). The objectives were to assess the needs of stakeholders for enhancing QPM maize production and productivity; share experiences of success stories of QPM and other biofortified maize cultivars; create awareness of nutritional benefits of QPM among farmers, consumers and industries; strategize the research efforts for accelerated development of micronutrient enriched QPM and value-added processed foods, build effective networking and a framework for policy interventions to promote QPM.

The Workshop was attended by more than 100 participants, including government representatives, policy makers, and scientists from the National Agricultural Research System (NARS) and international research organizations, public and private seed agencies, processing industry, progressive farmers and NGOs. Dr. S. Ayyappan, the then Director General, Indian Council of Agricultural Research (ICAR) & Secretary, Department of Agricultural Research and Education (DARE), Government of India was the Chief Guest, to inaugurate the workshop which was presided over by Dr. Raj Paroda, Chairman, TAAS. Dr. S.K. Vasal, Former Distinguished Scientist, CIMMYT and the recipient of World Food Prize for his pioneering work on QPM gave special remarks on the occasion.

Maize has emerged as one of the most important crops as food, feed and industrial applications. Together with rice and wheat, maize provides at least 30 per cent of the food calories to more than 4.5 billion people in 94 developing countries. Maize alone contributes over 20 per cent of total calories in human diets in 21 countries, and over 30 per cent in 12 countries that are home to a total of more than 310 million people. Globally, maize is cultivated in 184 mha with a global production of 1016 m tons. Asia produces 304 mt of maize from 59 million hectares. During 2013-14, India produced 24.35 mt of maize from nearly 9 mha. 23 per cent of the maize produce in India is used for human food, while nearly 63 per cent is utilized for poultry- and animal-feed. Between now and 2050, the demand for maize in the developing world will double, as the current global population of seven billion is likely to cross nine (9) billion by 2050.

Inaugural Session of the Brainstorming Workshop

Participants of the Brainstorming Workshop

As per Food and Agriculture Organization (FAO) of the UN, India is home to 194.6 million undernourished people, the highest in the world. This translates into over 15 per cent of India's population, of which ~42 per cent of children (<3 years old) are underweight and 58 per cent of them are stunted by two years of age. The challenge is, therefore, to deliver nutritious, safe and affordable food to an ever-increasing population in the coming decades to eliminate food and nutritional insecurity.

Quality Protein Maize (QPM), by virtue of its 2-3-fold higher lysine and tryptophan compared and enhanced protein quality over conventional maize, holds immense promise for alleviating protein malnutrition. Also, due to its higher biological value, balanced nitrogen index and leucine-isoleucine ratio, QPM offers significant nutritional benefits, which were well-demonstrated worldwide, both in terms of human food and animal feed. An array of QPM varieties has been released in sub-Saharan Africa, Latin America and Asia over the last three decades. India released its first generation of soft endosperm-based nutritious maize composites, viz., '*Shakti*', '*Ratna*' and 'Protina', way back in 1970. In 1997, the first hard endosperm QPM composite, Shakti-1, was released. The first QPM hybrid, '*Shaktiman-1*' was released in 2001. So far, a dozen QPM hybrids have been released in India with wider adaptability to different agro-ecologies.

Despite the well-established nutritional benefits and varietal releases worldwide since last 3-4 decades, widespread cultivation and use of QPM as food and feed remains elusive. Of the 90 mha of maize grown in Mexico, Central America, sub-Saharan Africa, and Asia, only an estimated 1% or less is QPM. In India, the area under QPM cultivation is negligible, as compared to the conventional maize.

The Workshop provided a platform to discuss in depth specific constraints/bottlenecks in QPM value chain, and opportunities for up-scaling QPM production and utilization in India for enhanced nutritional security. The Workshop was structured in two plenary sessions, and six technical sessions, focusing on various aspects of QPM R&D, including: (a) staple food; (b) feed; (c) seed production and delivery; (d) policy support for promotion; (e) post-harvest processing and value addition; and (f) breeding challenges and opportunities. Salient recommendations that emerged out of these discussions are presented below.

Recommendations

The workshop participants unanimously agreed that QPM maize has great potential to address a major challenge of malnutrition being faced by large number of people in India (around 180 million), 43 per cent of whom are children below 5 years of age. QPM innovation, therefore, needs to be outscaled to ensure household nutrition security. For this, public awareness needs to be created to make maize an important food crop, instead of its current use as feed. There is also need for urgent research, development and policy interventions in a mission mode approach.

QPM-based Food

- To harness full potential of QPM, there is an urgent need to sensitize the processing and value-addition industry in India on nutritional benefits of QPM, so as to generate and deploy QPM-based value-added food products in both rural and urban markets. Village-level entrepreneurships and community-based QPM processing units (incentivized by *Gram Panchayats*) should be established for promoting QPM consumption in rural India. QPM-based products, such as QPM corn flakes, snack items, and QPM-fortified multi-grain '*atta*' can be effective in reaching the health-conscious urban population. Proper labeling, suitable branding (e.g., Nutri-maize) and aggressive promotion would attract consumers towards QPM-based products.

- For effectively meeting the demand of the processing and value-addition industry, QPM varieties should be systematically evaluated for basic food quality parameters (industry-provided check-list) required for manufacturing specific products. Once suitable varieties are identified, continuous supply of QPM grains for the industry needs to be ensured through effective backward linkages; contract farming and 'buy-back' policy could ensure sustainable supply of quality QPM maize.
- 'Nixtamalization' is an important technological intervention that improves shelf-life of maize in general, including QPM, and it also helps in preventing aflatoxin contamination of stored products. This is being extensively used in c Mexico, where maize is a staple food and hence could be introduced in India.

QPM as Feed

- India is the fifth largest poultry producer and third largest egg producer, with enormous growth potential (more than 10% per annum). The potential of QPM, especially yellow QPM, in strengthening the maize-poultry value chain needs to be effectively exploited. This will require awareness generation among the poultry industry about the nutritional benefits of QPM. A special workshop on "QPM Specialists-Poultry Sector Interface" should be organized for making the poultry industry aware of the benefits of QPM over conventional maize, and for devising a Road Map for promoting the use of QPM in poultry sector.
- Synthetic lysine is presently available at relatively cheap price to the poultry industry. Therefore, proposition of incorporating high-lysine QPM in poultry feed may look less appealing, given the fact that QPM grain is expected to be costlier than conventional maize requiring isolation distance for its seed production, besides need for market segregation. Therefore, it is critical to communicate the beneficial effects of tryptophan, which is high in the QPM maize. Tryptophan helps in regulating egg laying. Hence, benefits of availability of enhanced tryptophan in QPM grain should be compared *vis-à-vis* other sources of tryptophan in the feed, like soy meal, to demonstrate comparative advantages of QPM.
- To enhance the use of QPM in the poultry and livestock industry, research needs to be undertaken on:
  - The cost-benefit ratio to determine the value gained in terms of kg of meat or number of eggs by using QPM over conventional maize.
  - Understanding better the nutritional benefits of QPM (over conventional maize) on the quality of meat and eggs; this is required for creating specialized markets for more nutritious meat and eggs. So far, studies have focused only on the weight gain attributes of QPM feed over conventional maize feed.
  - The interface between QPM breeders and the poultry industry needs to be strengthened to understand better the trait and product preferences of the clients, and to reorient the breeding programs based on such feedback; for instance, recent studies have shown strong interest of the poultry industry in India in traits such as high methionine, provitamin A and high oil content.

Developing New QPM Varieties for Needed Impact

- To derive genetically diverse, high-yielding and climate-resilient QPM varieties that meet the requirements of stakeholders, QPM breeding program in India must be significantly strengthened, including selections from elite conventional x QPM crosses to generate new improved QPM inbreds; creation of new QPM synthetics/pools (with an understanding of heterotic groups) for extracting novel QPM inbreds with biotic and abiotic stress resilience; and diversifying the QPM germplasm base.
- As a short-term goal, fast-track conversion of some of the most popular and widely-grown conventional maize hybrids to QPM versions through marker-assisted selection (MAS) and doubled haploid (DH) technique, is the best possible option to develop QPM hybrids with wider adoption and acceptability. As a part of this strategy, the possibility of converting some popular private-sector maize hybrids into QPM versions through public-private partnerships, and introducing these QPM hybrids in the market needs to be immediately explored as this will significantly strengthen the QPM supply chain for the processing industry.
- More than 150 single-cross maize hybrids have been released so far by public and private sector organizations in India. These hybrids in particular have helped in doubling the maize production over last one decade in the country. While hybrids are adopted in ~60-65 per cent of the maize-growing areas, ~35-40 per cent of the area, especially in the tribal regions and North-Eastern states, is still under low-yielding landraces, local varieties and composites. Incidentally, these are also the areas where maize is a staple food. Hence, as an alternate strategy, the possibility of developing and deploying improved QPM synthetics as well as low-cost, affordable maize hybrids, with higher grain yields and quality, needs to be actively explored.
- A Mission-Mode Project on developing the next-generation biofortified maize varieties (QPM, provitamin A, kernel zinc etc.), should be initiated immediately with strong emphasis on multi-disciplinary and inter-institutional partnerships. This project having immense potential to contribute to nutritional security in India must receive required funding support through the National Agricultural Science Fund (NASF) of the ICAR.
- 'Nutritional Quality Service Labs' must be set up for strengthening the breeding programs for biofortified

crop varieties, such as QPM. Capacity development programs at the accredited nutritional quality labs will help in building skilled manpower needed urgently for QPM research and development in India.

- Nutritional quality traits, such as enhanced lysine and tryptophan in QPM, are "invisible" traits. Farmers, thus, would face obvious difficulty in convincing the traders regarding betterquality of produce while selling in the market. Development, validation and deployment of a low-cost portable device that rapidly determines the amino-acid quality of the maize produce (through quantitative estimation) would be of great help to the farmers. Brix meter is one such example, where sugar concentration in sweet corn is analyzed rapidly.

Seed Production and Delivery

- "QPM Seed Villages", with "One QPM Hybrid-One Village Approach", must be established for community-based production of quality seed, through active engagement and training of progressive farmers. QPM Seed Villages should be particularly targeted in Tamil Nadu, Karnataka, eastern Uttar Pradesh, Rajasthan, Bihar and West Bengal, where opportunities for marketing (e.g., poultry/feed industry) exist. This will also help in reducing the cost of transportation as well as ensure timely availability of quality QPM seed to the industry.

Public-Private Partnerships

- Strong and active engagement of private sector in QPM R&D in India is important for up-scaling QPM adoption and utilization. Private sector seed companies with significant maize breeding, seed production and distribution network capacity in India should take up QPM development and delivery in the target markets. The 'AgriInnovate-India' should play an important role in this regard. Government programs such as NSFM must support QPM seed production, irrespective of whether by public or private sector.
- Public-private partnerships for QPM research, based on mutual trust, focused objectives, respect for each other's intellectual property, and ABS (access and benefit sharing) should be encouraged by providing an enabling environment by the Government. Bottlenecks, if any, with regard to effective exchange of germplasm / breeding materials between public and private sectors must be explored through an agreed standard material transfer agreement (SMTA).

Awareness Generation and Enabling Policies

- Lack of adequate awareness among consumers is one of the major reasons for the poor demand for QPM. Intensive awareness campaigns, supported well by the Government, must be taken up to popularize the nutritional value of QPM and for enhancing its demand for consumption as food at the household level. QPM can potentially contribute significantly towards nutritional security, especially in the North-Eastern states and the tribal areas in India.
- In view of its potential benefits to the household nutritional security, QPM must be considered for inclusion in the 'rural transformation' project under NITI Aayog. QPM should also be an integral component of the Government-sponsored agricultural development programs like National Food Security Mission (NFSM) and *Rashtriya Krishi Vikas Yojana* (RKVY), as well as the nutrition intervention programs, such as 'Integrated Child Development Scheme' (ICDS) and 'Mid-day Meal Program'.
- QPM requires policy support during the initial stages of takeoff in the form of seed kits, extension, and market support. QPM should also be supported through Market Intervention Scheme in the states where farm harvest prices are below MSP. Processing industry should also be incentivized to use QPM in various food and feed formulations.

25. Agroforestry for Sustainable Development: The Way Forward

(A Regional Consultation, October 8-10, 2015)

The Regional Consultation on 'Agroforestry: The Way Forward', organized by the Trust for Advancement of Agricultural Sciences (TAAS) jointly with the Indian Council of Agricultural Research (ICAR), the World Agroforestry Centre (ICRAF), the National Academy of Agricultural Sciences (NAAS), the Indian Society of Agroforestry (ISAF) and the Asia-Pacific Association of Agricultural Research Institutions (APAARI), including the participation from Afghanistan, Bangladesh, Bhutan, India, Indonesia, Malaysia, Nepal, Philippines, Sri Lanka and Vietnam, from October 8-10, 2015 in New Delhi, have agreed on the following plan of action for promoting agroforestry in both Indian and regional contexts:

New Delhi Action Plan

In order to ensure speedy implementation of the recommendations of World Congress on Agroforestry held in 2014, during which India's National Agroforestry

Dr RS Paroda speaking during Inaugural Session of Regional Consultation

Policy was adopted, and to address the Sustainable Development Goals (SDGs) adopted recently by the UN (October, 2015) as well as to build partnership through regional network while;

- Reaffirming that agroforestry has a major role to play in addressing problems of food, nutrition, energy and environment;
- Noting that effective land use systems, among which agroforestry makes up significant part, would play a meaningful role towards meeting SDGs;
- Recognizing that as the landholdings are shrinking, optimum land use under agroforestry practices would enable smallholder farmers to cater to their subsistence needs of food, fuel, fodder, fibre, medicine and timber; to create employment opportunities, and additional income;
- Further recognizing that agroforestry practices by farmers would also contribute to enhancing the national tree cover and 'ecosystem services' in countries of the region; Realizing that integrating tree farming into conventional agriculture would contribute to optimizing the total factor productivity;
- Recognizing in the climate change context that agroforestry modulated microclimatic modification and carbon sequestration would be helpful in contributing to resilient and sustainable agriculture by mitigating its adverse effects and inducing greater on farm adaptation;
- Aware of the problem of massive land degradation from unsustainable land use and poor stewardship and the restorative potential of agroforestry practices especially those with multiple benefits;
- Understanding that agroforestry offers substantial opportunities to address gender bias and inequality in resource control, use and allocation, and accrual of benefits;

Indian Context

1. The Agroforestry Policy adopted by Government of India in 2014, is indeed most innovative step globally. In this context, a National Agroforestry Mission on the lines similar to National Horticulture Mission be established to ensure an aggressive approach for promoting agroforestry.
2. As envisaged in the policy document, an Agroforestry Board must be established immediately on the pattern similar to Rubber Board, Coffee Board, Tea Board etc., to facilitate the process of pricing, processing, value addition, procurement, credit, insurance, marketing, and to provide incentives to agroforestry farmers and other stakeholders for environmental services.
3. Agroforestry practices can potentially contribute towards increasing the present 24 per cent tree cover of the country to meet the national target of 33 per cent. To achieve this, sufficient investments must be made to cover about 12-14 million hectares i.e. 8-10 per cent of the total cultivated area under agroforestry practices. Also, for faster accomplishment of the set national targets, other niche for agroforestry practices such as the degraded lands and arid areas should also be covered.
4. The most important agroforestry tree species for each agro-eco region in the country need to be "identified" on priority and action be initiated to "denotify" them immediately.
5. In order to accelerate efforts on agroforestry at national level, it is strongly recommended that one position of subject matter specialist in each KVK, out of increased strength during 12th Plan be exclusively earmarked for this discipline.

Participants of the Regional Consultation

6. A Working Group of Experts be established soon to suggest agro-ecological region wise scientific land use planning to promote the most remunerative tree species identified based on research results available.
7. Special efforts are needed now to produce high quality seed and planting stocks of elite material so identified by the research institutions, associated with much needed certification and accreditation systems.
8. National sustainable development strategies should integrate agroforestry more fully into key areas such as poverty alleviation, rural livelihoods security, skill development, natural resources management, agricultural productivity enhancement, and restoration of degraded landscapes in order to more effectively contribute towards India's Intended Nationally Determined Contributions (INDCs) to the United Nations Framework Convention on Climate Change (UNFCCC).
9. With India's INDCs pointing towards climate justice, agroforestry becomes a potent instrument of resilience-building for vulnerable and resource-poor communities, its potential for adaptation to climate change needs to be mainstreamed and highlighted in all measures related to farmers' welfare.
10. Investments in agroforestry projects and programmes by public and private sectors (including the Corporate, and Small Cooperatives) for research, extension, enterprise, and education be encouraged and incentivized. Innovative financial mechanisms, including climate finance, for agroforestry be developed to benefit small agri-business enterprises and smallholders from people participatory partnerships.

Regional Context

1. The Nodal Ministry/Agency/Focal Point for dealing matters relating to agroforestry needs to be clearly defined at the national and sub-national levels.
2. Development of country-specific national policies on agroforestry and enabling mechanisms for their implementation need to be given high priority. Indian experience, ICRAF's expertise, APAARI's facilitating role, and assistance from international agencies could be useful to further this initiative.
3. A Regional Consortium-cum-Network on Agroforestry with facilitation role of ICRAF, in partnership with APAARI, needs to be initiated quickly to hasten appropriate policy advocacy, public awareness, research collaborations, sharing of knowledge and germplasm, capacity development, and other collective actions.
4. The proposed regional network should accord a high priority to the development of sound regional agroforestry database, information system, and eco-region based Decision Support System. Sharing of success stories of countries in the region also needs to be encouraged through open access to relevant information.
5. An independent scientific study be facilitated for identification and assessment of suitable determinants to scale up innovations for agroforestry including market mechanism, import and export policies, support prices, etc.
6. Investments being critical to promote agroforestry research, education, training and extension be at least doubled at national, regional and international levels.
7. Medium- to long-term collaborative studies to quantify contribution of agroforestry to ecosystem services, carbon sequestration, climate change mitigation and adaptation to, etc., need to be institutionalized by the International Agricultural Research Centers (IARCs) and the regional institutions.
8. Development of agroforestry value chains would be critical for scaling up promising innovations, and to create win-win situations in the agroforestry sub-sector. Business planning and development involving all stakeholders in the value chain (farmer-to-consumer) needs to be institutionalized in a Mission Mode approach.
9. Awareness for public-private partnership through creation of enabling environment such as process patenting, branding, incentives to both producers and industry, etc., need to be created to further promote agroforestry in the region. Agreed and affirmed on the 10th of October 2015 in New Delhi by all the participants and co-organizers.

26. Innovative Extension Systems for Farmers' Empowerment and Welfare –A Road Map

(A National Dialogue: December 17-19, 2015)

Background

Agriculture is a solution and not the problem for achieving the sustainable development goals (SDGs). On the contrary, an inclusive agricultural growth would demand innovative, cohesive and synergistic extension

Dr. A.K. Singh, DDG (Agri. Extn.) speaking during Inaugural Session

mechanism. To achieve sustainable food and nutritional security, and to address effectively the adverse impact of climate change, 'agriculture research for development' (AR4D) now needs a paradigm shift to 'agricultural research and innovation for development' (ARI4D) duly supported by reinvigorated agricultural research, education, and extension system. The current multi-faceted challenges in Indian agriculture have led to gradual decline in total factor productivity (TFP) as well as farm profitability. To address these, our agricultural extension urgently needs a radical change. For this, a policy reorientation towards farmers' welfare through innovative and efficient technology delivery system, remunerative rural based low cost value chains, and assured market linkage is required. Apparently, the complexity of these challenges cannot be overcome by routine transfer of technologies. Hence, a forward looking, innovative and participatory extension system is urgently called for. Accordingly, a demand driven multi-stakeholder extension approach towards integrated farming systems is considered a way forward.

In this context, the Trust for Advancement of Agricultural Sciences (TAAS), in close collaboration with Indian Council of Agricultural Research (ICAR), National Academy of Agricultural Sciences (NAAS), Department of Agriculture and Cooperation (DoAC)/ Ministry of Agriculture and Farmers' Welfare (MoA&FW), Bill and Melinda Gates Foundation (BMGF), Cereal Systems Initiative for South Asia (CSISA), *Bharat Krishak Samaj* (BKS), and Young Professionals for Agricultural Development (YPARD) organized a "National Dialogue on Innovative Extension Systems for Farmers' Empowerment and Welfare" on 17-19 December, 2015 at the National Agricultural Science Centre (NASC) Complex, New Delhi. TAAS facilitated the process by providing a common platform to 242 stakeholders to debate, discuss and come out with a Road Map for transforming Indian national agricultural extension system to be more innovative and efficient in empowering farmers with good knowledge and technological options for productive, sustainable and profitable agriculture. The dialogue received excellent response from all stakeholders, including farmers. The Hon'ble Union Minister of Agriculture and Farmers' Welfare in his inaugural speech highlighted

Sh. Radha Mohan Singh, the then Min. of Agriculture and Farmers' Welfare inaugurating the National Dialogue

Dr. R.S. Paroda speaking during National Dialogue

the recent pro-active initiatives taken by the Central Government for the farmers' welfare and urged for in-depth deliberations and discussion over the next three days as per well thought out and nicely tailored program to bring out specific recommendations defining further actions. The participants of the dialogue broadly brought out prior to the event, and resolved unanimously that a renewed thrust is necessary to transform the current agricultural extension system to make it more meaningful, relevant and effective through a Road Map that meets the rising aspirations of farmers to make Indian agriculture globally competitive. Accordingly, the participants recommended that: (i) it is to reaffirm that effective and efficient agricultural extension and advisory services are critical to achieve higher productivity, promote agricultural trade to help raise the farmers' income, while achieving a national target of 4 per cent in agriculture; (ii) the scope of agricultural extension has undergone certain fundamental changes with growing number and diversity of extension service providers; The public extension system caters merely to 15 per cent, whereas such services provided by others like private sector, NGOs, farmers, social media etc. are yet to be optimally organized and mainstreamed; A real transformation in the existing agricultural extension requires demand driven, multi-dimensional, multi-agency, market-oriented, pluralistic, and an out-ofbox approach; and (iii) empowerment of women and youth for agricultural extension and farmers' welfare is critical for large scale adoption of highly scientific, resilient, productive and remunerative secondary and speciality agriculture by the farming communities; (iv) knowledge sharing on good agricultural practices (GAP), without dissemination loss, is indeed critical to achieve better successes in agriculture sector for which role of print, social media like radio and TV, ICT (especially mobile phones) is being considered essential; Innovations in agricultural extension would henceforth demand 'paid extension' services; especially when there is scope to increase farmers' income, for which an enabling policy environment is now emerging for the private extension system through small scale entrepreneurs as s technology agents and input providers.

The Road Map

Need for a New Extension System

1. To overcome the multiplicity and increasing complexity of problems being faced by the farmers, we now need:
2. 'FARMERS First' approach to be promoted with twin objectives; on one hand, to better understand the critical needs of farmers, and on the other to identify options that can address these needs in a manner that would benefit all involved in agricultural value chain;
3. Multi-disciplinary, inter-institutional efforts towards translational research must be accelerated with required policy and financial support, especially to outscale innovations after validation and needed refinements;
4. Conscious deployment of rural youth, women, farmer professors, authorized / trained / certified input providers be ensured through innovative approaches, such as formation of Farmers' Self Help Groups (FSHG), Farmers Cooperatives, Farmer Producer Companies, Farmer-to-Farmer Trainings, Agri-Clinics etc., to catalyse speedy technology transfer and diffusion;
5. Foresight approach to ensure a paradigm shift from Top-down to Bottom-up be adopted to meet new demands for innovations, products, information and extension services such as;
    - Ensure farmers' participation at the grassroot level and to have confidence-building among the farming communities to take risk and adopt more scientific and resilient farming technologies. Simultaneously, provide policy incentives for critical inputs as well as farmers' participatory activities by all stakeholders and market players;
    - Encourage farming systems' extension by the inter-disciplinary, inter-institutional extension teams comprising of subject matter experts as was envisioned under earlier institution-village linkage program (IVLP) for effective agricultural extension;
    - Promote knowledge sharing on good agricultural practices aimed at minimising the dissemination loss for services relating to inputs, technologies, insurance, processing, value addition, markets, etc.;
    - Encourage required partnerships among key stakeholders to promote demand driven, multi-stakeholder oriented agricultural extension around integrated farming systems. This be ensured through in-built incentives to adopt innovative technologies that would optimise the use of natural resources, though requiring more adoption time to assess, refine and diffuse natural resource management (NRM) related technologies on the farmer's fields;
    - Provide innovative alternate knowledge / information dissemination systems with authentic content in farmer-friendly communication mode such as; *Kisan* TV Channel, ICT, Smart Phones, Print Media and Radio to ensure their farthest reach and effectiveness.
    - Emphasize on linking farmers to market (LFM), as a key step towards inclusive market oriented development (IMOD) for smallholder farmers. Also to design women and youth centric program for their active role in market oriented agri-food value chains with provision of right and timely incentives.
    - Stimulate the national agricultural extension system beyond free extension; paid extension services through agri-clinics be encouraged with an in-built safeguard mechanism in place.
6. Private sector participation in the national agricultural extension system be encouraged through their corporate social responsibility (CSR), and also

Participants attending the National Dialogue

through much needed public private partnership, supported well by an enabling environment.

7. Emphasis be laid on documentation and wider dissemination of successful extension models under diverse agro-ecologies and farming situations. Similarly, lessons learnt from failure cases be assessed to take corrective measures elsewhere.
8. Extension research should now go beyond production to post-production extension. As such, higher emphasis needs to be placed now on innovativeness, growth and development.
9. Communication Systems in rural areas (ICT, TV, Smart Phones, Print Media, Newspapers, etc.) be enhanced to play more proactive role in effectively reaching the farming communities through excellent linkages with agricultural universities/ colleges, ICAR institutes, NGOs, private companie.s, and other key R&D players

Enabling Institutional Mechanisms

1. A National Mission on Agricultural Extension be established on priority by the Ministry of Agriculture and Farmers' Welfare (MoA&FW) to plan, undertake and promote collaborative extension interventions by public, private, NGO and progressive farmers, and to give modern extension thrust across the board, optimise effective coordination, and evolve efficient convergence mechanisms. The new National Mission may also oversee coordination and convergence of various state and district level extension activities by the KVKs, ATMA, Private Sector, NGOs and the progressive / innovative farmers. Initially, a budgetary provision of around Rs. 1,500 crore annually would be necessary for the much needed Mission Mode approach in agricultural extension to accomplish inter-alia the following:
    - Establish Agri-Clinics, by encouraging well trained group of individuals as small scale private entrepreneurs, or by a group / club / association of progressive farmers. At least one agri-clinic per 10,000 farm families be got established under the National Mission, with funding provision of around Rs. 50 lakh each (preferably on 50:50 basis). Accordingly, in order to cover the existing 14 crore farm families, 14 thousand Agri-Clinics would be needed for which a budgetary requirement of around Rs.3500 crore to be met from the overall budget of proposed National Mission on Agricultural Extension. Moreover, all agriclinics may not be established in one go and hence could be taken up in a phased manner over next 5 years (needing around 700 crore each year) based on well defined accreditation / recognition process.
    - Induct Farmer Professors to facilitate farmer-to-farmer knowledge extension and skill transfer without dissemination loss, provide vocational trainings for rural youth and farm women for 'Skill up India' and 'Stand up India' initiatives, build capability of *Panchayats*, and ensure better support of existing institutions for technology/ input delivery, credit, subsidy, insurance, value addition, marketing, etc. To begin with, around 5-10 Farmer Professors could be inducted in each district, for which budgetary provision of approximately Rs. 50-100 crore may be kept in the Mission's overall budget.
    - Establish a 'National Farmers' Innovation Fund' of about 100 crore with support of both Government and Private Sector to encourage and involve progressive and innovative farmers to promote farmer to farmer extension and to support needed initiatives to build farmer scientists linkages for out scaling innovations through testing, refinement and adoption on large scale. It should also provide incentives and rewards in different forms to the innovative farmers.
2. A 'Cabinet Committee on Farmers' Welfare' needs to be constituted to meet the aspirations of Indian farmers as well as those who are contributing to the sustainable development and growth of agriculture. In particular, this Committee has to ensure much needed coordination and convergence for the cohesive implementation of agriculture and rural development related programs being implemented by different Union Ministries and Government Departments.
3. Without further delay, concerted efforts be made to implement the recommendations of the High Power Committee on the Management of *Krishi Vigyan Kendras* (KVKs), headed by Dr. R.S. Paroda, to ensure improved efficiency, effective monitoring and required relevance of farmerscience connect.
    - To emphasize on strengthening, coordination and modernization of KVKs rather than their further multiplication. For sector-wise strengthening of much needed site specific programs/activities, there is need to revisit the enhanced cadre strength of ten scientists per KVK and to redeploy some subject matter specialists to take care of diversified / relevant areas such as: horticulture, agroforestry, animal science, fisheries, post-harvest processing, social science etc.
    - To establish Agricultural Technology Information Centres (ATICs) in all KVKs so as to promote 'Land-to-Lab' linkages and to reap the benefits of research through promoting new innovations.
    - To revisit existing ATMA-KVK convergence model and to bring in needed reforms concerning allocation of resources to meet the contingent and exigency needs for training and knowledge/information sharing related to agriculture and other line departments with local farmers through KVKs, and to

shed redundancy and improve efficiency in all district / local level agricultural extension matters.

4. To ensure expansion of scope of the proposed 'National Agricultural Education Project (NAEP)', to be funded by the World Bank and implemented by the ICAR, to address much needed reforms in the public extension system and to strengthen capacity development activities, through informal training of private entrepreneurs so as to act more effectively as technology agents, the proposed project should thus be revised and implemented as 'National Agricultural Education and Extension Project (NAEEP)'. This would trigger innovations by creative and skilled young minds for serving the society and agriculture sector with human face.
5. '*Kisan Aayog*' (Farmers' Commission), on the pattern of Punjab and Haryana, be established across the country in each State to facilitate required transformation in agricultural extension, promote both the national and local sustainable agricultural development agenda, and to assist/ advise the States in promoting relevant farmers' welfare related policies and programs based on well defined and formally adopted State Agriculture Policies.
6. Revamp agricultural extension related education by initiating new courses on Rural Entrepreneurship, Agricultural Journalism, Agribusiness Management etc. to bring innovative concepts and new economic options for rural youth. Also there is an urgent need to teach agriculture as a subject for science students in the High Schools to generate much needed awareness on the role of agriculture towards household/national food and nutritional security.

27. Promoting Biotech Innovations in Agriculture and Related Issues

(A Roundtable Discussion: August 4, 2016)

Background

GM technology is highly relevant for Indian agriculture for accomplishing the vision of doubling the farmers' income by 2022, and also bringing in the second green revolution as soon as possible. Farmers need technologies that can save cost on their inputs and are also environmentally safe while ensuring faster production growth to meet ever increasing demand for food and nutrition, especially through customized genetic modification, including the designer crops and biofortification. The GM food crops may have a key role for nutritional security to help mitigate the malnourishment among children and anemia in pregnant women which are very high in India as compared to other countries in the world.

In view of the importance and key role of biotechnology, the Trust for Advancement of Agricultural Sciences (TAAS) organized a brainstorming roundtable discussion on August 4, 2016 in New Delhi. About 50 participants representing various stakeholder categories including eminent scientists, government officials, industry representatives and legal experts attended. The deliberations were comprehensive and meaningful which focused on the promotion of biotech innovations in agriculture and related policy and regulatory issues, including the instant issue of price and trait value fixation of Bt cotton seed. The active deliberations resulted in general consensus for promoting biotech innovations in agriculture for overall development and sustainability. For this, the need was felt for institutional arrangements for facilitating and regulating biosafety, respect for innovation and fair opportunity for competitiveness among market players, and capacity building of the secretariats of regulatory agencies.

Recommendations

The round table discussion had resulted in specific recommendations needed to promote further agricultural innovations, especially in the field of agricultural biotechnology, for accelerated growth and development in the national interest. These are summarized below for consideration:

Licence Agreement and Trait Value Guidelines

- The first step taken by the Ministry of Agriculture and Farmers' Welfare (MoA&FW) to withdraw the Gazette Notification issued concerning cotton seed price and trait value royalty fixation guidelines on May 18, 2016 and put it on hold for 90 days, inviting stakeholders' and public comments on May 24, 2016 is a step in right direction. It was a considered view of participants that the notification was not well thought of action as its implementation would certainly discourage innovation culture in agri-biotech research in the country. Therefore, it must be permanently withdrawn in the first place.
- Our national system must respect intellectual property (IP) to facilitate introduction of new innovations related to agriculture in India. Also

A Roundtable Discussion among GM Stakeholders

Participants of Brainstorming Meeting

the IP laws must be seen in compliance to the International Treaties to which we are signatory to.

- Before some decision is taken on any further corrective step, it is highly necessary to officially review, analyse and rationalize the entire techno-legal and socio-economic scenario as well as the seed industry perspective which had led to this unprecedented situation. For this, a High Powered Committee (HPC) comprising eminent scientists, senior officials, legal experts, and the representatives of all stakeholder groups (seed sector, farmers etc.) be appointed by the Government with a well defined TOR and timeline. Also the technical backstopping of all concerned government agencies and regulatory bodies like DBT, MoEF&CC, DIPP, ICAR, PPV&FRA, Patent Office, etc. must be sought in this regard.
- The proposed HPC may recommend to the government about the gaps, if any, in the provision for compulsory licensing made under the PPV&FRA, and the Patents Acts, and how to harmonise various provisions under the two Acts with that of the new National IPR Policy 2016. HPC may also consider if any required understanding/ guidelines need to be issued or any amendment(s) in the Act are required to resolve the discrepancies or implementation difficulties in the best interest of innovators, industry and the farmers. The recommendations of HPC must consider initiatives that can promote further innovations needed for the growth and development for Round Table Discussion on Promoting Biotech Innovations in Agriculture and Related Issues of seed sector in India. Due attention should be given to farmers' welfare while making recommendations for market regulations of both protected and generic inventions/plant varieties. Exceptional conditions under which the provision of compulsory licensing has to be enforced must be clearly defined to avoid any ambiguity with international agreements or the national IPR policy.
- A wider consultation with farmers on this subject is necessary to understand whether there is really some problem in accessing seeds and technology, and their quality and to come out with short, medium and long term strategies for implementation in future.
- Capacity building, including management development of government departments/ agencies engaged in regulatory tasks concerning agri-biotech R&D, biosafety, NOC, IP, marketing and trade, bioresources/ABS, other benefit sharing, etc., must be accelerated in some organized and transparent manner. Training of staff in the areas of market competition, confidentiality, and information/ RTI and other related matters may, therefore, be ascertained from time to time.

Promoting Agri-biotech Innovations

A National Policy on Agricultural Biotechnology embracing GM crops must be brought out to promote, respect and protect innovation in agri-biotech and to ensure its benefits to all stakeholders and end users. Such a policy is needed on lines of already available policies, for example: the national agricultural policy, new seed policy, new IPR Policy etc. It may be considered jointly by the Department of Biotechnology, Ministry of Agriculture and Farmers' Welfare (MoA&FW), ICAR, Ministry of Environment, Forests and Climate Change (MoEF&CC), Ministry of Commerce and Industry, and the Ministry of Law. To ensure this, a Task Force of eminent experts, agri-biotech Industry representatives, progressive farmers, eminent biotechnologists etc. with

well-defined Terms of Reference (ToR) and secretariat be constituted by DBT to come out with a well articulated policy document at the soonest possible.

- Steps be taken to strengthen and further streamline the existing regulatory system for testing and release of GM crops while making it simple, effective and efficient so as to facilitate and promote agri-biotech research and innovation both in public and private sector. For this, DBT, ICAR, MoA&FW, MoEF&CC and DIPP/IP India must take a joint initiative for wider consultation to identify focused areas for reforms and initiating determined steps for better coordination and convergence. The purpose is Round Table Discussion on Promoting Biotech Innovations in Agriculture and Related Issues 5 to visualize a simple, efficient and transparent regulatory system, and its processes which overcome ambiguity and duplication of efforts. Further, till the time BRAI Act is passed by the Parliament, it was a considered view of all that the needed reforms should be stepped up by strengthening the secretariats of RCGM and GEAC as independent entities, for enabling competition in seed industry by timely GM approvals. Also facilitation role of ICAR for testing/validation of technologies and involvement of MoA&FW for commercial release under the existing provisions of Seed Act be ensured simultaneously.
- Committee of Secretaries involving Agriculture, Environment, Biotechnology, Science and Technology, Industrial Policy and Promotion vis-a-vis IPR may consider specific complexities arising and ensure harmonization of existing laws, and regulatory processes particularly the related executive actions/steps; provide due encouragement to innovativeness, protection of innovation, and respect innovators' interests while ensuring that farmers benefit from the technology. Such directions may include steps for creating better public awareness, catalysing public sector research in agri-biotech, public confidence building, and strengthening of public-private partnership.
- For translating the potential of agri-biotech into products, and their up-/ out-scaling, Public Private Partnership (PPP) must be promoted, being the most effective mechanism that would help increase farm productivity and improve the economic conditions of farming community. Such partnerships should be based on common goals, and driven by complementary strengths and resources; aimed at achieving the objectives of mutual (industry-industry; industry-farmer, etc.) as well as national interests. The partnership should start from the beginning (research stage) rather than at a later stage in the R&D chain to merely share the finished products for multiplication, commerce and trade. There is a need for building capacity, transparency and mutual trust for ensuring much needed PPP, and any such guidelines must focus on Good Operating Procedures.

28. Access and Benefit Sharing – Striking the Right Balance

(Brainstorming Meeting: October 22, 2016)

Background

India has been proactive in implementation of international treaties and conventions including the CBD (1993), WTO (1995) and ITPGRFA (2004) by developing and effectuating compatible legislative, policy, and administrative steps. Facilitated access to bio/genetic resources and equitable sharing of benefits arising from their use figured among the key objectives of CBD, besides conservation for sustainable use of biodiversity and its components. The ABS regime introduced by CBD in 1992 has been elaborated subsequently under ITPGRFA in 2004 and the Nagoya Protocol in 2012 bringing clarity with regard to the national domains of ABS for bio/genetic resources within their own jurisdictions as well as at international levels. Through enactment of the PPV&FR Act, 2001 and the BDA, 2002, and establishment of PPV&FRA and NBA, India has simultaneously implemented the spirit of WTO (protection for plant varieties) as well as CBD (utilization of genetic resources). Indian regime has created exceptional provisions of Farmers' Rights and compulsory approval from NBA for patenting related to bioresources to pave way for equitable sharing of benefits. Massive awareness programs about the rights of farmers and communities have been taken-up on genetic and bioresources. However, there are intricacies that demand sensitization of stakeholders, upgradation of skills in implementing agencies and resolution of ambiguities arising in individual cases of agrobiodiversity access and use vis-à-vis innovation management. As a result, central and state governments, district administration and the constitutional authorities established to regulate biodiversity and farmers' rights as well as all agrobiodiversity stakeholders need to come forward to harmonize compliant approaches, appropriate processes and good practices that would contribute to the evolution of an effective and efficient ABS domain acceptable to all.

Dr R.S. Paroda speaking during Brainstorming Meeting

Experts exchanging views during Brainstorming Meeting

It is recognized that paucity of awareness and lack of clarity are creating difficulties in real time handling of cases. There exists a variety of legal dimensions and instruments in the utilization of genetic resources and associated traditional knowledge at the national as well as international level. They include laws governing administrative processes, intellectual property, environment, contracts, property, etc. Core issue in the area of ABS implementation is integrating multiple statutes, multiple ministries issuing multiple guidelines, and multiple agencies in order to benefit the stakeholders. There is a need to strike the right balance between the 'access' and the 'benefit sharing' concerns, possibly by enhancing tools to analyze such concerns raised by affected stakeholders, and refining the processes and protocols for their adherence to the regulatory norms.

India organized the 1st International Agrobiodiversity Congress (IAC 2016) on 6-9 November, 2016 (wwwiac2016.in). More than 1000 participants from 60 countries participated in the congress to deliberate on thematic issues of global importance, with major emphasis on rational and effective use of agrobiodiversity for food, nutrition and environmental security. The program committee gave focused attention to the ABS centric issues and concerns while developing the technical program of the 4-day congress. Anand and Anand, a leading full service intellectual property Law Firm (anandandanand.com) has been duly conversant with the developments and also emerging concerns related to ABS in bio/genetic resources post-implementation of relevant acts and guidelines. Anand and Anand was contemplating having an awareness drive in ABS processes, post Nagoya Protocol, and approached the organizers of IAC 2016 to co-organize a suitable pre-Congress event on ABS issues.

Accordingly, a "Brainstorming Meeting on Access and Benefit Sharing was jointly organized by the Indian Society of Plant Genetic Resources (ISPGR), Trust for Advancement of Agricultural Sciences (TAAS) and Indian Society of International Law (ISIL) at India Habitat Centre, New Delhi on 22 October, 2016 to raise awareness and also brainstorm on the issues related to ABS vis-à-vis the Nagoya Protocol and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA)

Recommendations

Implement ABS in letter and spirit to ensure protection of bioresources, their conservation, facilitated access, sustainable use and equitable sharing of benefits

- As there is a serious need for accessing bioresources for research and development in agriculture and health, that national legal frame work, institutions and authorities are in place, it is time to move forward for scientists, lawyers and regulators for collective action to ensure effective implementation of ABS regime.
- The ABS implementation should ensure intended use of accessed material, alongside suitable mechanisms to address misuse. conservation, facilitated access, sustainable use and equitable sharing of benefits
- There should be opportunities to share experiences by practicing IP lawyers and scientists to form an effective amalgam of solutions for ABS implementation; India is yet to have case law in ABS; its implementation can be shepherded by experience in other IPRs.
- There is a need to put in place adequate checks and mechanisms to prevent illegal export of genetic material out of country.

Establish a simplified and enabling system for effective ABS regime

- Simplification of forms and reasonable time-frame for disposal of applications.
- Set up a "Single Window System" as a clearing house to facilitate effective and efficient ABS system as per provisions of the Nagoya Protocol.
- Put in place end-to-end guidelines for access and sharing the benefits

Bring about clarity on critical issues for effective implementation of ABS

- Events of pre-BDA access and commercialization of such accessed bio-resources such as a cut-off date for implementation be considered in line with extant variety protection system provided under the PPV&FR Act.
- Permission to access genetic resource (e.g. insect, pest or weed) "not to be used to test" as a resource per se but "to be used to test against" them for research needs to be revisited and clarified.
- Case studies have shown that applicants and lawyers can take the route of court of law for unambiguous interpretations in the form of orders, clarification on rules and amendments.
- Criteria defining an Indian Company according to BDA needs revisiting in today's context.

Dignatories on the dais during Brainstorming Meeting

- Clarity on overlapping jurisdictions of NBA and PPV&FRA.
- Defining what constitutes a "biological resource", a "genetic material", "value added product", conventional breeding, occurring in India.
- "Exemptions" for approval needs clarity and consistency.

Utilize ABS regulations to facilitate the exchange of PGRFA and to ensure benefit sharing rather than slowing down the exchange

- Modalities for access to genetic resources need to be harmonized before benefit sharing issues are implemented.
- MTA for bilateral agreement with another country needs to be drafted in harmony with multilateral SMTA.
- Revisit the stringency of filing requests at NBA with respect to authorized signatory, extent of criminal liability and resultant reluctance of authorities to sign the document.
- Innovative approaches to share material with global community (and share benefits) to ensure access to important material from other countries as well as to shed conservative and protectionist image of India.
- Execution of issues provided under the law and agreed upon in principle (e.g. SMTA) without which access is a non-starter.
- Immediate action on enabling multilateral access to genetic resources committed under Treaty. Facilitate access to users within the country including private sector for research; benefit sharing will follow.

Build greater convergence and harmonization among government agencies governing ABS

- In India, ABS is affected by multiple statutes, governed by multiple ministries issuing multiple guidelines, and executed by multiple agencies. Coordination and cooperation among agencies (NBA, PPV&FRA and IPO) must for effective implementation of ABS.
- A strong interface required between PPV&FRA and NBA as well as NBA and IPO to iron out gaps and to frame rules and procedures that are non-encroaching, complementary and compliant through technical and legal experts.
- Ensure same set of biodiversity rules apply in every state such that no disparities

Establish systematic and comprehensive system of documentation and database and integrated ABS platform

- Creation of a well-defined integrated database of genetic resources, bioresources, associated traditional knowledge like TKDL available with all stakeholders including private sector to ensure effective implementation of ABS mechanisms.
- Need to develop an online integrated platform for cases relating to access to bio-resources and eventual benefit sharing Different regulatory and approval authorities like NBA, PPV&FRA and IPO may have dedicated modules for administering relevant jurisdictions. For user, it shall be a single window system, guided at every stage, time-line determined, over-laps as well as gaps identified and taken care, documentation at every step facilitating transparency.

Strengthen regulatory and implementing agencies with structural reforms

- Regulatory authorities (e.g. NBA) need to be staffed adequately with competent people.
- Usher in "Time Revolution" i.e. time taken to deal with cases should be reasonably minimal (requiring change in both mind-set and technical knowledge);

a time-line should be established. e.g. reforms in administrative procedures at IPO and PPV&FRA taking place to overcome delay; rules amended to enforce timelines to make the entire process faster, simpler and professional.

- Recognize nature of issues to tackle them; the issues could be substantive (need definition and interpretation), administrative issues, or legislative (require either a change in a law or rule connection). Implement a simplified dispute settlement mechanism with the help of legal experts.
- Delegation of responsibilities of dealing with agrobiodiversity to MoA&FW with PPV&FRA and ICAR in matters of access and benefit sharing; five genetic resources bureaus functioning as facilitating points.

Organize regular programs of promotion, awareness and capacity building

- Awareness programs for stakeholders, industry and academia. e.g., awareness programs for applicants can bring down delay by reducing incomplete and incorrect applications.
- Capacity building for personnel of implementing agencies to understand legislations, formats, agreements, standards of royalties, flow of benefits, etc.
- Recognizing, rewarding and handholding farmers and communities for innovation and conservation activities enhances likelihood of access and benefit sharing (e.g. PPV&FRA has a dedicated Gene Fund).

29. Delhi Declaration on Agrobiodiversity Management – Outcome of International Agrobiodiversity Congress 2016

(An International Congress- November 6-9, 2016)

International Agrobiodiversity Congress held in New Delhi, India, from 6-9 November, 2016 was attended by over 1000 participants from 60 countries wherein delegates discussed various aspects of conservation, management, access and use of agrobiodiversity. Based on detailed deliberation, following declaration emerged:

Policy Issues

- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- Coordination among various government ministries needs to be ensured for effective implementation of laws related to agrobiodiversity management and use.
- 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.
- Urgent policy directives are needed to arrest agrobiodiversity loss at the national, regional and global level.

Quarantine, Biosafety, Biosecurity

- Convergence of WTO and CBD provisions at regulatory and operational level has to be achieved for conservation and use of biosecured agrobiodiversity.

- Safe-trade should be promoted as a driver for conservation and exchange of agrobiodiversity and to prevent spread of invasive alien species.
- 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.
- Green Pass criteria for the germplasm distribution from international genebanks should be developed to provide credibility on health status of germplasm to phytosanitary regulators.
- Seed certification programs, early warning system and the pest surveillance have to be strengthened in all developing countries.
- '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

- Completeness of collections in genebanks should be achieved on the basis of gap analysis and targeted germplasm explorations/collecting
- 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).
- 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.
- Global common platform for documentation of available accession-level information be developed and made available to breeders in order to ensure their enhanced use.
- 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.
- 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

- Incentivize in situ/on-farm conservation and genetic approaches be adopted for sustainable on-farm management of landraces diversity.
- Pilot projects for in situ conservation should be developed for the mitigation and adaptation to climate change effects.
- *In situ*/on-farm conservation should be supported by providing scientific inputs, monitoring, measuring transitions and proper documentation.
- Agrobiodiversity hotspots are to be protected and *in situ* conservation of farmers' varieties be ensured through establishment of community seed banks.
- 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.
- Traditional knowledge available with rural and tribal communities, especially with women farmers, be documented on priority for effective use of agrobiodiversity.
- Creativity among farmers be encouraged by required incentives for their innovation and enterprise initiatives.
- 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

- National climate strategies and action plans be developed concerning information, policies, institutions and capacity-building.
- 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.
- *In situ* conservation of animal genetic diversity be ensured within their ecoregional context.
- Agro-ecological zone based maps of agrobiodiversity should be prepared to asses both spatial and temporal changes due to climate change.
- Genetic base-broadening approach at farm and landscape level be promoted by introducing adaptive inter- and intra-species diversity.
- Discovery of useful traits and genes by characterization of ex situ collections under the hot spots be given high priority.
- 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 prebreeding should be developed in order to deliver at the farmer's fields.
- 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)
- 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

- Agrobiodiversity Index should be developed and implemented to help monitor ongoing genetic resource conservation and management efforts, with particular emphasis across existing agrobiodiversity hot spots.
- 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.
- Regional and national CWR strategic action plan be put in place for their effective assessment, management and utilization.
- 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.
- 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.
- 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.
- 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.
- 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.
- Value addition of animal and fish genetic resources and certification of their bioproducts may be initiated/ intensified at local level to enhance their sustainable use; Also the registration procedures of biopesticides need to be simplified to ensure their commercialization.
- 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.
- Scaling up of expeditions to explore and document insect and microbial diversity has to be done with greater emphasis on unique species.
- 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.
- '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

- 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.
- ICT based approaches should be explored (e.g. mobile apps based crowd sourcing, crowd funding, crowd bonding, etc.) to develop partnerships with effective involvement of stakeholders and to bridge digital device.
- Sustained support of the governments and donors must be sought to facilitate networks and partnerships among stakeholders, research institutions and development agencies.
- Indicators for a successful partnership be also developed in order to evaluate and strengthen these across disciplines, commodities and regions.
- Regional and international cooperation needs to be established/ strengthened to facilitate accessibility of germplasm in genebanks.
- Synergy between formal and informal seed sectors be also sought by adopting integrated seed sector development approach.
- Brood stock banks and stakeholders must be involved in the scientific management of animal genetic resources.

30. Strategies for Implementation of Delhi Declaration for Agrobiodiversity Management in India

(Brainstorming Meeting, 28 August, 2017)

Background

Agrobiodiversity includes crop varieties, livestock and fish breeds, and agriculturally useful insect and

Dr. R.S. Paroda speaking on strategies for implementation of Delhi Declaration

Dignitaries on dais during Inaugural Session

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 per cent 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

A brainstorming meeting on "Strategies for Implementation of Delhi Declaration on Agrobiodiversity Management in India" was held at the National Agriculture Science Centre (NASC) Complex, New Delhi, on 28 August, 2017. The meeting was co-hosted by the Indian Council of Agricultural Research (ICAR), ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) and Indian Society of Plant Genetic Resources (ISPGR), in collaboration with Bioversity International (BI), Trust for Advancement of Agricultural Science (TAAS), Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA) and Indian Society of Genetics

Participants of Brainstorming Meeting on Agrobiodiversity Management

and Plant Breeding (ISGPB). The objective was to chalk out a plan for effective implementation of the 12-point Delhi Declaration on Agrobiodiversity Management Delhi Declaration on Agrobiodiversity Management, adopted by the 1st International Agrobiodiversity Congress (IAC 2016) event co-organized by the ISPGR and Bioversity International. The brainstorming meeting was attended by 97 participants belonging to ICAR institutes, NBA, PPV&FRA, State Biodiversity Boards (SBB), CGIAR centers and experts from various fields of agrobiodiversity management. This document summarizes the deliberations of the meeting and more importantly comprises of the proposed action plan for management of genetic resources of different commodities (plants, animals, fish, insects and microbes) keeping in view the key issues, ongoing activities and perceived gaps in various domains. The follow-up action on 'Delhi Declaration' is expected to draw the roadmap

Box 4: Delhi Declaration

- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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.
- 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

for genetic resources management in India to achieve the Sustainable Development Goals and Aichi target.

Action Points

All the five Genetic Resources Bureaux of ICAR have been carrying out several activities suggested in the Delhi Declaration. However, helps prioritize and strengthen the core activities (Delhi Declaration). Following key areas were identified:

1. Research projects to focus on enhancing nutritional security through the use of genetic resources.
2. Generate Biodiversity Index; work on genebank enrichment index; utilization index etc.
3. Outreach programs (e.g. farmers' days, agrobiodiversity day, FARMERS' First, MGMG, etc.) and trainings to focus on women conserver/farmer participation.
4. Awareness programs on agrobiodiversity focusing school children, civil society, etc.; among breeders and other researchers regarding MTA; popularize agrobiodiversity as an option of CSR.
5. Work with global agencies in terms of capacity building for researchers from Africa, Central Asia, SAARC, etc.
6. Inventorize ITK related to genetic resources; publish and make these available to all stakeholders to increase recognition of the custodians.
7. Focus on in situ on-farm conservation and scientific studies on different crops; making native people partners of conservation efforts and greater engagement with farmers.
8. Specific allocation of funds like Tribal Support Project and North East to focus on communitybased seed bank efforts.
9. Modernization of genebanks for reducing environmental impact and cost, and increase efficiency.
10. Focus on CWRs for collection, conservation and pre-breeding; establishing facilities for maintenance of CWRs.
11. Use of genomics, space, computational and nano-technology in basic and strategic research proposals to add value to genetic resources and to enhance their utilization.
12. Increase germplasm exchange through collaborative research projects.
13. Efficient documentation and implementation of ABS as and when necessary.
14. Enhanced research back-up on quarantine activities

31. Sustainable Development Goals: India's Preparedness and Role of Agriculture

(National Conference: May 11-12, 2017)

Background

Despite specific temporal and spatial efforts, poverty and hunger are twin challenges still faced by

Dignitaries on dais during Inaugural Session

human civilization globally. Although extreme poverty has been reduced by more than half since 1992, more than 1 billion people continue to live on less than $1 a day. Additionally, roughly half of the world's population lives below $2.50 a day, and one in every nine persons is undernourished. Among children below five years of age, nearly 3.1 million (nearly 45 percent) die every year due to poor nutrition. In fact, every 3.5 seconds, a child dies because of poverty. All these statistics underline the imperative need to produce affordable, nutritive, safe, and healthy food more efficiently and sustainably. Agriculture today faces a bigger threat than ever before due to degradation of natural resources, especially land and water, and climate change. It becomes important to combat these threats, but without compromising on economic development. This requires a new set of farm policies, technologies, and institutional reforms. In 2015, global leaders came together to chart their progress and evaluate where they stood with regard to the Millennium Development Goals (MDGs).

It was a unique joint effort by leaders of different countries on combating poverty, hunger, undernourishment, and other global issues. It is a matter of satisfaction that most of the developing countries have made substantial efforts to achieve various goals,

Participants discussing SDG during the conference

especially poverty reduction. They reduced poverty by half between 1990 and 2010, although the decline in poverty was uneven across countries. In 1990-1992, the number of poor people in Asia was about 740 million, which declined to 565 million in 2010-2012. China has done remarkably well – poverty declined from 60 per cent in 1990 to less than 10 per cent in 2008. Other East-Asian and Pacific countries have also done quite well. Within Asia, the largest concentration of poor is in South Asia, which houses nearly 304 million poor. In South Asia, India has the largest poor and food-insecure population - 71 per cent of the poor in South Asia live in India. Like other countries, India could accomplish most of the MDGs well before 2015, but the pace has been far slower compared to China and other countries in South East Asia.

Also, the progress in achieving some of the development goals has been rather inconsistent. The official estimates reveal that while India achieved the target of poverty reduction, it fell short when it came to reducing undernourishment. To continue the global collective efforts more vigorously, the countries adopted a post-2015 agenda, which included a renewed set of goals to end poverty, protect the planet, and ensure prosperity for all as part of the new Sustainable Development Goals (SDGs). The resolution Preamble 2: Proceedings of the National Conference on Sustainable Development Goals adopted by the United Nations (UN) has a much broader inter-governmental agreement, which, while acting as the new agenda, builds on the Resolution, popularly known as "The Future We Want". There are 17 aspirational "Global Goals", with 169 targets under SDGs. Among these, the goals having direct relevance to agriculture are: 'No Poverty', 'Zero Hunger', and 'Climate Action', besides the one related to 'Life on Land'. In India, agriculture is the major provider of livelihood to the poor, especially in the rural areas. However, the agricultural sector is facing big challenges like declining size of landholdings, deteriorating natural resources (especially soil and water), adverse impact of climate change, declining factor productivity, rising input costs, fluctuating markets, and declining farm income. All these factors make agriculture a riskier means of livelihood. The questions that arise are: How can agriculture contribute towards achieving SDGs? What should be the strategy to promote agriculture for achieving SDGs?

What lessons can other developing countries, especially of South Asia, learn from India or vice-versa? The development of improved varieties/hybrids and adoption of better management practices have immense potential in achieving the SDGs. It is encouraging that the National Agricultural Research System (NARS) has developed several technologies that promise to increase incomes, reduce production cost, conserve natural resources, improve food quality and nutrition, and minimize various kinds of risks. The need is to create an enabling environment to scale-out useful and efficient technologies/innovations for wider adoption and large-scale impact on production and income of smallholder farmers.

The Government of India gives high priority to the agricultural sector and plans to make it more efficient, competitive, sustainable, and resilient. 'Doubling Farmers Income by 2022' is the latest policy initiative of the government. The other programs that aim to increase farmers' income, conserve soil and water resources, improve resilience, and reduce risks include Prime Minister's Irrigation Program, Prime Minister's Agricultural Insurance Scheme, National Food Security Mission, National Horticulture Mission, National Mission on Sustainable Agriculture, National Agricultural Development Plans, and National Livestock Mission. There are initiatives to connect farmers with remunerative markets through e-NAM (One Nation One Market) and consolidate farmers to derive benefits

Group photograph of participants attending SDG meeting

of economies-of-scale through Farmer Producer Organizations/Companies. All these efforts demonstrate India's commitment to accomplish the SDGs related to agriculture. There is, however, an urgent need to ensure reorientation of on-going efforts toward higher efficiency and effectiveness of various initiatives by developing a road map by which to achieve the goals well before 2030.

The organization of 'National Conference on Sustainable Development Goals: India's Preparedness and the 'Role of Agriculture', jointly by the Trust for Advancement of Agriculture Sciences (TAAS), Indian Council of Agricultural Research (ICAR), and. International Food Policy Research Institute (IFPRI) was an attempt in this direction. The conference was attended by about 160 delegates from India and abroad, representing professionals, policy researchers, policy planners, students, and representatives of private institutions, banks, and research institutions.

Recommendations

To achieve the SDGs in India, the following key action points/recommendations were made:

Higher investments in agricultural R&D

- Advance frontiers for nutrition-driven technologies. - Breed high-yielding, high-nutrient crop varieties/ hybrids. - Develop and disseminate biofortified crops.
- Support technologies that promote diversification of agriculture.
- Invest in human capital and skill development.
- Ensure investment of at least one percent of the agricultural GDP in agriculture research for development (AR4D).

Improve land management systems

- Develop situation legalize land leasing and disseminate NITI Aayog's Model Agricultural Land Leasing Act, 2016.
- Site-specific land-use plans for different agro-ecological regions/ sub-regions/zones/sub-zones.
- Focus on irrigation management with the aim of 'per drop more crop'.
- Strengthen the Soil Health Card Scheme for applying soil-test based nutrients.
- Develop geo-portal and mobile Apps for national and international connectivity.

Accelerate climate action

- Invest in development of climate-smart agriculture.
- Develop and disseminate drought-tolerant, submergence-tolerant, salinity-tolerant and aerobic stress-tolerant varieties of crops.
- Promote conservation agriculture technologies; for instance, develop institutional arrangement for custom hiring services to especially promote small-farm mechanization.
- Mainstream climate and agriculture related education.
- Develop a long-term weather forecasting system.
- Ban crop residue burning completely.

Reform policies and interventions

- Revisit investments strategies that have favored a few better-off states and regions.
- The paradox of investment vs subsidy need deeper analysis, because it is believed that investments contribute to growth but subsidies incentivize only farmers. Whether India should focus on rationalization or reduction of input subsidies should be thoroughly examined.
- Ensure effective implementation of various social safety net programs.
- Develop the non-farm sector to de-stress the agricultural sector, enabling income enhancement of rural households, and checking rural-urban migration.
- Promote the bee-keeping, livestock, poultry, and fisheries subsectors of agriculture.
- Popularize the 'Umbrella Program on Natural Resource Management' initiated by NABARD.
- Replicate collective initiatives like *Bhoochetana*, *Rythu Kosam* (of Andhra Pradesh) and Bhoosamrudhi (of Karnataka) that have provided better crop yield, and higher income.
- Evolve farmer-friendly crop insurance products.
- Initiate dialogue and have clear policy on GM crops.

Strengthen agri-marketing systems

- Focus on agri-marketing and pricing issues. Undertake price monitoring and forecasting of major food commodities frequently for timely trade decisions.
- Develop warehousing, cold chains, and food processing (preferably at the production sites)

32. Underutilized Crops for Food and Nutritional Security in Asia and the Pacific

(Regional Expert Consultation: 13-15 November, 2017)

Despite Green, White and Blue Revolutions, poverty and hunger are still the twin challenges being faced globally. There are three SDG goals which have direct relevance to agriculture. These are: 'No Poverty', 'Zero Hunger', and 'Climate Action'. In addition, the one on 'Life on Land' is indirectly related. The three main objectives of food, nutrition and health care are to be addressed by each nation to achieve the SDGs at a faster pace. At least 12 of the 17 SDGs contain indicators that are highly relevant for nutrition, reflecting nutrition's central role in sustainable development. In this context, agriculture assumes major role and is an important

Dignitories on dias during Inaugural Session

sector to help achieve the SDGs. At the same time, agriculture is currently facing numerous challenges, such as decline in the size of land holdings and natural resources (especially soil and water), adverse impact of climate change, productivity decline, rise in cost of inputs, fluctuating markets, and decline in farmers' income. Hence, they all make agriculture a risky preposition requiring diversification, sustainability and resilience through good agronomic practices.

Currently, global food security is largely dependent on a handful number of crops. Over 60 per cent of the global requirement for proteins and calories are met by just three crops - rice, wheat and maize. This is a paradox, considering that in human history, 40-100,000 plant species have been reportedly used for food, fibre, industrial, cultural and medicinal purposes, including 30,000 species of edible plants in wild, semi-domesticated or fully cultivated forms. Although some 7,000 cultivated species are in use today around the world, yet only about 30 species provide 90 per cent of global food demand. In contrast, there are hundreds of 'neglected or underutilized crops' with known economic value, including good source of food and nutrition. These have lost attention over the years because either they were less researched, or less recognized for their nutritional value, or had poor consumer preference/ awareness or tagged as 'poor people's crops', overlooked by research, extension services and policy makers. Governments rarely allocated resources for their promotion and development, which resulted in farmers planting them less often and reduced access to high quality seeds.

It is now increasingly being recognized that securing future food and nutrition security requires a paradigm shift from the conventional Green Revolution. One such approach is to explore non-conventional pathways such as wider adoption of underutilized crops (UUCs), as possible future crops due to the fact they are adapted to a range of agro-ecologies, are nutrient-dense and offer better prospects in marginal production areas with low input agriculture. In fact, this approach is an affirmation of sustainable farming systems and human wellbeing known to indigenous local communities for generations. The domestication of new crops would promote agricultural diversity and could provide a solution to many of the problems associated with intensive agriculture. Being nutritionally very rich, they have proved good potential for food and nutritional security, health and income generation especially for local communities. The use of modern science to improve their productivity, value addition and use by agro-industries needs to be harnessed.

Successful food systems effectively draw on locally available food, food variety and traditional food culture. This involves concerted efforts in research, public policy, promotion and required action in support of multi-sectoral and community-based strategies linking rural producers and urban consumers with traditional and underutilized food systems. Paucity of agronomic and nutritional information, negative public perception towards traditional foods, policies not recognizing sufficiently their important role in food security and health benefits, and lack of markets, are few important aspects which need urgent attention. While the value of these hardy staples under climate change is clear, it is essentially required to give attention to UUC/NUS to promote more balanced diets so critical for good health. Initiatives on R&D and promotion of these species in the past has been done by Bioversity International (e.g. *kodo* millet in India and *Digitaria* in Mali), Crops for the Future (CFF), FAO's Regional Office for Asia and the Pacific (RAP) on underutilized grain legumes and pseudocereals, All India Coordinated Research Project on Underutilized Crops (now All India Coordinated Network on Potential Crops) at the ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR). The development and commercialization of UUC/NUS is also one of the priority activities of the Second Global Plan of Action for Food and Agriculture, under the aegis of FAO Commission on Genetic Resources for Food and Agriculture adopted in November 2011.The 'Delhi Declaration on Agrobiodivesity Management' adopted during the '1st International Agrobiodiversity Congress (IAC 2016)' laid emphasis on use of crop wild relatives in crop improvement.

Thus, keeping in view the immense importance of UUCs and the fact that greater attention is

Dr. RS Paroda interacting during the Technical Session

required in their R&D and promotion, the APAARI under its program on APCoAB and the Council of Agriculture (COA), Taiwan, in collaboration with the World Vegetable Centre (WorldVeg), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Crops for Future (CFF), International Centre for Agricultural Research in the Dry Areas (ICARDA), Bioversity International (BI) and Department of Agriculture (DoA), Thailand, organized the "Regional Expert Consultation on Underutilized Crops for Food and Nutritional Security in Asia and the Pacific", at Bangkok on 13-15 November, 2017.

Recommendations

Research and Education

- Genetic resources of UUCs in the APR should be mapped and a baseline database be developed on species and diversity, to enable preparation of a comprehensive status report on these plants. APAARI may take a lead in collaboration with NARS, CABI, CFF, CGIAR and other relevant institutes in respective regions.
- Documentation and validation of indigenous/ traditional knowledge/ethnobotany, culinary recipes and local uses of UUCs, should be undertaken on priority. A web-based encyclopedia may be established for collating all such published information (e.g. Global Knowledge Base for UUCs, for diversification of agriculture by CFF).
- PGR management of UUCs should be given greater thrust for survey, collecting, characterization and evaluation (nutritional and health). For holistic conservation, facilities (in situ, on-farm, ex situ, field genebank, in vitro, cryopreservation) for these plants need to be strengthened. Equally important is facilitation of germplasm exchange among countries in the APR. For this, an assured funding system needs to be established, both at national and regional level.
- Research for developing good multiplication protocols and agricultural practices to get better production, enhancing the efficiency of hybridization techniques in small millets, pseudocereals and grain legumes, evolving varieties for specific end-uses and increased health benefits, improved quality for higher income, breeding region-specific, high yielding, stress tolerant varieties that do not have anti-nutritional factors commonly associated with some UUCs, development of technologies to manage important pests and diseases during production and storage, development of cost-effective processing technology and improvement of shelf life, are the priority areas in agronomy and breeding. Bioprospecting UUCs to develop novel products is another important area which needs to be given priority attention.
- School, college and university curricula should include information about UUCs which needs to be given priority attention to raise awareness about their importance among the youth. A global/ regional/national funding system for scholarships, exchange, projects targeting UUCs would ensure more research output in these plants.

Participants of the Regional Expert Consultation

Development

- A holistic rather than reductionist approach to mainstream major UUCs cropping patterns, seed production, etc. should be adopted. A value chain that spans genetic resources to potential markets for particular UUCs at any location needs to be developed. Primary production of UUCs requires availability of quality seed, and private sector should be engaged for this purpose.
- While mainstreaming UUCs, it is important to keep in view the information from the demand side. Development of competitive and sustainable agro-food industry, increase of income of agricultural entrepreneurs, raising awareness of the consumers and farmers about nutrition and cultivation of UUCs, lack of adequate government support for marketing of UUCs and promotion in international market, insufficient planting material of herbs and medicinal plants are some challenges which need to be addressed.
- Issues of supply chain (procurement, bulking, aggregation, storage and processing) need to be studied. Supporting local food chains and establishing local processing industries and linking with eco-tourism, organic trades, hospitals and school feeding programs are areas requiring attention.
- Promoting custodian farmers for effective conservation and sustainable utilization, developing value chain and market support, and popularizing family nutrition garden involving women self-help groups, are pathways for long-term sustainable development, need to be paid greated attention.
- There is need for creating investment opportunities for collaborative R&D, and marketing linking to agro-tourism and processing to enhance promotion of UUCs.

- Mass media (TV, internet, celebrity endorsements), technology parks/incubator parks and food festivals in PPP mode needs to be promoted for awareness generation, promotion and marketing.

Policy

- A 'functional definition' of UUCs at global, regional and national levels is urgently required. An expert committee may be formed to develop a document to bring about synergy amongst various countries for classification of this group of plants.
- As cultivation and use of UUCs would address the SDGs of ending hunger, poverty alleviation, and for good health and well-being, sustainable production and consumption, climate change and sustainable use of ecosystems, governments need to accord adequate attention, priority and funding for its development and mainstreaming.
- 'Steering Committees' needs to be constituted at national level comprising policy makers (e.g. Ministry or Department of Agriculture), researchers, NGOs/NPOs, private industry players (especially for value addition) and farmer's representatives.
- The Steering Committees should coordinate R&D activities at national level and make policy decisions on behalf of the government, besides monitoring fund allocation. 'Working Groups' and 'Technical Groups' may be established at national and regional levels. The Chairs of these working groups should be members of the Steering Committees to develop a national policy on UUC/NUS.
- Policy based interventions like food subsidy, cultivation subsidy and promotion of government food schemes (e.g. mid-day meals, promotion of multi-grain flour, etc.) would significantly promote UUC/NUS, and address the welfare of the poorest of the poor.

Regional Cooperation and Networking

- It was unanimously agreed that strong partnership between IARCs, NARS, Universities, Regional Networks, NGOs, NPOs, Scientific Societies and Farmers Groups is required to strengthen work on UUCs. Sharing of information among and between these stakeholders can be done by development of databases on crops, experts and research activities at national level, and focal institutes should be identified in each country.
- A Centre of Excellence, with necessary expertise on UUCs, may be established for capacity building, networking and multi-stakeholder partnerships. Research institutes and Universities may be utilized to develop competencies and skills. Collaborative research programmes should be developed to enhance capacity and skills.
- Knowledge management system needs to be developed at regional level may be established and it may be facilitated by APAARI.
- Bilateral or regional cooperation/networking may be developed for efficient and effective germplasm exchange and exploration.
- Capacity building, especially for in vitro, cryo and molecular techniques at regional level is required, especially in the Pacific regions. Further, capacity building of farmers is required for marketing of produce and products of UUCs.

33. Harnessing Intellectual Property to Stimulate Agricultural Growth

(Brainstorming Meeting: New Delhi, 27 July, 2018)

Background

Globally, the nations that laid significant emphasis on scaling, incentivizing and protecting innovations have progressed much faster than the others. In India, research in plant breeding during mid-nineteen sixties enabled the country to achieve Green Revolution. This was one of the most significant achievements leading to household food security as well as reduction in poverty and hunger. However, an ever-increasing population, shrinking agricultural land holdings, over exploitation of natural resources and adverse impacts of climate change are posing serious threats to India's food security and sustainability. While over the last five decades, food grains production has increased more than five-fold to around 284.4 mt, India still would need about 345 mt of food grains by 2030, which based on the present production trends, may rather be difficult to achieve.

Participants during the Brainstorming Meeting

In addition, the problem of hunger and malnutrition is far more serious. India currently has around 20 per cent population facing an abject poverty and almost 40 per cent children below five years of age are stunted and malnourished. Hence, the country not only needs food security but also household nutritional security. Therefore, there is an urgent need to give a major thrust to scaling-up innovations that can ensure better food, nutritional and environmental security in the diverse agro-ecological regions of the country. In this context, innovations in biotechnology provide a range of opportunities to increase crop productivity and ensure sustainability of the production systems. However, research in modern biotechnology, such as genetically

Dr T. Mohapatra & Dr R.S. Paroda busy in exchanging views

modified (GM) technology, is relatively expensive. It also requires regulatory compliance which involves lengthy testing procedures before approval and release of final products.

Presently in India, Patents (Amendments) Act, 2005 (Patents Act) and Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA), 2001 are the two regulatory systems for intellectual property (IP) protection in agriculture. Innovations in identification, isolation and application of novel gene sequences and their products are protected under the Patents Act. Patents are mainly granted on products and processes that meet the patentability criteria of novelty, inventive step and utility. Further, a patented technology is invariably licensed between the parties through mutually agreed bilateral contracts. Accordingly, so far GM technology innovations and products thereof have been provided protection under the Patents Act.

On the contrary, the new plant varieties and farmer conserved varieties are protected by 'registration' under PPV&FRA after fulfilling the criteria of distinctiveness, uniformity and stability (DUS). In their case, the provision and modalities of benefit sharing exist in PPV&FRA. Hence, both public and private sector organizations/ seed companies have been granted patents on gene technologies and have also been granted registration of crop varieties under PPV&FRA thus safeguarding the interests of the innovators. In the process, thus far around 3,000 plant varieties have been protected under PPV&FRA and about 1,000 gene sequences that may have application through incorporation in seeds/ plant variety/hybrids have been protected under the Patents Act.

However, this understanding of the two acts with respect to the protection granted to plant biotechnological innovations in the background of new varieties has been questioned legally, especially in view of Section 3(j) of the Patent Act, according to which plants and animals other than microorganisms but including, varieties and species and essentially biological processes for production of plants and animals are non-patentable. Recently, in this context, Hon. Delhi High Court as per decision of 11 April 2018 ruled that since a synthesized gene sequence inserted into a plant genome has become a part of the plant and its functioning is an essentially biological process, it is to be considered as a part of plant only and hence such innovation cannot be patented under the Patents Act .

In view of this, a need has obviously arisen to have a clarity as to how the Breeders' Rights granted under PPV&FRA for new varieties developed through plant breeding can co-exist with Patent Rights granted under Patents Act for biotechnological innovations, including incorporation and expression of novel gene sequences in plants and their products, in a transgenic variety developed through plant breeding.

To address the above issues through an in-depth dialogue among the concerned stakeholders, a one-day

Group of experts participating in Brainstorming Meeting on Harnessing IP

brainstorming meeting on "Harnessing Intellectual Property to Stimulate Agricultural Growth" was organized by the Trust for Advancement of Agricultural Sciences (TAAS) at ICAR-IARI, Pusa Campus on 27 July 2018. A total of 51 senior officials from Indian Council of Agricultural Research (ICAR), Department of Biotechnology (DBT), the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), National Research Development Council (NRDC), Technology Information Forecasting and Assessment Council (TIFAC), Consultative Group of International Agricultural Research (CGIAR) Centers, Asia-Pacific Association of Agricultural Research Institutions (APAARI), South Asia Biotechnology Centre (SABC), intellectual property (IP) legal experts, biotechnologists, plant breeders, and representatives of seed associations participated in the brainstorming meeting.

Recommendations

Incentives for Innovations

- Biotechnological innovations, especially those that involve huge development and commercialization costs, would need to generate proportionate financial returns in order to ensure continued investment in innovations and greater benefits to farmers and the society. Hence, the development and introduction of desirable traits and new varieties using biotechnology must continue receiving high priority and the needed incentives through protection under both Patents Act and PPV&FRA need to be in place.
- Indian agriculture in the present context needs innovations such as Bt technology that led to a dramatic increase in both cotton production and profitability. Disruptive technologies, while threatening the market value of previous technologies and products, certainly help in benefitting the farmers as well as the consumers. Such technologies at times may result in monopoly. To safeguard against this, both the public and private sector research institutions must be strengthened to ensure healthy competition.
- Rapid advances are being made by the global seed and biotechnology industry towards identifying and utilizing new genes and developing novel gene modification technologies and products. It is recommended that the Indian national agricultural research system and the seed sector should substantially enhance their ARI4D in such technologies and cooperate to synergize both technology and product development as well as to promote healthy competition especially to guard against possible technology and price monopoly.
- For the benefit of both R&D investors and end-user farmers/consumers, the concerned IP related statutory bodies and the Ministries of Commerce & Industries and Agriculture and Farmers' Welfare, in consultation with public and private sector organizations/stakeholders must proactively revisit the existing rules, laws and acts on the subject of innovations in agriculture. Where necessary, required amendments need to be brought about to create an enabling environment to encourage new innovations and their adoption and to achieve faster the goal of 'Make in India".

Revisiting Legal Provisions

(a) Patents Act

- Section 3(j) of the Patents Act presently excludes plants and animals in whole or any part thereof other than microorganisms but including seeds, varieties and species and essentially biological processes for production or propagation of plants and animals from patenting. This Section seems to have been introduced in 2002 as an amendment in the Patents Act of 1970, as a consequence of harmonisation for protection provided to plant varieties under the PPV&FRA, which got enacted in 2001.
- It is well established that DNA modification technology and related variety development is quite distinct from the conventional plant breeding and involves several artificial processes or products that otherwise do not occur in nature. These include: use of microbial or synthetically manipulated genes, development of DNA construct having the gene of interest and other DNA modification technologies like CRISPR/Cas 9, and transfer of the artificial gene construct into a host plant DNA through artificial transformation techniques. These innovations, therefore, should not be treated as essentially biological processes, with no provision of IP protection on them once transferred into a variety.
- Hence, it is recommended that Section 3(j) of Patent Act be revisited and its coverage clarified on scientific and logical grounds considering the actual processes involved and to protect the interest of innovators relating to genetic modifications and concerned varietal developments. Such clarity is necessary since similar biotechnological processes and products thereof (e.g. insulin, antibiotics, etc.) are in use in pharmaceutical industry. Hence, innovation of similar kind in agricultural biotechnology need not be put to any disadvantage, especially when the gene expression is manifested after the incorporation in a plant/variety. This being fundamental for the growth of agricultural innovations, biological innovations must be protected through required legal provisions.

(b) PPV&FRA

- PPV&FRA is a unique suigeneis system of protection of plant varieties that also protects the rights of farmers as variety developers and conservers of agricultural biodiversity. However, the Act in its present form does not accord

protection to genes, gene constructs and related biotechnological processes and products. Hence, there is need to revisit the law and address the following:

- PPV&FRA defines a 'variety' as, ".. a plant grouping except microorganism within a single botanical taxon of the lowest known rank, which can be - (i) defined by the expression of the characteristics resulting from a given genotype of that plant grouping; (ii) distinguished from any other plant grouping by expression of at least one of the said characteristics; and (iii) considered as a unit with regard to its suitability for being propagated, which remains unchanged after such propagation, and includes propagating material of such variety, extant variety, transgenic variety, farmers' variety and essentially derived variety". The Act specifically excludes microorganisms from the definition of a variety. Hence, the processes and products of microorganism manipulation, as may be involved in the development of gene constructs, are out of its domain. Further, a gene though conferring a trait to the plant does not qualify by itself for protection under PPV&FRA till the particular genotype carrying the transformation event is distinguishable from other known varieties on the basis of descriptors specific to the essential characteristics of the crop species. Consequently, processes of plant transformation also cannot be protected under the Act which, thus should be protected under Patents Act
- The general process of benefit sharing under PPV&FRA is limited to a registered variety only where the claim is that it has been derived from a previously existing variety (Section 26/1). Hence, no claims for the use of any previously existing variety is possible under the law if the beneficiary does not register the variety so evolved. Also, the amount of benefit sharing has to be decided by the Authority (Section 26/5), and the amount has first to be deposited in the National Gene Fund (Section 45/1a) from which the payments are to be made to the claimant. This mechanism is quite different from the prevalent licensing and sublicensing arrangement of patented genes or gene construct technologies under agreements between two parties.
- Currently, irrespective of whether it is an approved GM variety or otherwise, any variety registered under PPV&FRA can be used by other breeders to develop new varieties, except for its repeated use where permission from the developer of registered variety is required (Section 30). Thus, this exemption under Researcher's Rights does not permit maintenance of any IP right by the inventor for use of the GM event for development of a new or an essentially derived variety. This aspect has to be examined and needed amendment, as necessary, should be brought about in the Act to ensure mutual advantages to both GM event inventor and the user plant breeder in the case of GM event usage.
- In view of above concerns, it is recommended that PVP&FRA in its present form would obviously require revision to remove ambiguity related to overlap or coexistence with the Patents Act and to ensure necessary protection to genetic modifications related processes under the Patents Act while continuing to protect new plant varieties developed through plant breeding taking advantage of biotechnology inventions especially under the PPV&FRA.

General Recommendations

- An exercise on needed harmonization of PPV&FRA with Patents Act and the Biological Diversity Act 2002 is needed with respect to community rights, awarding biodiversity conservers, and identifying biodiversity hot spots to avoid disagreement and duplication of efforts.
- PPV&FR Authority should develop an information portal which can be accessible to the breeders, trait developers, farmers, communities and public at large on all registered varieties, their source parental lines, traits descriptors and related information.
- An online system of filing application for registration of new varieties by the PPV&FRA, including community varieties, should be developed on priority to facilitate application process, follow-up action and needed guidance.
- Section 29(3) related to exclusion of certain varieties from registration was brought in primarily to prevent the perpetuation of products of Genetic Use Restriction Technology (GURT) or Terminator Technology which are likely to be injurious to life or health of humans or animals. There is scope for misinterpretation of the clause, "....no variety of any genera or species which involves any technology which is injurious to the life or health of human beings, animals or plants shall be registered under this Act". For example, the incorporation of male sterility could be misinterpreted as being injurious to the life of plant since pollen is otherwise needed for sexual reproduction. Deletion or appropriate amendment of this section is, therefore, required to prevent any misinterpretation. All the registered varieties and hybrids (with their parents) must be DNA fingerprinted. The fingerprint and other key information should also be encoded on each seed bag before sale in order to enable verification of its authenticity and genetic purity. This step is critical to ensure providing authentic seed to the farmers. z The importance of ethics in science need not be re-emphasized. A healthy seed industry with a global reach cannot be expected without technology acquisition and profit sharing. In this regard, declaration under section 18(h) of PPV&FRA, of having acquired the parent genetic material lawfully, must be insisted upon for needed transparency and to ensure benefit sharing.

34. Motivating and Attracting Youth in Agriculture – A Road Map

(Regional Conference: New Delhi 30-31 August, 2018)

Background

The global population is expected to be around 8.0 billion by 2025. The ageing rural population, better opportunities outside agriculture, and declining natural resources are posing some serious concerns today as to who will feed the world tomorrow? Under such circumstances, concerns are also raised as to how will we meet the targets of sustainable development goals (SDGs)? In this context, the role of youth (both male and female) in accelerating agricultural growth cannot be underestimated. In fact, those nations have progressed much faster where youth has been motivated to get involved mainly in creative, secondary and specialty agriculture – supported well by an enabling policy environment.

India presently has the largest population of youth (356 million between 10-24 years) in the world (UN Report, 2014), even more than that of China (269 million). This obviously be seen to reflect a bright future since almost half of this population (nearly 200 million) live in the rural areas, which could be motivated and attracted professionally to agriculture

Dignitaries on the dais during Inauguration Session

and allied fields. Contrary to this, unfortunately only around five per cent of the rural youth is currently getting engaged in agriculture. This is simply because they do not find agriculture a creative, profitable and above all a respectable profession which can provide better living conditions. Thus, we do see an exodus of youth from rural to urban areas in search of alternative employment/option. Moreover, a clear strategy and enabling environment to motivate and attract youth in agriculture are lacking. Youth is disinterested in agriculture mainly because of poor infrastructure, less education facilities, practically no skill development opportunities, lack of incentives and rewards, and problems of land ownership, credit facilities and availability, value chain and farmer-market linkages. In addition, agriculture is currently faced with numerous daunting challenges such as overexploitation of natural resources (land, water and agrobiodiversity), a decline in factor productivity, costly inputs, low income and production uncertainties due to adverse effects of climate change.

Under such a scenario, the involvement of youth in agriculture is a challenge since they are energetic, innovative, and more receptive to new ideas/adoption of advanced technologies rather than traditional agriculture. In addition, they do have the courage to take the risks, so critical for any new enterprise. Moreover, the present-day agriculture requires intelligence and hard work, besides the will and commitment. Hence, the future strategy should motivate the youth to become job providers and agents of change rather than to remain as job seekers.

In this context, urgent steps are needed to motivate and attract youth in agriculture, who are not only energetic and willing but also innovative. This can be achieved only when required knowledge and education, technical skills, sustained encouragement and the enabling policy environment are provided. In addition, the required policies, incentives and rewards need to be put in place to attract young talents to undertake innovative farming that is not only profitable and sustainable but also respectable. Thus, the new strategy should be to reorient present-day agriculture from crop based to farming system based with emphasis on 'plough-to-plate' approach which is more relevant, efficient, demand-driven, productive, competitive and profitable. It must also ensure food, nutrition and environmental security for all, being important to achieve sustainable development goals (SDGs). Hence, there is an urgent need to develop a clear Road Map for motivating and attracting youth in agriculture. Also, there is a need to devise a suitable mechanism for its effective and speedy implementation, especially to accelerate growth in agriculture in South Asian countries.

With the above rationale, 227 participants from India and some South Asian countries (Afghanistan, Bhutan, Nepal and Sri Lanka) representing the National Agricultural Research Systems (NARS), private sector, civil society organizations (CSOs) (non-government organizations (NGOs) and farmer organizations (FOs), progressive farmers, entrepreneurs, policy planners, Consultative Group on International Agricultural Research (CGIAR) Centers, and development departments deliberated on this important subject in the Regional Conference on Motivating and Attracting Youth in Agriculture (MAYA) held at National Agricultural Science Centre (NASC) Complex, New Delhi on 30-31 August 2018. The conference was organized by the Trust for Advancement of Agricultural Sciences (TAAS) jointly with Indian Council of Agricultural Research (ICAR), M.S. Swaminathan Research Foundation (MSSRF), Asia-Pacific Association of Agricultural Research Institutions (APAARI), Young Professionals for Agricultural Development (YPARD), Skill India, Agriculture Skill Council of India (ASCI), and National Bank for Agriculture and Rural Development (NABARD).

Participants of the Regional Conference on MAYA

Recommendations

For attaining faster the sustainable developmental goals (SDGs), all nations in South Asia need to develop and promote a sound strategy around "Role of youth for accelerated growth in agriculture" for which the following 'Road Map' offering the youth a number of opportunities for economic, social and agricultural development, was proposed at the conference:

- There is an urgency to have a 'National Mission on Youth in Agriculture' with an aim to impart better knowledge and skill to youth on: i) sustainable, secondary and speciality agriculture, ii) efficient knowledge dissemination, including information communication technology (ICT), iii) technical backstopping for innovative farming, iv) new agri-business models, and v) entrepreneurship as well as linking farmers to markets through value chain. Under the Mission, concerted efforts are needed to build new skills of youth for innovative agriculture through both formal and informal education. The best option for this is to impart agricultural education right from school level. In addition, the central and state agricultural universities and ICAR institutes must initiate entrepreneurship training through vocational and formal diploma programs. Also, the university curriculum needs to be revisited to address the emerging needs and aspirations of present-day youth and markets.
- Priority attention needs to be given to develop a new research agenda for ' Youth-Agriculture Nexus' which (i) delineates different contexts for youth-oriented agricultural research, (ii) identifies opportunities for young people's engagement in agricultural research and innovation for development (ARI4D), and (iii) determines youth's future pathway for attaining sustainable agricultural growth and income.
- Involvement of youth in 'Plough–to-Plate' initiative can help in doubling farmers' income. Hence, their greater involvement as entrepreneurs will be the key to future growth and development. For this, networking for knowledge sharing/dissemination, participation of youth in outscaling of innovations through their validation using technology parks/ innovation platforms, use of ICT, creation of agri-clinics, much needed support for mentoring/ hand-holding, and awareness regarding intellectual property rights (IPRs) need to be the essential components of the proposed mission on youth.
- There is need for a paradigm shift from narrow focus on 'youth as a farmer' to 'youth as value chain developer'. To provide better economic opportunities for rural youth in the changing agricultural scenario, there is an obvious need to move beyond the plot/field level agriculture i.e. from production to post-production level and to link with market for better income opportunities. The combination of agricultural value chains, technology and entrepreneurship will unlock vast economic opportunities for youth in both the farm and non-farm sectors and hence youth need to be encouraged to set-up agri-service centres to offer custom-hire services for small and marginal farmers for mechanizing their farm operations to enhance production at reduced cost.
- The role of well trained and competent youth, with expertise in ICT application for e-NAM, start-up, stand-up and skill development schemes, agribusiness enterprises, etc. is extremely important. Youth would thus need enabling policies for long-term investments, availability of easy and soft credit, provision of subsidy upfront to the entrepreneurs, farmer-farmer exchange visits, easy market accessibility, land law reforms for entrepreneurs, no taxation system for rural-based primary value addition involving youth, review of

Agri-Clinic support system by the National Bank for Agriculture and Rural Development (NABARD), reforms in marketing laws such as scrapping of Agricultural Produce Marketing Committee (APMC) Act, provision of ready insurance for covering risk of 'start-up' entrepreneurs, etc. would immensely encourage youth to embrace agriculture.

- The private sector has also to play a proactive role in creating much needed 'Agri-Youth Innovation Corpus Fund' as part of their corporate social responsibility (CSR) and enhance rural employment through special projects. Such an effort would enhance rural employment opportunities through small agri-business start-ups, publicprivate as well as private-private entrepreneurship. They may also help through soft loans and mentoring programs for involving rural youths as input dealers/suppliers as well as paid extension agents.
- There is an urgent need to 'institutionalize incentives' and 'award/reward system' in order to reward highly successful agricultural entrepreneurs and innovators. This will inspire as well as attract the youth to adopt agriculture as a profession for their happy living. Such an approach should be a strategic priority at the local, state, country, and the regional level to ensure youth-led inclusive growth in agriculture.
- Success stories/case studies of young agricultural entrepreneurs and innovators need to be brought out and widely disseminated. Such selective studies must be well documented and nicely published. The successful entrepreneurs be also recognized and encouraged to act as role models and help in capacity development/ technical back-stopping for other youth to be equally successful. In this regard, a compendium of youth-led success stories in various sectors of agriculture from different ecoregions of the country be brought out on priority and made accessible to others.
- It is high time that the Ministry of Agriculture and Farmers' Welfare (MoA&FW) creates a separate 'Department of Youth in Agriculture'. This will ensure collaboration and coordination with concerned departments in other Ministries such as Science and Technology, Skill Development and Entrepreneurship, Food Processing Industry, Rural Development, Commerce and Industry, Chemicals and Fertilizers, etc. so as to meet the aspirations of youth in agriculture. Such an institutional mechanism, with funding support through the proposed 'Mission on Youth in Agriculture' will help in motivating and attracting youth in agriculture and allied fields.
- A 'Regional Platform on Youth in Agriculture' needs to be established through facilitation role of global/ regional/national fora like Asia-Pacific Association of Agricultural Research Institutions (APAARI), Trust for Advancement of Agricultural Sciences (TAAS), Young Professionals for Agricultural Development (YPARD), etc. for knowledge sharing, capacity development, partnership and policy advocacy. They all could play an important proactive role in providing neutral platforms to youth for their capacity development and confidence building for entrepreneurship.
- It is well understood that youth (men and women) of today has a different mind-set and outlook. Unfortunately, there exists an 'aspiration-attainment gap'. Hence, their aspirations must be addressed on priority. They like to pursue intellectually satisfying, commercially viable and socially empowering activities. All these are critical for future growth and development of any nation and would, therefore, need an enabling environment through policy and institutional support by all concerned.

35. Dryland Agrobiodiversity for Adaptation to Climate Change

(Satellite Symposium: Jodhpur, 13 February, 2019)

Background

Drylands, which encompass deserts, semi-deserts, grasslands and rangelands, occupy 41.3 per cent of the land surface on Earth, but are among the lesser-researched ecologies with respect to agriculture and somewhat over-looked by decision- and policy-makers. Considering the fact that drylands are home to about 44% of area of all the world's cultivated systems and 50 per cent of the world's livestock and habitats for wildlife, it is imperative to give focussed attention on the role of agrobiodiversity in these regions to address the issues of food, nutrition and livelihood security of the nearly 2.1 billion people inhabiting these terrains, especially in the context of climate change threats.

Amongst the total 34 global hotspots, 9 are in the drylands and about 0.5 per cent of the plant species are endemic to the region. In terms of agriculture, plant species endemic to the drylands make up 30 per cent of the plants under cultivation today, including many ancestors and crop wild relatives (CWRs). However, exact

Dignitaries on the dais during Inaugural Session

Experts discussing climate change issues

status of species in the drylands remains unknown, as no comprehensive assessment has been collated.

The main occupation of humans who inhabit drylands are agriculture and animal husbandry. Local inhabitants use the agrobiodiversity in drylands for multiple purposes like food, feed, wool production, dairy, medicines and transport. However, due to the fragile natural resource base, achieving food security in drylands has been a great challenge. With the threat of climate change looming large and additional threat of massive out-migration, the livelihoods of people who live in these areas, will be further at considerable risk.

Species and ecosystems in drylands are a result of distinctive evolutionary process, developing strategies to cope with environmental constraints such as water scarcity, extreme hot and cold temperatures, and unpredictable long drought periods with sporadic rainfall. In plants, these manifest into features such as short growth cycles, long roots, water storage in roots and trunks, and dormancy during dry seasons. Livestock species and breeds have adapted by optimizing the use of scarce vegetation and water, minimizing their water loss, being able to walk long distances over rough terrain, and other characteristics. Paradoxically, agricultural genetic resources are of fundamental importance for adaptation to climate change, and also become a casualty under certain extreme edapho-climatic changes.

Many dryland areas, especially mountain regions, which are the centres of origin and/ or diversity of domesticatedplants and animals (including their wild relatives) are under threat. Domestication of plants and animals in these regions is the outcome of efforts of farmers and herders who bred and selected the innumerable varieties/breeds specifically adapted to these niche areas. These farmers and herders are the most extraordinary innovators and conservers of agrobiodiversity, as they managed to develop unique and highly technological agriculture and pastoral management systems – many of them still in use – adapted to very adverse and changing environments. Empowering local communities and combining farmers' and external knowledge have been identified as some of the strategies for meeting the challenges in such ecologies. There is urgent need to understand the link between agrobiodiversity and climate change resilience, using a trans-disciplinary approach.

With respect to use of plant genetic resources (PGR) to address challenges in drylands, efforts are required on the development of varieties that are tolerant to higher temperatures and more frequent droughts. In this context, landraces and CWRs that are still found within the prevailing traditional farming systems in the drylands are potential sources of useful genes for plant breeding, especially to overcome adverse effects of climate change, which must be conserved. Unfortunately, many of the remaining hotspots of dryland biodiversity which have potential to contribute to climate change solutions are under rapid erosion, due to the combined effects of overexploitation, destruction of natural habitats, and modernization of traditional farming systems. Hence, an important aspect of food security within the context of climate change will be to take measures to secure the genetic resources of agricultural drylands.

The problems of dryland degradation, climate change and agrobiodiversity loss, along with issues such as resource depletion, pollution, and urban expansion into productive farmland are symptomatic of lack of understanding of natural processes by society in general. Global changes in drylands will not only affect the local inhabitants, but also the livelihoods and welfare of a considerable portion of human population. Land management systems that protect top soil, conserve and recycle nutrients, conserve and concentrate water are those that will maintain productivity in the drylands. Agrobiodiversity contributes to resilience through a number of, often combined, strategies: the protection and restoration of ecosystems, the sustainable use of soil and water resources, agroforestry, diversification of farming systems, various adjustments in cultivation practices and the use of stress-tolerant crops and crop improvement.

Sharing of knowledge, capacity building of all stakeholders and partnerships, to research and adopt new technological options is imminently required for meeting the future demand of managing agrobiodiversity of dry areas to optimize adaptive mechanism and risk aversion. Increased and targeted use of genetic resources, for new varieties and breeds through fast track utilization of germplasm is needed to cope with changed production environments.

Agrobiodiversity management in drylands also requires functional convergence of global policy and regulatory frameworks that deal with biodiversity, food and agriculture, desertification and climate change. Specifically, they relate to the Earth Summit (1992) in Rio de Janeiro, which led to the establishment of the three sister conventions: Convention on Biological Diversity (CBD, 1993), United Nations Framework Convention on Climate Change (UNFCCC, 1994) and United Nations Convention to Combat Desertification (UNCCD, 1994).

Other instruments are the FAO's International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA, 2001), Nagoya Protocol on Access and Benefit Sharing (NPABS, 2010) and Aichi Targets (2011-2020). Global commitment for greater coordination in legal, policy and management issues shall pave the path for sustainable livelihood security in drylands and in converting dryland areas from grey to green.

In light of the above, the Indian Society of Plant Genetic Resources (ISPGR), New Delhi, Bioversity International, New Delhi and Asia- Pacific Association of Agricultural Research Institutes (APAARI), with support from United Nations Environment Programme (UNEP) and Asia-Pacific Consortium on Agricultural Biotechnology and Bioresources (APCoAB) co-organized a Satellite Symposium on 'Dryland Agrobiodiversity for Adaptation to Climate Change' during the 13th International Conference on Dryand Development (13th ICDD) at Jodhpur, India. Issues were addressed through in-depth deliberations among researchers, intellectuals, policy makers, executives and other stakeholders on a common platform. The idea was to enhance awareness about the importance of agrobiodiversity of drylands, share the knowledge, experience and on-going research activities among the diverse stakeholders, to provide an effective platform for networking, and discussing policy implications related to dryland agrobiodiversity, with reference to efficient conservation and sustainable use of agrobiodiversity to ensure food and livelihood security in the drylands, in the changing climate change scenario

Recommendations

- Agrobiodiversity conservation and use should be comprehensive, not limited to crops on farm land, but include other components of dryland ecosystem, especially trees, shrubs, grasses and animal biodiversity.
- For mitigation of climate change in dryland ecosystems, research on the distribution, collecting, documentation, conservation and legal protection of agrobiodiversity requires to be intensified. Development of a Red Data Book for dryland diversity would be an important requirement to determine conservation priorities and minimize genetic erosion.
- Collection, characterization and evaluation animal and crop diversity of arid region that already withstand abiotic and biotic stresses must be undertaken on priority. Use of new tools and techniques like phenomics, genomics, space and robotic technologies should facilitate identification of valuable traits and genotypes better adapted in the drylands despite climate change scenario.
- There is need to promote and strengthen mixed cropping and agroforestry as well as silvi-pastoral systems (horticultural trees, multipurpose perennials, bushes, grasses and livestock) to reduce the risk and stabilize income support to resource poor farmers, despite adverse conditions on account of climate change.
- Precision water management technologies (such as conservation agriculture, precision land levelling, micro-irrigation including sub-surface drip and field bunding) should be popularized and promoted through appropriate policy and programs. The list of crops suitable for growing in drylands need to be reviewed especially with respect to water requirement.
- Primary agro-processing units need to be established in rural and peri-urban areas to minimise the losses of farm produce and fetching better prices to farmers. Entrepreneurship involving youth and women at local level need to be created and supported.
- Models to incentivise farmers need to be developed for facing ecological burden, in order to promote agroecology based cropping/farming and other agriculture systems. Also, environmental services for in situ and on-farm conservation of biodiversity and agrobiodiversity in the dryland ecosystems should be indexed and both incentives and reward systems be developed to support farmers promoting these sustainable practices. Crops and varieties adapted to local environments need to be mainstreamed to harness the benefits of their resilience to climate change and nutritional significance.
- Circular bio-economy needs to be promoted, which is based on reduced use of inputs, recycling and reutilization for sustainable mode of renewal form of economy. Modification of the traditional integrated farming system and introduction of modern technologies need to be reassessed for small and marginal farmers in developing countries, by increasing subsides or other means of compensation.
- A more balanced approach in terms of policy is required for increased public funding/support to dryland farming and farmers, laying greater focus on research and development, production and marketing, on par with crops in the irrigated region.
- The need to develop effective cooperation and partnership through either a consortium or a network was also recognized for knowledge and germplasm sharing as well as for capacity building and sustainable use. For this, the role of international centers like Bioversity International and APAARI was recognized.

36. Youth as Torch Bearers of Business Oriented Agriculture in South India

(Regional Workshop: Hyderabad, 21-22 October, 2019)

Background

India is experiencing change in two areas that promises to have profound impact on the economic and global leadership status of the country Agriculture and

Youth. With its youth population of 356 million, it is likely to have the world's largest workforce by 2027, with one billion people aged between 15 and 64 years. Half of the population is under the age of 25 years and two-thirds are less than 35 years which could be a game changer to exploit avenues for engaging them effectively in modern agriculture to sustain agriculture production in order to meet with the demand of the increasing population. The increasing literacy rate in the rural youth makes them amenable to modern farming technology including internet of things (IoT) based farming practices, much needed in the changing scenario of market oriented farming. However, it has been observed that changing aspirations and lure of stable income from sedentary jobs in urban cities induce rural youth to neglect agriculture that supports their families.

Revitalizing agriculture sector is the most important policy agenda in the country. Nearly 200 million young people live in the rural areas, a large section of who do not perceive a good future for themselves in agriculture due to low profitability and income in the traditional agriculture, and lack of infrastructure and required basic amenities in rural areas. Even the agriculture professionals are moving away to alternate sectors which are a big concern for 0.4 million workforce trained in Indian agricultural universities and institutes. At the same time, current agriculture faces numerous daunting challenges such as: overexploitation of natural resources (land, water and agro-biodiversity), a continued decline in total factor productivity, costly inputs, low income and production uncertainties due to adverse effects of climate change. Therefore, ageing agriculture coupled with waning interest of youth and multi-facet agricultural challenges are posing serious threats to sustain agricultural production and achieve sustainable development goals (SDGs) by 2030.

Dignitaries lighting the lamp during Inaugural Session

The sustainable development goals (SDGs) emphasize the need for food and nutritional security to bring down poverty and malnutrition. In tune with this objective, farming in India today is changing from a production for quantity to meeting the market oriented designer food requirements of the global populace. While taking into consideration the changing resource availability, life style changes based consumer needs, health consciousness and nutritional dietary preferences, there is a disconnect between the producer, processor and the consumer, resulting in poor price realization for the farmer, lost opportunities for processors and higher price of food products for consumers. Urban development is pulling away youth from rural areas leaving farming to older generation and women who are disadvantaged by skewed land ownership policies and connected subsidies, banking and finance opportunities. With this backdrop, it is the ideal time to relook at the way agriculture is promoted at all levels to make it appealing to the youth of today rural or urban who are a powerhouse of creativity, vibrant energy, innovation and focused motivation which, when not channeled in the right direction would turn into a wasted destructive resource for the country.

There is a need to INSPIRE - ideate, navigate, skill, perform, innovate, reach out, engage community) Sow an idea, skill and sustain, plan and precipitate, innovate through IoT, reach out to technology and finance providers and finally end users to sell the product for making the farm a viable business enterprise. There are several corporate organizations, community based organizations, development sector organizations, farmer cooperatives, processing industries, input providers, public domain institutions which have the knowhow to empower the interested youth (men and women) in the art of protable farming while ensuring welfare of communities. However, the linkages between these change agents are localized depriving a larger audience to learn about the opportunities, challenges and success stories of young men and women who have ventured into the agribusiness domain. There is an obvious need to create an appropriate platform for exchange of ideas, sharing knowledge and experiences, suggesting measures for solving problems, providing inputs for creating needed policies and most importantly a networking among the stakeholders.

The Professor Jayashankar Telangana State Agricultural University (PJTSAU), the youngest agricultural university in the country catering to an industrious farming community of the State of Telangana, has initiated a unique skill oriented, enterprise building training program for young farmers (men and women) under 35 years, known as Telangana Yuva Rythu Sagubadi in 2015 which has received high appreciation from the beneficiaries. Inspired by earlier successes and considering an urgent need for motivating and attracting youth in agriculture especially through agri-entrepreneurship, PJTSAU hosted a Regional Workshop on Youth as Torch Bearers of Business Oriented Agriculture in South India in collaboration with Trust for Advancement of Agricultural Sciences (TAAS), New Delhi; Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok and ICAR-National Academy of Agricultural Research

Girl students talent to the fore during the Workshop

Management (ICAR-NAARM), at Hyderabad during 21-22 October, 2019.

Recommendations

Universities

- Establish Agri-hubs/incubators in Universities to offer vocational training, mentoring and hand holding services for students, faculty and rural/ urban unemployed youth to develop themselves as agripreneurs.
- Develop Agri-Technology parks in Universities in collaboration with allied institutes or organizations to showcase innovative technologies and enterprises to prospective agripreneurs.
- Universities need to develop IPR policy and establish an IP Cell to enable research prioritization tending towards patentable innovations in technology for Agriculture and allied Universities.
- Encourage the faculty for sabbatical/deputation to Industry to build innovation ecosystem in the Universities.
- Attract Industry sponsored PG and Ph.D. research for skill development among student community.
- Facilitate change in mindset/attitude, aligned to entrepreneurship both in faculty and students through capacity building, exposure visits, networking workshops and Ideathons.
- Incentivize promising innovations brought out by faculty and students.
- Promote a congenial environment for healthy collaboration amongst applied, technology and basic science Universities for promoting agri-innovations.
- Solicit Alumni support technical and financial for faculty and student agri innovations.

Industries

- Create Innovation Corpus Fund to support AgriIncubators in Agricultural Universities and Government recognized Rural Innovation Centres.
- Promote commercialization of innovations and technologies developed by Universities as CSR activity.
- Encourage synergy between private and public institutions in promoting rural innovations in food processing, value addition, mechanisation, supply chain management and IoT based agri-innovations.

Government

- Launch a dedicated National Mission on Youth in Agriculture to INSPIRE and empower youth towards digital agriculture and agribusiness.
- Provide policy support and incentives to promote Agri-Start ups with special emphasis on Self-Help Groups, Farmer Producer Organizations and rural youth.
- Incorporate agriculture and agri-entrepreneurship in school and pre-graduate curricula in close collaboration with Universities and Industries to attract them towards agriculture sciences.
- Converge activities of all Government departments concerning agriculture and allied sectors for skill and enterprise development among rural youth especially women.
- Establish Rural Innovation Centres to mentor and support grass root level innovators in collaboration with development sectors/and organize INSPIRE workshops at district level to empower rural youth.
Financial Institutions
- Formulate agri-entrepreneurial friendly norms for financial lending and recovery to support entrepreneurial activities of farmer collectives, rural youth especially women.
- Sponsor capacity building workshops, skill development trainings for rural youth including farmers for fostering agri- entrepreneurship.
- Support to innovations products and processes in agri and allied Universities.

37. Land Use for Integrated Livestock Development

(National Dialogue: New Delhi, 1-2 November 2019)

Background

Livestock sector, an integral component of India's agricultural economy, has been growing at much faster rate (over 4%) compared to other components of the agriculture sector. It has emerged as an important source of income to the farmers. Moreover, this sector contributes 31.6 per cent to the national agricultural gross domestic product (GDP) and the demand for animal food products is growing much faster.

It is also evident that the sustainability of livestock sector depends mainly on sufficient availability of feed and fodder resources at affordable cost. In dairy farming, nutrition constitutes about 60 per cent of the total expenditure. Thus, feed and forage of high nutritive value and better digestibility are critical for the viability of dairy sector. Their scarcity is a major constraint for accelerating growth of livestock production. India with about 2.3 per cent of the land area of the world supports about 10.71 per cent of the world's livestock population, which is expected to grow at the rate of around 1.24 per cent in the coming years. In 2019, India had 535.78 million animal heads. The number of cross-bred female cattle has increased (39%) from 33.76 million (2012) to 46.95 million (2019). Likewise, the number of indigenous female cattle rose (10% increase) from 89.22 million (2012) to 98.17 million (2019). India is the world's largest and leading buffalo germplasm holder and its Murrah germplasm is under demand worldwide. It is estimated that only 5 per cent farmers have access to livestock related new technologies and information. Pricing of milk is mostly based on its fat and SNF contents ignoring feed prices. Cooperatives cover around 17 million farmers and procure about 11 per cent of total milk output.

Dignitaries on dais during the Inaugural Session

The large Indian land mass has among other things to generate nutritional support to a huge animal (536 million), poultry (740 million), human (1,352 million) populations besides an additional vast population of pet and stray canines, wild life and a vast populations of fauna. This raises a relevant, question as to how effective is our land use and how it will sustain such a large population in future. The three main sources of forage supply are crop residues, cultivated fodders and forage from common property resources like forests, permanent pastures and grazing lands which are presently contributing 54, 28 and 18 per cent, respectively. Currently, India faces a challenge to feed its livestock population. The projected demand for dry fodder, green fodder and concentrate for 2020 is 468, 213 and 81 mt on dry matter basis, whereas the availability is estimated. to fall short by 11, 35 and 45 per cent, respectively. Hence, bridging the existing gap is a major challenge presently.

Hence, any attempt towards enhancing availability of feed resources and economizing the feed cost would result in enhanced livestock and dairy production and increased income to livestock farmers. Despite all these,

Participants attending National Dialogue on Land use for Integrated Livestock Management

India has achieved 'White Revolution' on account of rich animal diversity, institutional and infrastructural support and competent human resource, besides policy support for linking smallholder farmers to markets. Today, India is the world's largest milk producer with around 185 mt in 2018-19.

As per the current estimates, area under cultivation of fodder crops is about 4 per cent of the total cultivated area with slightly higher share (7-10%) in the states of Punjab, Haryana and Western Uttar Pradesh. Moreover, common grazing lands comprise 3 per cent of the geographical area and are an important source of fodder, especially for landless and small landholders. The grazing lands, on the contrary, are degrading continuously both quantitatively as well as qualitatively. Moreover, between 1980-81 and 2008-09, the area under pastures and grazing lands has declined by 14 per cent. In India, around 69 mha of land is under forest cover, a part of which is also used to grow grasses, shrubs and trees to augment fodder requirement.

In order to address above issues, a "National Dialogue on Land Use for Integrated Livestock Development" was organized at NASC Complex, Pusa, New Delhi on 1-2 November 2019 by the Trust for Advancement of Agricultural Sciences (TAAS) jointly with the Indian Council of Agricultural Research (ICAR) and International Livestock Research Institute (ILRI) and supported by the Arid Zone Research Association of India (AZRAI). A total of 115 participants from the national agricultural research system (NARS), private sector, Department of Animal Husbandry, Dairying and Fisheries (DoAHD&F), Central Forest Department, civil society organizations (NGOs, FOs), livestock farmers, entrepreneurs, and policy makers attended the Dialogue.

Recommendations

For harnessing full potential of land for integrated fodder and livestock development, sound strategies need to be developed, promoted and implemented expeditiously for which the following major recommendations need urgent attention:

- The availability of both dry and green fodder as well as concentrate for the livestock is continuously decreasing throughout the country. As per best estimates available, the projected demand for dry fodder, green fodder and concentrate is 468, 213 and 81 mt on dry matter basis, whereas the availability is around 417, 138 and 44 million tons leaving a short fall of 11, 35 and 45 per cent, respectively. This wide gap between demand and availability is of prime concern and hence needs to be addressed on priority. As a first step, the Government needs to have more reliable estimates of area under fodder cultivation in the country, for which use of big data and geographic information system (GIS) could be helpful. Also, the minimum area under fodder production has to be almost doubled as against 4.6 per cent at present. Similarly, the estimates of demand and supply of feed and fodder as well as area under cultivation are based on secondary data and are highly variable. As feed and fodder is an important component, the need for reliable data at field level is most critical. For this, the National Statistical Office (NSO), Ministry of Statistics and Program Implementation (MoS&PI), should generate reliable data on a regular basis being a national priority. Also, an expert committee should be constituted to assess and suggest ways to meet the requirements of green and dry fodder as well as concentrates for accelerating the growth of livestock sector in India. The committee could comprise of Animal Husbandry Commissioner, Directors of ICAR Institutes (ICAR-IGFRI, ICAR-NDRI, ICAR-NIAP, and ICAR-CAZRI), Project Coordinator (Forage Crops), ICAR and some senior scientists including economists/statisticians. This committee could also review the database on feed and fodder resources, forage seed production requirement, economics of livestock production, marketing, credit and finance, and trade related issues and suggest measures for future growth.
- Availability of quality seed is the most important input for increased fodder production. Hence, priority attention is needed towards increased availability of quality seed and planting materials. Also, the old varieties need to be denotified and replaced with new high yielding varieties/hybrids and their seed production be accelerated through public/private partnership. The Central and State Government fodder farms need to be assessed for their better utilization for production of seed and planting material. Forage seed indent and production chain must be maintained through better coordination and advance planning. Keeping in view the shortage of feed and fodder, a well-planned and closely monitored program on forage development including quality seed production under the on-going "National Livestock Mission" must be strengthened and monitored closely. Also, there is a need to establish fodder banks/seed banks for use during the natural calamities. The National Seeds Corporation (NSC), State Seeds Corporations (SSCs) and other certified seed companies need to think some 'Out of Box' solutions like establishing producer companies, farmer associations, market linkage with private sector agencies, follow seed quality norms strictly, need to revisit the seed quality standards, explore possibilities to market fodder seeds beyond cooperatives and promote seed production, etc. Involving ICAR institutions, State Agricultural Universities (SAUs), State agencies, private sector along with farmers' participation in a holistic manner could help in addressing this issue in proper perspective.
- Adoption of improved production technologies and promotion of some important fodder resources for diverse edaphoclimatic conditions like: Azolla (humid and sub-humid conditions), turnip and fodder beets (intensive management system), spineless cactus (semi-arid and arid conditions) and para grass and coix (water logged conditions)

can augment fodder resources during the lean period. Similarly, many other non-conventional feed resources considered as waste can also be used effectively to supplement the existing feed resources. Use of hydroponics, fodder cultivation on field bunds and use of agriculture waste as bioresource for feed could be other possible alternatives. Concerted efforts are, therefore, needed for promoting new food-fodder-based production systems; forage production from problem soils, fodder conservation (bailing, densifying, silage, hay making, complete feed block, leaf meal, legume blocks, etc.) and better utilization of tree biomass as fodder.

- There is an urgent need for establishing a 'National Grassland Development Authority (NGDA)', which could have an oversight role to develop national policy on land use for fodder production, national grazing policy and to take care of all aspects relating to integrated fodder and livestock development. Also, such an institution could build stronger linkages for better coordination and convergence among Ministries and Departments such as: Department of Agriculture and Cooperation (DoAC), Indian Council of Agricultural Research (ICAR), Department of Animal Husbandry, Dairying and Fisheries (DoAHD&F), Forest Research Institute (FRI) and Ministry of Environment, Forests and Climate Change (MoEF&CC).
- The existing 'National Livestock Mission (NLM)' commenced from 2014-15 should also include Fodder Mission for addressing feed and fodder requirement in the country for better impact. Under the umbrella of Mission, there should be provision of advancing credit and needed subsidy to small and marginal farmers engaged in livestock production. In the livestock sector, insurance scheme which is presently spread in 300 selected districts requires to be promoted to all districts in the country to provide protection mechanism to the farmers and cattle rearers against any eventual loss of their animals and to enhance their risk bearing capacity. Also, there is need to augment the efforts of the states to allow small and marginal farmers to gain better price realization, access to markets, improved technologies for value addition and technical support. In general, the marketing of livestock has not been given due attention either in National Livestock Mission (NLM) or in *Rashtriya Gokul Mission* (RGM). The technologies for fortification of crop residues for making good fodder need to be outscaled. Value addition of dairy products, namely, milk, dahi, cheese including mozzarella, whey powder, dairy probiotics and nutraceuticals have provided handsome returns and therefore, become imperative for the dairy industry.
- There is full justification for an eco-regional planning in all States for the cultivation of fodder crops. For this, greater focus needs to be given on: (i) characterization of agro-ecological zones (AEZ) coupled with establishment of regional AEZ databases, (ii) initiation of farmer-led innovations through community and stakeholder involvement in agroecology-based agricultural crop planning and implementation, and (iii) utilization of locally available information for most sustainable cropping/farming practices. It is, therefore, suggested that greater emphasis needs to be given now on eco-regional scientific land use planning that is farmer and stakeholder participatory and ecologically sustainable in long-term and will immensely help in bridging the gap between demand and supply of feed and fodder. Also, there is need for intensifying research to develop and grow high yielding nutritive varieties of fodder crops that can withstand well to the changing climate scenario. The local genetic resources need to be tapped for such purposes and the farmer perception of the older vs. newer varieties must also be kept in view. A single policy approach for the entire country may not be practical and regional needs are required to be considered. Also, research on integration of livestock production and farming systems need to be initiated on eco-regional basis.
- Grasslands are invariably in very poor state and need to be restored on an urgent basis. In this context, there is an urgent need for improving rangelands, enhancing fodder production from problem soils and from village common property lands. For this, available resources under Mahatma Gandhi National Rural Employment Guarantee Act (MGNREGA), *Rashtriya Krishi Vikas Yojana* (RKVY), and watershed programs for development of pastures, common property resources (CPRs) and forest lands through involvement of village communities and panchayat raj institutions (PRIs) could help to a great extent.
- The livestock sector, though critically important for sustainable development of agriculture and nutritional security of teeming millions in the country, has not received required policy and funding support which it deserves. The R&D allocation to the livestock sector has hardly exceeded 4 per cent. Therefore, the budget allocation to the livestock sector be increased either to match its contribution to agricultural GDP or at least it be doubled as a first step to overcome existing imbalance. Currently, the sector is facing several challenges rooted to their high population numbers with low production capacity, changing life style of animal owners, reduction in farm size due to family division, limited and poor quality feed/nutrition, expanding urbanization, accelerated climate change and an acute rural/urban divide. Appropriate policy initiatives with adequate investment support needs to be in place to ensure that each of these challenges are converted to opportunities not only to enhance the farmers income but to bring a quality change in the health and nutrition standard of the animal population.

- Among other major concerns for the livestock sector are the poor animal health and disease situation which gets further badly dented by poor feed and nutrition shortage. The endemic and newly emerging diseases, shortage of vaccines, poor vaccination coverage, wide gap between availability and requirement of proven dairy bulls, reproductive diseases/disorders, infertility problems and poor diffusion of latest technologies result into a huge financial loss to the national economy. Any road map for livestock development must include a massive inclusive development investment into health sector. By 2050, the milk demand in the country would be 350-380 mt, and the number of animal farms will decrease and herd size would become large (around 250), partly due to involvement of smallholders to form producer companies which will require strong technological backstopping. Hence, the viable options for further improvement of dairy sector are technology-driven production, and enhancing processing and value addition which need to be given priority attention. There is shortage of frozen semen and progeny tested bulls, and artificial insemination (AI) covers only up to 30 per cent of dairy animals and hence the focus on animal breeding demands immediate attention. Also, the extension system in livestock sector is very poor leading to inefficient delivery system which needs to be addressed on priority.
- There is need to optimize the number of livestock population in the country. It also needs to be ascertained whether this sector has to be developed based on resource-driven approach (feed, fodder, breeding and health services) or supply-driven approach (number-driven growth). In the circumstances, the country either has to restrict the livestock population or increase area under fodder production to meet existing fodder deficit. Problem of surplus and unproductive animals needs to be addressed urgently under a well defined policy, including scientific intervention like sexed-semen use as a viable option. There is also need to distinguish between non-descript cattle and recognized indigenous dairy breeds, and to optimize the number of desired breeds and their population.
- With majority of our livestock being reared by owners who are landless or having marginal land holding, the animals have to be fed or taken to pastures for nutrient intake. Grazing pastures and other village *Gochar* grazing lands are particularly essential for pastoralists, who move from place to place for grazing these animals. In some ecosystems in the country animal species like camel, goats and sheep are exclusively reared under hot, dry, desert conditions with animals surviving mostly on browsing. There is an urgent need to provide policy support to these nomads/pastoralists and facilitate and strengthen their nutrient resource base through massive eco-regional agroforestry and/or silvipasture. Also, there is a need for developing an enabling policy framework under which the nomads/pastoralists can operate smoothly.
- There is an urgent need for a suitable policy to make provision of dedicated fodder marketing chain on priority with increased interactions among buyers and sellers, including value addition of dry fodder, use of straw based feed blocks, creation of storage systems on-farm as well as en-route to distant markets. There is great need to revamp the market, pricing, and finance and trade issues in the livestock sector. For example, pricing of milk to be changed from two axis (fat and SNF) to three axis model (fat, SNF and bacterial load/quality). Also, we must develop appropriate guidelines for regulation of imports and exports of feeds, and fodder seeds, etc. The technology of developing straw based densified feed blocks for easy transportation from surplus production areas to deficit areas is now available with many institutions but needs a suitable mechanism for popularization among farmers. There is need to provide institutional support like credit facilities, technology development and fodder processing facilities to smallholder farmers.
- There should be a clear mechanism in place for faster delivery of extension technologies in the livestock sector which has remained grossly neglected in the past as only about 5 per cent of the farm households in India have access to information on livestock technology. Innovative extension strategies are to be developed along with increasing the outreach program through media (print, electronic and social) to motivate farmers to go for fodder production. *Krishi Vigyan Kendras* (KVKs), Agricultural Technology Management Agency (ATMA) and private extension agencies would need to demonstrate the economic significance of fodder production over crop production on research farms and fields for different micro-agro-situations. Also, concerted efforts need to be made to make quality fodder seeds available through milk unions and milk cooperatives (currently it is around 25%), and enhancing research focus on developing improved varieties of fodder crops and improved fodder extension services. There is need for training and capacity building of extension workers of Govt., private sector, dairy cooperatives and NGO's in fodder production and utilization technologies the latest technologies.
- Technology on decomposition of ligno-cellulosic material holds great promise. Available technologies need to be assessed and gainfully adopted. There is an urgent need for institutional, especially public-private partnership, for technical assessment and socioeconomic feasibility, since 1 per cent increase in digestibility can enhance milk yield by 6-8 per cent. Such an option can increase productivity and income of farmers tremendously. Integrated feeding system with animal-specific nutrient management along with interactive digitization of feed information is to be taken-up on priority

for efficient feeding management. In order to meet the nutritional requirements of animals, there is a need to increase the bioavailability of nutrients from feeds and fodders using biotechnological approaches.

- Private sector including NGOs can play major role to commercialize the seed production of HYVs of fodder crops to reach to the end user on a large scale. It can contribute significantly towards developing new technologies for breeding better fodder crop varieties, fodder production through hydroponics, and preparation of good quality silage, leaf meals, feed blocks, etc. Community based initiatives also need to be taken up for agrobiodiversity, silvipasture management, upscaling of scientific pasture development, and policy support for fodder production. Entrepreneurship model needs to be developed and publicprivate participation be encouraged to enhance feed and fodder production to fill the gap between demand and availability.
- A synergistic approach between the forestry and livestock departments needs to be adopted for controlled grazing and/or for dry fodder production. Animals under controlled grazing help considerably in providing rest period to the grazing areas for further revival of their vegetation cover. Moreover, the forest departments also need seeds of different grasses and legumes with high quality biomass yields. The plantation of trees which have high fodder value needs to be given a high priority under different afforestation programs. For this, the staff of forest department needs to be educated and trained. Hence, an appropriate system for livestock management needs to be evolved through interdepartmental cooperation and proper understanding. In order to have a faster pace of integrated livestock development, better coordination and management between crops and animal science sectors is required, quality forage seed production chain be maintained, seed bill needs to be passed by the Parliament, a rolling plan be prepared and the role of private sector, as in other sectors, must be encouraged. The problem of shortage of feed and fodder can also be solved to some extent by reducing waste of dry fodders and horticultural wastes for fodder purposes and linking it with incentive to the farmers.

38. Way Forward for the Indian Seed Sector-A Road Map

(Stakeholders' National Dialogue: New Delhi, 22 February 2020)

Background

With fast changing climate scenario, seed will be the key to unlock the potential of new advanced technologies to meet the challenges of both abiotic and biotic stresses. Currently, the Indian seed industry is valued at USD 3.6 billion (4.4% share of the global

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trade) and has emerged as the fifth largest seed market across the globe. For boosting Indian seed sector, innovative technologies, enabling policy support, cost-effective production of high quality seeds and seedlings and efficient delivery services are critical. Despite emergence of strong seed system, the informal seed sector still meets 39 per cent of total seed demand (e.g. 31% in oilseeds, 36.4% in cereals, 55.5% in pulses, etc.). The need to improve the existing seed production and quality system is quite obvious for which strong technological, institutional and policy support is paramount. Besides internal market, India also has great potential to emerge as an important player in the global seed market.

In view of the above, a "Stakeholders Dialogue on Way Forward for the Indian Seed Sector" was jointly organized by the Trust for Advancement in Agricultural Sciences (TAAS), a neutral Think Tank for strengthening agricultural research and innovation for development (ARI4D), and the Indian Society of Seed Technology (ISST) at New Delhi on 22 February, 2020 in which 65 eminent seed experts, senior research managers, government officials, administrators, policy planners, seed industry stakeholders and farmers participated. The objectives of the Dialogue were: i) to discuss major constraints and find possible solutions for faster growth of Indian seed sector, ii) to seek views of different stakeholders on the revised draft 'Seed

Dr R.S. Paroda expressing his reviews on Indian Seed Sector

Arvind Kapur & Ashish Bahuguna during the National Dialogue

Bill 2020', iii) to suggest measures to strengthen seed health and quality assurance system in the country, and iv) to review options for promoting seed export from India.

During the dialogue, the discussion centered around global perspective for Indian seed sector, role of research institutions and public seed system, private sector perspective, future of seed sector in Asia and the Pacific region, and the regulatory reforms required for the growth of Indian seed sector. the private seed sector will continue to make significant contributions to Indian agriculture for which stronger partnership with public research institutions will be needed. Also, all out efforts are needed to increase India's share in global seed export market through partnerships and enabling policy environment.

The Road Map

To ensure faster growth and harness full potential of the seed sector, the following Road Map emerged through an effective dialogue:

I. Policies and Regulatory Framework

1. The regulatory system along the seed value chain needs to be effectively implemented to ensure availability of quality seed and planting material to farmers at reasonable price. Regulatory system needs to be efficient and foolproof and implemented judiciously both at the central and state levels.
2. The proposed registration of varieties/hybrids in the New Seed Bill 2020 is a welcome step but the process has to be efficient and time bound. For this, a "National Seed Registration and Export Promotion Council (NSRR&EPC)" needs to be created. The test period for value for cultivation and use (VCU) should not be more than one year using multilocation testing under defined agro-ecological conditions (2 years testing under exceptional cases), using accredited facilities created by both public and private R&D institutions/companies.
3. The New Seed Bill 2020 proposes only fruit nurseries for registration. The word 'fruit nursery' be replaced by 'plant nursery' so as to include also the vegetable and other crops.
4. The recognition of national level seed companies with R&D capabilities, variety evaluation system, seed production, testing and storage facilities is missing from the New Seed Bill 2020 which need to be included. Unique identification number (UIN) could be assigned under the National Registry System. All related information of seed production, quality assessment and performance be recorded at the national level and shared with the State organizations.
5. The current provision of truthfully labeled (TFL) seed should be permitted in the Act. However, provision of safeguards is needed in the New Seed Bill 2020 to reduce the footprints of poor quality seeds sold

Participants attending National Dialogue on Indian Seed Sector

by 'Fly- by- Night Companies'. As per Section 30(1) of the proposed New Seed Bill 2020, seed certification may be voluntary, but the provisions in the guidelines are necessary for self-declaration and accountability. The quality assured TFL should also qualify to get seed subsidy and linked to area coverage under new HYVs/hybrids.

6. The New Seed Bill 2020 be based mainly on science-led evidences. The legislation should give broad framework and its implementation be based on mutual trust and data verification. The self-regulation should be the key element of New Seed Bill 2020. Laws under it need to be liberal but with strict enforcement.
7. The practice of seed price control adopted by the Government of India needs to be re-examined and in fact, be implemented only in exceptional situations that too under well defined guidelines, and not individually by the State Governments.
8. Under the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act, if a registered variety fails in its performance, farmers can file claims for compensation before the PPV&FR Authority, which is not included in the New Seed Bill 2020. This needs to be revisited and the disputes on compensation should not be decided as per the 'Consumer Protection Act 1986'. The powers to regulate seed price in emergent situations (such as seed shortage, abnormal increase in price, monopolistic approach, profiteering, etc.) should remain only at the discretion of Central Government and not by the States. In nutshell, the mechanisms of addressing farmers' grievances should be simple, accessible and time bound.
9. Criminalization of violations and imprisonment may be categorized either as a major or a minor penalty and clear guidelines be defined for proper understanding by the State Government and all others concerned. Deliberate violations with intent to cheat the farmers may be categorized as an offence for heavy penalties with provision of compensation to the farmers once proved through an assessment by the expert committee constituted mainly for the purpose. The criminal penalties which impose imprisonment and fines need to be re-visited.
10. The seeds of varieties imported for commercial use will have to be registered. The New Seed Bill 2020 does not make any provision for phytosanitary standards for the import of large quantity of seeds after pest risk analysis (PRA). This needs to be specified in the guidelines after the New Seed Bill 2020 is passed by the Parliament.
11. Actually, 'farmer' includes the farmer himself or another person engaged in cultivation on behalf of the farmer. In New Seed Bill 2020, definition limits the 'farmers' only to land owners. 'Any other category' is rather discretionary. Hence, clarification needs to be provided on other categories of farmers.
12. Under the Central Seed Committee (Section 4-viii), the Director, ICAR-Directorate of Medicinal and Aromatic Plants Research (DMAPR) is proposed to be a member which is not necessary since both Deputy Director Generals (Crop Sciences & Horticulture Sciences) are already included as members. Instead, ADG (Seeds) who coordinates the production of Breeder Seed may be included.
13. The New Seed Bill 2020 is silent on crop diversification. In fact, the New Seed Bill 2020 should ensure varietal as well as crop diversity, check the trend towards monopolization and provide space to different seed players to grow.

II. Seed Research, Production and Quality Assurance Systems

14. The national seed system must ensure smooth and timely flow of quality, genetically improved, healthy, safe, and need-based seed in adequate quantity from breeders' plots to farmers' fields.
15. There is need to intensify research on seed quality enhancement technologies, including the seed priming, coating, pelleting, treatments with nano-molecules, micronutrients, plant growth regulators, biologicals and seed biomes; and identifying substitutes for micro-plastics in polymer coating.
16. In the entire seed chain, varietal purity plays a critical role which needs priority attention for maintenance breeding.
17. Reliable database is the necessity of hour. Effective seed plan for the next decade using Big Data Analytics tools need to be prepared and implemented. Data need to be generated for actual availability and use of seeds by different public and private sector organizations.
18. A full-fledged 'National Mission on Seeds' to accelerate the quality seed production, strengthening seed technology research, maintenance breeding, and capacity building should be in place. Incubators in all State Agricultural Universities (SAUs) and accredited Seed Testing Laboratories in each district need to be provided which would ensure seed-oriented entrepreneurship as well as attract and retain youth in agriculture. Qualified Seed Technologists should also be provided in each of the *Krishi Vigyan Kendras* (KVKs) to undertake and promote quality seed production and availability.
19. Most suitable/alternate areas for high quality seed production may be selected in the changing climate scenario. The Indian Minimum Seed Certification Standards (IMSCS) also need to be revisited particularly in case of vegetables, flowers and medicinal plants based on scientific data from multilocations. Seed testing protocols must be upgraded based on international protocols. Use of biochemical and molecular markers be made for establishing the distinctiveness of varieties, particularly the essentially derived varieties (EDVs), and lab based tests to supplement the Grow Out Test (GOT) for genetic purity.

20. User-friendly molecular detection kits for fast and accurate identification of varieties, hybrids, pathogens and GMOs should be in place. Research on seed certification, traceability, isolation distance from non-GM crops and cost effective kits for detection of transgenes by using micro-array chips and proteomic approaches has to be carried out. Fiscal incentives like tax exemptions, advancing credit on soft terms, duty free import of equipments and infrastructure development through PPP may be ensured.

III. Accelerating Seed Export

21. There is an urgent need for conducting 'scoping study' which would provide useful guidance to both public and private sectors to identify most potential export destinations. This in turn, will help in identifying crops and country specific SPS requirements thus enabling an ease in seed exports.
22. Good quality seeds/planting materials matching international standards need to be developed. National seed companies need to be recognized by granting National Seed License which simultaneously eliminates present need for obtaining licenses from each State. However, the manufacturing license for processing and packing of seeds from respective State Government could continue.
23. The ICAR and its institutes or GoI are presently not responsible for testing seed samples of private companies meant exclusively for export except a few internationally/nationally accredited laboratories to cater to this requirement. There is an urgent need for competent persons for crop inspection, especially for the export related seed production in defined zones.
24. The well-defined seed testing protocols would help in promoting a forward looking, long-term seed export policy. An enabling policy environment needs to be created through a single-window system of clearance of export related proposals.
25. Seed export to various countries needs to be promoted, especially in South Asia and Africa. The current contribution of India (1%) to the global seed market could easily be enhanced to 5 per cent in the next one decade provided a long-term export policy is put in place. For ease of doing business, the varieties meant exclusively for export and not to be grown for commercial purpose within India could be exempted from the registration process. India needs dry port with all modern warehouses, good seed testing laboratories and efficient processing and packaging facilities including robust guidelines for export.
26. There is need to ensure: i) variety registration process in a time bound and scientific manner, ii) efficient seed certification system through accredited laboratories, iii) promoting use of seed of improved varieties while increasing the seed replacement rate (SRR), iv) building effective public-private partnerships, and iv) regulating smooth quality seed movement both within and outside India. For accelerating the seed and other agricultural exports, the position of Agricultural Counselor needs to be created in selected Indian Embassies abroad.

39. Motivating and Attracting Youth in Agriculture (MAYA) in North India

(Regional Workshop: 28-29 February, 2020)

Background

India has the world's largest youth population with 356 million people in the age group of 10-24 years old (UN report, 2014). Out of this, almost 200 million young people live in the rural India. These population parameters indicate an availability of demographic dividend in India. The potential economic gains can be realised through a "demographic dividend", which can occur when a county's working age population is larger than the population that is dependent. Young people are the innovators, creators, builders and leaders of the future. But they can transform the future only if they have skills, health, decision-making, and real

Dignitaries lighting the lamp during Regional workshop

choices in life. In order to maximise the dividend, it must be ensured that our youth is equipped to seize opportunities for jobs and other income-earning possibilities. Though this projects a bright future, yet relatively few young people (around 5%) prefer to remain in agriculture. The major reasons attributed to this are: decreasing income, greater risk due to adverse climatic factors, poor rural infrastructure and lack of enabling policy environment. Obviously, youth do not find agriculture a creative, profitable and esteemed/ white collared profession, besides relatively poor living conditions. At the same time, present day agriculture is faced with numerous challenges such as over-exploitation of natural resources (land, water and agro-biodiversity), a continued decline in factor productivity, expensive inputs versus low returns, and production uncertainties due to adverse effects of climate variability. The ageing agricultural practices coupled with the decreasing interest of the youth in

Dr. R.S. Paroda speaking about need of youth involvement in agriculture

Participants attending the Regional Workshop

agriculture having multi-faceted challenges are the serious threats for sustainability of Indian agriculture. In order to be economically attractive and sustainable Indian farming needs to become resilient, diversified, and intellectually satisfying too. Agricultural transformation needs to revolve around rewarding jobs/ entrepreneurship in agro-based value chain activities, better social amenities in rural areas, increased public and private sector investments in agriculture and rural infrastructure, establishment of small agro-based firms with better linkage mechanisms with markets, etc. The basic educational and training standards need to be improved for reorienting agricultural education towards agro-based food and value chain systems, inculcating efficiency in financial, social and environmental terms, reorienting social security programs with increased labour market flexibility and ensuring egalitarian distribution of income.

Agricultural extension system also needs to transform into an innovative platform that delivers technology based demand driven knowledge and services in order to empower and motivate rural youth. Empowering youth through vocational training and building a cadre of 'Agricultural Technology Agents' to provide technical backstopping as well as custom hiring services to the small holder farmers would go a long way in linking research with extension and thereby accelerating agricultural growth. It is the high time now Agricultural Technology Agents to become job creators instead to job seekers. To meet the twin challenges of sustainable agriculture development and to motivate and attract youth in agriculture, a "Regional Workshop on Motivating and Attracting Youth in Agriculture (MAYA) in North India" was organized jointly by the Punjab Agricultural University (PAU) Ludhiana, the Trust for Advancement of Agricultural Sciences (TAAS), New Delhi and the ICAR-Agricultural Technology Application Research Institute (ICAR-ATARI) at PAU Ludhiana on February 28-29, 2020. This workshop provided an opportunity to all the stakeholders to interact and discuss various options and avenues for not only attracting youth to agriculture but even motivating them towards entrepreneurship options in agriculture and allied sectors. The senior research, development and policy related officials/ managers from National Organizations, State Agricultural Universities, Education and Training Institutions, Civil Society Organizations including Non-Governmental

Scientists, farmers & other stakeholders attending Regional Workshop on MAYA at PAU Ludhiana

Organizations and Farmers Organizations participated in this workshop. The private sector was specifically invited to discuss various ways to motivate, attract and retain youth in agriculture. Also, an exhibition showcases the entrepreneurial ventures 'Attracting and Retaining Youth in Agriculture (ARYA)' with the theme -value added products and earnings through it' wherein Punjab, Himachal Pradesh, Uttarakhand, Jammu, and Kashmir participated.

It was pointed out that youth want to work with dignity and honour; therefore, a new dimension may be given to agricultural profession. It was also stressed the need of institutional support to the newly trained entrepreneurs in terms of finance, technical knowhow and guidance in the form of professional hand holding. The role of mentorship in making successful entrepreneurs was also duly emphasized. Further, it was stated that youth is the future and maximum number of youth resides in India. With several options available in agriculture, there is a need to re-motivate the youth. Young graduates can play a key role in educating the farmers regarding different aspects of agriculture where they can derive benefit from the opportunities available in agriculture. There is need to have strong connect among planners-scientists-farm youth to implement schemes and programs which can be helpful in generating employment in agriculture. Following recommendations emerged to attract youth in agriculture:

Recommendations

- Rural youth need vocational trainings in the potential areas like information communication technology (ICT), high value agriculture, processing, value addition, packaging, supply chain management, storage, etc. so that they can be motivated for entrepreneurship development. The well trained youth will be asset to the society and can become active technology agent which can accelerate the process of technology diffusion.
- Rural youth need to be empowered with knowledge and scaling-up their skills in priority areas like specialty agriculture, high-tech horticulture, protected cultivation, IPM/bio-control, dairying, fisheries, bee keeping, community nursery, seed production, linking farmers with markets etc. Well trained and competent youth will embrace agriculture if enabling policies for long-term investments, availability of easy and soft credit, provision of subsidy upfront to the entrepreneurs, farmer-farmer exchange visits, easy market accessibility, are at place.
- To promote farm mechanization, the custom hiring services for farm machinery is to be promoted on priority. 'Farm-machines at door step' can be a successful model by involving youth. Accordingly, youth must be supported with technology and credit facilities to develop custom hiring centres.
- Venture capital / funds need to be created in the SAU's to promote entrepreneurship among students. Soft loans may be given to students.
- Creation of agri-clinics needs to be prioritized at block levels. The agriculture/ veterinary graduates can run these clinics and accordingly youth may be supported by knowledge based empowerment and financial provisions for bankable projects.
- Farmer Cooperatives, SHGs, Clubs, and Farmers Producer Organizations (FPOs) can play a vital role in the dissemination of new technologies as a service window system and hence can attract youth in agriculture. Therefore, at initial stage, the financial and infrastructural support to these organizations will give boost in establishing service windows and provide employment to youth. Further, motivating young women in agriculture by empowering them with new knowledge and technology will help a great deal. SHGs, FPOs and other women organizations/ societies need to be encouraged and supported well to play an active role.
- Farms of the progressive and forward looking farmers, who have excelled in different enterprises should be recognized as "Centres of Excellence" to facilitate visit and training of youth for required confidence building so that they take risk while taking up their own enterprise in agriculture. For that, adequate fund need to be made available.
- Agricultural graduates should be given specialized training linked with distribution of licenses for the sale of inputs, machinery and tools, as is being done in case of pharmacy. It will help in proper technology transfer on one hand and use of quality inputs for productivity enhancement on the other end.
- Integrated farming System (IFS), and emphasis on peri-urban farming, protected cultivation, especially of export oriented crops, vegetables and flowers will encourage youth to build domains which can not only economical empowerment but also export oriented outlook.
- There is a need to revise the curriculum of agricultural graduates with emphasis on skill development and entrepreneurship from initial years rather than in the final year. It should include project management, environmental analysis, report writing etc.
- Institutional support should be provided to promote entrepreneurship. Mentorship should be provided by a teacher and in return teacher may be paid some honorarium.

40. Current Challenges and Way Forward for Pesticides Management- A Road Map

(Stakeholders Dialogue (Webinar) 24 July, 2020)

Background

The Trust for Advancement in Agricultural Sciences (TAAS), a neutral Think Tank for strengthening agricultural research and innovation for development

Participants attending the Stakeholders' Dialogue (virtual mode)

(ARI4D), in collaboration with the Society of Pesticide Science (SPS) India, the Indian Phytopathological Society (IPS), and the Entomological Society of India (ESI) organized a "Stakeholders Dialogue on Current Challenges and Way Forward for Pesticides Management" through webinar on 24 July, 2020. It was attended by about 80 participants including eminent experts, senior research managers, government officials representing diverse stakeholder groups, viz., central and state governments, scientific societies and institutions, pesticide industry and farmers. The main objectives of the Dialogue were: i) to discuss major constraints and explore solutions for phasing out banning of certain pesticides, ii) to seek views of stakeholders on proposed 'Pesticides Management Bill 2020' and suggest possible alternatives for accelerated growth of pesticides in India, and iii) to review and suggest reorientation of pesticides management, present regulatory system, existing policies and enabling environment for growth of pesticide industry to promote botanicals and agro-chemical R&D in the country.

Major Issues Discussed

In-depth discussions were held around regulatory mechanisms for pesticides management including time line for processing registration application, re-registration, 'Me-Too' registration, excessive jurisprudence, regulatory data protection, pricing, and bulk ban of 27 pesticides including tricyclazole, buprofezin and glyphosate. Discussions were also held on rationality of alternatives, ecotoxicity, reasonable data requirements on bioefficacy and toxicity, and mandatory application of glyphosate by PCO.

Various issues relating to crop losses, pesticide registration system, Current Challenges and Way Forward for Pesticides Management sale of spurious pesticides, banning of pesticides, and an enabling environment for faster growth of pesticide industry were discussed. The discussion on issues of R&D and innovation centered around: i) development of new molecules-their search, synthesis, isolation, identification, bio-activity, product optimization (SAR, now software available), and physicochemical, preliminary safety information; ii) formulation for recipe development, product optimization (physico-chemical parameters, bio efficacy, phytocompatibility, toxicology, etc. and iii) safety aspects- mammalian, avian, environmental, non-target organisms safety / toxicology /compatibility, and transformations, metabolism, detoxification, etc.

The Road Map

During the dialogue, in-depth discussions were held on various aspects of pesticides management and a need was felt for developing a clear Road Map for disruptive innovation in the field of chemical pesticides and botanicals through greater investment in R&D, both by public and private sector, and through creation of centres of excellence to achieve desired goals. The outcome of the dialogue is the development of a clear Road Map with the following three-pronged recommendations:

I. Reorienting the Regulatory Mechanism

In-depth discussions were held around regulatory mechanisms for pesticides management including time line for processing registration application, re-registration, 'me-too' registration, excessive jurisprudence, regulatory data protection, pricing, draft notification on proposed bulk ban of 27 pesticides including tricyclazole, buprofezin and glyphosate. The bulk ban will affect 134 formulations registered for use on 74 field and horticultural crops, household insects and vectors, and locust management affecting agricultural production. Discussions were also held on rationality of alternatives, ecotoxicity, reasonable

data requirements on bioefficacy and toxicity, and mandatory application of glyphosate by Pest Control Operators (PCOs). The following major recommendations emerged:

1. In the ambit of world trade order and domestic food and nutrition security, there is an urgent need to have a 'National Policy on Agrochemicals' with emphasis on use of safe pesticides. The National Policy should aim for gradual reduction of pesticides while taking into account the technological options like GM technology which redefines the relationship between seeds and pesticides. Hence, Government is urged to give high priority to constitute an expert group, involving different stakeholders, and seek the assistance of Think Tanks like TAAS and NAAS to put in place a forward looking policy draft for consideration and approval of the Government.
2. Farmers need improved seed treatment practices which can help in increasing their crop yields. The Central Insecticides Board and Registration Committee (CIB&RC) should allow usage of custom seed treatment blends developed by seed companies to effectively manage local pests and diseases as allowed in some advanced countries for which necessary regulatory provisions need to be made. In this context, a national program in Mission Mode needs to be launched for safe and efficient on-farm seed treatment through 'Mobile Seed Treatment Operators' (mostly youth) in the villages especially at the time of seeding/planting. The rural youth could thus be trained as operators by the *Krishi Vigyan Kendras* (KVKs). For this, the funds available under corporate social responsibility (CSR) of private sector could be availed through commitment of pesticide industry.
3. There is need for fast track transparent time-bound on-line registration system. It will be desirable to ensure participation of industry representative in the CIB&RC. The availability of novel green and safer pesticides would help both the environment and the farmers and would also support 'Make in India' program. Also, re-registration of pesticides (a mandatory practice after 10 years of registration) be done to make sure that genuine producers continue producing good quality and safe pesticides. National expertise through outsourcing needs to be utilized for fast-track evaluation of registration applications.
4. The current registration system needs to be revamped based on the recommendations of a duly constituted independent Expert Committee. Registration should be granted on the criteria of safety risk assessment and efficacy. The duration of registration process be made time bound, not to exceed one year for the new molecules and six months for "me too" registration, provided all required data are submitted along with the application. For confidence building, the data generation for new molecules should preferably be through notified/accredited laboratories.
5. The sale and use of spurious pesticides is indeed a real problem which needs to be addressed on priority. Granting 'me too' registrations liberally without verifying the credentials of applicants could encourage malpractices, which need to be curbed through effective post monitoring inspections and requirement for submission of periodic data on production and sale of such approved pesticides. Production of low quality or spurious pesticides just by a few brings bad name to the industry. It also harms the farmers' income, health and their safety, including the environmental health. Hence, it must be curbed at all cost and the defaulters be quickly penalized under the law.
6. For testing quality, there is need to create a chain of 'GLP compliant accredited pesticide testing laboratories' in each state where registrants can get the pesticide(s) tested and certified.
7. The in-country data for new molecules be generated preferably through notified GLP/NABL accredited laboratories only. A provision for data protection needs to be made for new molecules/formulations, introduced/developed in the country for the first time for a minimum of 5 years from the date of its registration in India.
8. The heavy workload of CIB&RC, currently with limited staff, has adversely impacted registration timelines for import of new molecules intended for import. The existing process leads to inordinate delays in scrutiny of dossiers requiring a multi-layered approval process. There is urgent need for a quick and transparent on-line registration system which is fully digitized allowing fast tracking of scrutiny status of dossiers as per global best practices.
9. The recent Government decision to ban 27 pesticides must be revisited which affect 134 formulations registered for use on 74 field and horticultural crops, household insects and vectors, and locust management affecting agricultural production. There appears no scientific basis/ rationale for imposing ban and restricting these products from production without a thorough and scientific review. Decisions taken in other countries should not be an important basis for proposing such ban. On the contrary, performance of a pesticide under different edaphoclimatic conditions should be taken into account to adjudge the pattern of their behavior, residues, degradation pattern, persistence, etc. Moreover, the voice of farmers, scientists, industry and other stakeholders should be heard before taking any such decision. As per Dr Anupam Varma Committee recommendation, the 27 pesticides notified for ban were the candidates that were supposed to "continue subject to review" based on data to be submitted over a period of time by the industry which apparently seems to have not been duly followed. Therefore, to ensure transparency, it will be desirable to review the

data on priority, as generated by the concerned industry/licensee, through a technical committee and the CIB&RC before taking any final decision in the matter.

10. There is a serious concern about the proposed ban of Carbendazim, Mancozeb, Thiram and Deltamethrin which are inexpensive and most widely used. This would lead to a collapse of the seed treatment process. Besides, the available alternatives are too costly. Thus, the cost of seed treatment shall go up and will adversely affect the farmers.

11. As stated earlier, the Government Order (GO) for ban on pesticides minimizes the choice for the farmers and puts them obviously under disadvantage. Therefore, the Government must take a science based decision, in consultation with, scientists, farmers, industry and other important stakeholders. For example, a recent ban on glyphosate being imposed in different states, a most studied and safe herbicide approved and used in 160 countries including India by paddy farmers and others including the tea growers for efficient weed control, will put farmers and the industry in dilemma, especially when no effective substitute is available and weed management is critical for assured crop production and higher productivity. Further, the mandatory application of glyphosate in the presence of PCOs as per the recent notification by GoI is not feasible since PCOs are not available in most of the villages. Moreover, any such requirement is expected to encourage malpractices thereby impacting farmers adversely.

12. It is important that we come out with a generic policy on the chemicals that has lasting impact and promotes the growth of agriculture in the country. A stable policy environment and supportive and progressive regulatory system will nurture innovations, offer sustainable solutions to the farmers and will lead to realize "Discover in India and Make in India" objectives.

13. For any pragmatic and agriculture centric Pesticides Management Bill 2020, which is now placed in the Parliament for approval, there is an urgent need to consider the 46th Parliamentary Standing Committee Report that had deliberated extensively the earlier PMB-2008 (PMB 2020). In this context, the pragmatic science based recommendations made recently by the National Academy of Agricultural Sciences (NAAS) be the basis for discussing the Bill which include: encouraging indigenous R&D for newer technologies and molecules, removing bottlenecks in the registration process, data protection, establishing accredited laboratories for quality and phytotoxicity analysis, needed trained manpower, curbing spurious pesticides, provision of punishments for malpractices, worker's safety, biopesticide quality, crop groupings and their importance in the context of pesticide choice for use, resistance management, etc.

14. To foster innovation and modernization, there is an urgent need to adopt and implement advanced technologies for better, efficient and eco-friendly environment.

II. Enabling Environment for Growth of Pesticide Industry

Efficient and judicious use of agrochemicals and crop protection solutions within the confines of a regulatory framework is important for sustainable agriculture. In India, the agrochemical industry has great potential for further growth in view of current low level of pesticide consumption compared to other agriculturally important countries. Accordingly, various issues relating to crop losses, pesticide registration system, sale of spurious pesticides, weeding out "fly-by-night" operators, banning of pesticides, an enabling environment for faster growth of pesticide industry were discussed at length leading to the following recommendations:

15. In order to realize the goal of 'Make in India' initiative, indigenous manufacturing of pesticides, agrochemicals and their raw materials has to be enhanced a great deal for which special manufacturing zones need to be created with common, shared waste treatment facilities and all other support systems. This would not only make India self-sufficient but would help in reducing current imports of active ingredients as well as raw materials/ intermediates, mainly from China. For '*Atmanirbhar Bharat'*, enabling policies around efficient regulatory system, simplified guidelines, incentive through intellectual property (IP) protection and promotion of exports need to be put in place urgently. Also, there is need to create cluster areas for the agrochemical industry.

16. A 'National Council on Agricultural Development (NCAD)' on lines similar to that of GST as recommended by Dr R.S. Paroda Committee, needs to be established urgently under the chairmanship of Prime Minister ensuring effective coordination and monitoring.

17. Urgent action is required to decriminalize the agro-input manufacturing sector without compromising the purity, biosafety, and quality of pesticides, since it can be counter-productive resulting in a negative investment climate.

18. Comparing global scenario, India has registered very few products (around 270) denying wider/ better choice of options to farmers for insect-pest management. Protection of regulatory data (PRD) encourages innovators to discover, protect, register and produce new solutions. In addition to manufacturing and R&D capabilities, this ensures India's position as an investor's hub. PRD will accelerate introduction of safer crop protection product, data generation for MRL setting, ensure proper product use from discloser to prevent unfair use and setting up R&D facilities.

19. India lacks in the skill and practice of assessing unregistered pesticides in imported commodities. Hence, as per international norms, GoI needs to

build its capability for the detection of pesticide residues in imported commodities and reject them based on presence of pesticide residues otherwise not registered in India. This shall protect India from non-tariff trade barriers otherwise imposed by many countries.

20. There is an urgency to alleviate trust, transparency and honesty deficits all along the value chain to create a level playing field and to establish effective collaboration between public and private sectors.

21. There is need for a clear policy direction and support to move forward to register and release biopesticides such as neem, Bt, *Trichoderma*, etc. Today, though the development of neem based pesticides in India is satisfactory, the overall progress on biopesticide front is not encouraging due to lack of required industry support and enabling policy environment.

III. Strengthening Pesticide Research and Innovation for Development

The discussion on issues of R&D and innovation centered around: i) development of new molecules-their search, synthesis, isolation, identification, bioactivity, product optimization using synthetic aperture radar (SAR) software, and physico-chemical, preliminary safety information; ii) formulation for recipe development, product optimization (physico-chemical parameters, bioefficacy, phyto-compatibility, toxicology, etc. and iii) safety aspects-mammalian, avian, environmental, non-target organisms safety/toxicology /compatibility, and transformations, metabolism, detoxification, etc. The important recommendations emerged were:

22. There is an urgent need for intensifying research on design and discovery of new green molecules as a national priority in the spirit of '*Atmanirbhar Bharat*' and 'Make-in-India' initiatives and investment in R&D of new molecules needs to be enhanced substantially. India must become a R&D and manufacturing hub for crop protection chemicals and try to become self-reliant.

23. A 'Centre of Excellence' on Agrochemicals with multifaceted wide spectrum and modern bioscreening facilities needs to be established urgently at ICAR-IARI, New Delhi, to be gradually elevated to a National Research Centre (NRC) on Agrochemicals, to lay high priority on developing new molecules and undertake related multifarious R&D activities using best techniques and the latest facilities.

24. Greater thrust needs to be given to develop low-cost technologies for mass production and bulk availability of biocontrol agents and biopesticides. Careful choice of potential candidates to be used as botanicals/microbials for investigation is essentially required.

25. There is a need to evaluate critically economics, performance, safety of the newer formulations, increased use of slow/CR products and to develop pesticide residue test kits to detect spurious pesticides.

26. To ensure safety measures, there is need for data generation under varying agroclimatic conditions, newer methodologies for validation in multiple GLP/ accredited laboratories, conducting transformation and toxicity trails of products, and increased efforts on MIP for more precision, etc.

41. Strategies for Safe and Sustainable Weed Management: A Way Forward

(Stakeholders Dialogue (Webinar): 9 December, 2020)

Preamble

Agriculture is a major source of livelihood for nearly half of the Indian population. The country, despite significant increase in agricultural production, would need to produce more than 400 mt of foodgrains to meet the demand of expected 1.65 billion people by 2050. Among various biotic factors limiting crop productivity, the crop losses due to weeds are quite significant. The crops compete with a large number of species of weeds for space, water, nutrients, and sunlight. Thus, weeds considerably reduce input efficiency and negatively impact farmers' harvest ranging between 10 to 30 per cent, if not managed timely. The ICAR-Directorate of Weed Research (ICAR-DWR), Jabalpur has estimated that the total losses caused by weeds amount to almost $11 billion per annum in just ten major crops in India. The highest loss is caused by weeds (33%), followed by pathogens (26%), insects (20%), storage pests (7%), rodents (6%), and others (8%). Efficient weed management is, therefore, vital both for increasing productivity and farmers' income.

In India, the weeds are primarily managed through manual and mechanical methods which are quite expensive accounting for 20-25 per cent of the total cost of cultivation. With labor becoming scarce and expensive, farmers are finding herbicides as a better alternative. Herbicides constitute more than half of the total pesticides used globally, whereas in India, the share of herbicides is only around 18.0 per cent of the total pesticides, which is quite low compared to insecticides (40%) and fungicides (33.4%) consumption. On the contrary, the trend is quite reverse globally. Further, it is interesting to note that use of herbicides is increasing in the last one decade in India at a much faster pace (15-20% annually).

Existing Constraints and Challenges

The weeds are a major constraint for agricultural production in India. The most prevalent weeds are: *Phalaris, Echinochloa*, weedy rice, *Cyperus, Cynodon, Parthenium* in crops; *Parthenium, Lantana, Mikania, Mimosa, Ageratum, Chromolaena, Saccharum and* para grass in non-crop areas; water hyacinth, *Salvinia,*

Participants attending Stakeholders' Dialogue on Weed Management

Hydrilla, and *Pistia* in water bodies; and parasitic weeds like *Orobanche, Striga, Cuscuta, Loranthus,* etc. To manage them effectively, the real challenges are: i) inadequate knowledge and awareness among farmers about herbicides, ii) non-availability of farm labor iii) lack of efficient machinery/mechanical tools, iv) building of herbicide resistance in some weeds, v) poor adoption of integrated weed management practices mainly due to non-availability of effective biocontrol agents/organisms etc. Concerning biological weed control, there is lack of availability and awareness about efficient bioherbicides. Further, though there had been examples of allelopathic effects of a few crops/weed species and some insects/microorganisms which could be used for weed control but then they have not been exploited so far for effective control.

It is quite evident that for effective control of weeds, use of efficient and safe herbicides is imperative. Somehow, both research and development efforts on herbicides in India have lagged behind and thus need to be accelerated. Further, timely availability of quality and cost effective herbicides, besides to some extent the spread of spurious and adulterated herbicides is also an important concern, which must be addressed effectively under the prevailing regulatory mechanisms as per Insecticides Act.

Issues and Options

I. Herbicide Regulations and Management

It is evident that herbicides provide cost-effective weed control. Through their wide window of application, effectiveness on diverse weed flora and timely control of weeds, herbicides reduce labor requirement, increase input-use efficiency and enhance crop yield quite substantially. Moreover, the cost of herbicide application is approximately one-third of the cost of two hand weeding operations. In India, 60 herbicides of different modes of action have so far been registered. Besides, over 700 formulations of herbicides are available in the market. Up to 2016, over 2,000 herbicides belonging to 15 different modes of action were introduced in the global market. In India, over 6,000 tons of herbicides are currently used for weed control, mainly in irrigated crops (about 77% in wheat and rice) and plantation crops (about 10%). Continuous use of herbicides leads to weed flora shifts and development of resistance in weeds. Development of resistance to herbicide isoproturon in *Phalaris minor* in north-west India in the early 1990s had threatened our food security. Somehow, priority registration then of alternate herbicides did restore the situation *albeit* temporarily. The widespread occurrence of *P. minor* populations exhibiting cross and multiple resistance to a host of recommended herbicides is currently an important problem to be dealt with. Moreover, for lack of policy and funding support, the new molecules with effective mechanisms of action may not be available in the near future.

Herbicide rotation and use of herbicide mixtures are good strategies to prevent/delay the onset of herbicide resistance in weeds. Application of herbicide along with seed and fertilizer under optimum moisture conditions gives the best results. Mixing compatible herbicides does improve control of specific weed populations, such as 2, 4-D applied with dicamba for broadleaf weeds. Also, tank-mixing of herbicides improves the spectrum of weeds controlled in a single application which saves time and labor. Herbicide combinations also ensure effective control of several weed types at the same

time, such as grassy and broadleaf weeds. Herbicides applied alone or in combinations have been regarded as essential options for effective management of weeds in different-ecosystems.

The Central Insecticide Board and Registration Committee (CIB&RC) has given approval for the use of a combination of herbicides having three active ingredients. This is useful in controlling diverse weed flora with a single application, thus saving both cost and time. Presently, 14 combination products of two active ingredients are available for broad-spectrum weed control in major crops like rice, wheat and soybean. However, there is an urgent need to develop and/or introduce new herbicides with higher efficiency and environmental safety. Selective herbicides such as clodinafop, quizalofop, halosulfuron, dicamba, sulfentrazone or 2-4-D are post-emergent herbicides used to target the type of plants to be eliminated, whereas glyphosate, a non-selective systemic and post-emergent herbicide, is widely used to kill perennial weeds. Also, genetic variation for tolerance to herbicides exists in maize, wheat, rice, sunflower, soybean, chickpea, alfalfa, etc. which needs to be exploited to develop herbicide-tolerant cultivars.

The recent notification to ban use of herbicides such as butachlor, 2, 4-D, pendimethalin, glyphosate, etc. has caused major blow to both the farming community and herbicide industry. Glyphosate is a popular herbicide with the farmers and is currently the largest selling product in the country with 30 per cent share. It is used in many wide-spaced crops such as cotton, sugarcane, fruit/plantation crops, etc. In the absence of effective alternative herbicides, such premature ban would create a major setback for our weed management strategy and adversely affect the farmers' income. The industry and the experts strongly feel that banning these herbicides is arbitrary and unscientific and needs to be reconsidered on scientific grounds. The record use of pendimethalin (one of the herbicides listed for banning) in Punjab and Haryana in 2020 saved the crops, thus is a case which needs to be given due attention. The states adopted in a big way the system of direct seeded rice to overcome labor scarcity that happened due to COVID-19 pandemic. Besides, water saving options like growing of direct seeded rice, use of low water requiring crops such as maize, soybean etc., would certainly require enhanced use of herbicides.

Pre-emergent herbicide application is of major concern especially in drylands. There is an obvious need to promote safe use of herbicides by following the principle of '5-R' herbicide stewardship (right kind, right dose based on soil type, right time, right method of application and right place with appropriate nozzle solving many herbicide related problems and resulting in excellent weed control), and creating awareness among the stakeholders who often resort to faulty/ indiscriminate use. The quality of herbicides is also a major concern. There is an urgency for effective regulatory control to test the quality of herbicides, and the sale and marketing of quality products to end-users. Also, there is no significant headway for efficient mechanical weed control. Hence, there is a need for developing efficient power-driven mechanical devices along with other methods as part of an integrated weed management (IWM) strategy.

ICAR- Central Research Institute for Dryland Agriculture (ICAR-CRIDA) has developed a precision planter and raised-bed planter where sowing, fertilizer and herbicide application can be done simultaneously. Such a device is especially suitable for conservation agriculture (CA) ensuring reduction in energy use. Weeds in non-cropped areas particularly in topographies of greater slopes and far from social communities need to be assessed for their carbon sequestration potential and arrest of land degradation. Further, weed control is invariably more expensive in community areas and water lakes.

In India, over 14 crore farmers live in 6.5 lakh villages making it impossible for any individual or organization to reach them. Hence, partnership with the private sector considering available strength and experience is extremely important. Around 6,000 companies have been issued registration, and even for one molecule, there are more than 500 to 1,000 registrations. Also, there is lack of IP protection, as data protection is lacking for 'me-too' registrants, the product is not properly used and thus resistance has been developed against many insect-pests. Also, new molecules are not being introduced mainly for want of data protection facility and enabling policies to promote growth of private sector. Apprehensions and misgivings about herbicide-tolerant crops, negative impacts on biodiversity, gene transfer between wild relatives (particularly in the centres of crop origin), development of super weeds, and health related issues demand effective public awareness campaign at the national level.

Genetically modified crops resistant to non-selective herbicides such as glyphosate have opened up an innovative approach for management of weeds. Introduced in 1996, GM crops are currently (as of 2019) being grown on over 190 mha area globally with 88 per cent area with herbicide tolerant (HT) crops. Glyphosate tolerant (Roundup-Ready) soybean, corn and cotton occupy 82, 30 and 68 per cent of the total cropped area, respectively. In India, the HT tolerant crops like maize and soybean, despite successful field trials, are awaiting the GoI approval for commercial use. Hence, due to lack of policy on the use of GM crops, there is already an illegal cultivation of HT Bt cotton in Maharashtra, Telangana, Andhra Pradesh and Gujarat.

II. Research and Development

Research is mostly centered on enhancing herbicide efficacy. Integrated weed management (IWM) which includes preventative, mechanical, cultural, chemical and biological methods, is advocated for effective use in crop production systems. Research on herbicides as a tool in weed management has been carried out over the past 4-5 decades and country-wide herbicide

recommendations are available for all crops and cropping systems. Knowing the limitations of over-reliance on herbicide use, there has been a concerted effort to include herbicides as a component in the overall IWM strategy. Attempts have been made to integrate herbicide use with tillage, competitive crop cultivars, inter/cover cropping, mulching, and mechanical and manual methods of weed control. Use of herbicides must be made economically and ecologically affordable to farmers by innovatively integrating with other components of IWM. There is a significant scope of growth in herbicide as a component of IWM. The expected concerns related to environmental and ecological impact of HT crops, including the development of super weeds, need thorough investigation.

Biological control is the most suitable option for management of weeds in non-crop areas, grasslands and forestry. Despite intensive efforts by the ICAR-DWR, Jabalpur for over three decades, the control of *Parthenium* with the use of Mexican beetle is far from satisfactory. In Australia, the weed is managed well by employing a large number of biocontrol agents including insects and fungi. The ICAR-National Bureau of Agricultural Insects Resources (NBAIR) and ICAR-DWR should focus on exploring such possibilities. Import and introduction of Smicronyx weevil will be useful for management of *Parthenium*. Introduction of new innovative molecules and sustaining the existing molecules and safe/judicious use are certainly important for sustained and greater use of herbicides.

In view of negative public opinion about GMOs, it would be wise to shift focus on developing HT crops using non-GM approaches such as gene editing (CRISPR/Cas9) technology. The Indian Agricultural Research Institute (IARI), New Delhi has been successful in developing rice cultivars resistant to imidazoline using the non-GM approach. Called as 'clearfield rice technology', this enables control of weedy and wild rice-problematic weeds in some ecosystems using imidazoline herbicides. There is, however, a risk of development of weedy/wild rice resistant to imidazoline herbicides with their repeated use. In this context, the public sector research also needs to be strengthened. It will be good if certified formulations of herbicides are also developed and made available to farmers in India. On the contrary, USA has developed and commercialized several microbials and efforts may be made to import these microbials for use in India.

Development of machineries/tools suitable to small farms is to be given high priority. The advanced technologies such as ICTs, artificial intelligence (AI), machine learning, sensors, and image processing have been found to have immense potential in weed management. Machines capable of identifying weeds in the crop field and removing them selectively either pulling them physically, or through laser beams, or spraying with herbicides need to be developed. The prototypes of self-driven robotic weeders are also being tested in many countries. The 'sense and spray' technology, which is commercially available in some countries needs to be adopted as it reduces herbicide requirement by 75 per cent thus saving money and reducing the herbicide load in the environment substantially. The rise of digital farming and dense geospatial data will enable prediction tools for the occurrence and spread of different weeds and herbicide resistance within fields and across landscapes. Weed omics will further contribute to better define these prediction tools.

The Dialogue

In view of above, the Trust for Advancement of Agricultural Sciences (TAAS), a neutral Think Tank, the Natural Resource Division of Indian Council of Agricultural Research (NRM-ICAR), ICAR-Directorate of Weed Research (ICAR-DWR), Jabalpur and the Indian Society of Weed Science (ISWS), Jabalpur jointly organized a virtual "Stakeholders Dialogue on Strategies for Safe and Sustainable Weed Management: A Way Forward" on 9 December, 2020. The major objectives of the Dialogue were to: i) discuss possible ways to avoid losses due to weeds and their efficient management, ii) suggest strategy for safe and sustainable use of herbicides and weed management; and iii) discuss policies on herbicide use and regulatory systems, including proposed ban of certain herbicides. A total of 61 participants/stakeholders (and 63 observers across the country) on one platform from the Central and State Governments, ICAR, State Agricultural Universities (SAUs), CGIAR Centers, scientific institutions, and private sector dealing with herbicides deliberated holistically science-based farmer-centric strategy on 'Issues to Actions' on weed management towards a sustainable food, nutrition and environmental security.

During the dialogue, in-depth discussions were held on constraints and challenges, herbicides regulations and management for sustaining farm productivity, banning of herbicides, research and innovation for development of herbicides, developing herbicide resistant crop varieties including transgenics by incorporating resistant genes from various sources, enhanced use of bioherbicides, enabling policies and understanding the industry's perspective. It was strongly felt that there is an urgent need to develop a clear **'Road Map'** for disruptive innovation in the field of chemical herbicides through greater investment in R&D, both by public and private sector.

The Road Map

A holistic approach with multi-disciplinary, multi-locational and multi-institutional involvement would be imperative to effectively tackle future weed problems. Decades of efficient chemical weed control have led to a rise in the number of herbicide-resistant weed populations, with a few new herbicides with unique modes of action to counter this trend and often no economical alternatives to herbicides in crops with large acreage. If these challenges are addressed appropriately and the new emerging trends in technology and innovation are well adopted, sustainable weed management will be ensured in future. The emergence of natural products leads to

discovery of new herbicides and biopesticides suggesting that new modes of action can be discovered, while genetic engineering provides additional options for manipulating herbicide selectivity and creating entirely novel approaches to weed management. Selective and non- selective use of herbicide is extremely important. Only red triangle herbicides are to be banned and certainly not those in other color triangles. A Road Map based on discussions related to IWM practices, managing weeds through judicious use of herbicides, developing bio-control measures, using biotechnological tools for managing weeds, monitoring alien invasive weeds, and developing techniques for managing weeds in conservation agriculture (CA), was suggested for safe and sustainable use of herbicides in agriculture, along with science-based herbicide related policies and regulatory systems, and a mechanism to gradually phase out certain herbicides. The salient recommendations that emerged as a result of in-depth discussion are given below:

Recommendations

I. Herbicide Regulations and Enabling Policies

1. There is an urgency to expedite the present registration process of herbicides, especially to ensure the availability of new and safe molecules much faster. Also, use of herbicides needs to be promoted as post-emergence application for controlling broad-leaved weeds in pulses (chickpea and lentil) and oilseeds (rapeseed-mustard) and also for controlling grassy weeds in standing crops of pearl millet, sorghum and other small millets. Similarly, the re-registration of herbicides (after 10 years of registration) be based on critical review and with reference to human/environmental health.
2. Product efficacy work done by various ICAR institutes should be considered for grant of label expansion, subject to the establishment of maximum residue limit (MRL) data wherever applicable. For this purpose, there is need to establish an expert committee involving representatives of DoAC, ICAR, CIB&RC and the private sector organizations working on herbicides to collate all available research findings and to develop recommendations for approval of new herbicides. Also, there is an urgent need for harmonization of MRL standards for individual herbicides across the globe.
3. An urgency is evident to have a transparent National Policy on GM Crops, based mainly on scientific considerations. GM herbicide tolerant crops used widely for weed management in several countries could also be promoted in India. In this context, release of both HT maize and HT soybean appears to be fully justified. In fact, India seemed to have lost almost a decade as well as an opportunity to harness higher productivity. Therefore, it will be in the national interest if the GoI takes an early decision to allow use of herbicide tolerant GM crops to increase both productivity as well as farmers' profitability. Also, herbicides need to be included in the "National Agrochemical Policy", as already recommended in the Proceedings of Pesticide Management Dialogue organized by the TAAS in July 2020. Further, it will be desirable to have a 'Status Paper' on future potential of herbicides in India, encompassing the entire gamut of weed management, such as availability of different herbicides, the level of their toxicity and future possibilities of research for innovation, development and extension.
4. An early decision by the GoI to put in place a mechanism for sale of quality herbicides exclusively by the trained professionals, setting of accredited laboratories in different eco-regions for testing herbicide efficacy, their bioefficacy including residue retention, and the quality testing to safeguard against supply of spurious/expiry date herbicides would help much faster growth of herbicides in India. Also, safeguard mechanisms to protect the farmers against adverse effects of herbicides handling would be desirable, including capacity building and public awareness.
5. Creation of an enabling environment for the private sector participation to accelerate growth of herbicide use will be in larger national interest and in line with the GoI initiative of '*Atmanirbhar Bharat*'. In this regard, data protection shall have to be ensured to facilitate introduction of new molecules. Also, proper guidelines need to be put in place for the introduction of microbials with proven safety record so as to promote environment friendly products required for enhancing organic agriculture. Special efforts are needed for establishing public-private partnership in a mission-mode in specific areas such as: i) herbicide application techniques, ii) safe handling of herbicides, iii) safe disposal of used herbicide containers, iv) combating herbicide poisoning, and v) establishment and use of first aid facilities. Public-private partnership could also help in promoting private extension for plant protection.
6. Non-chemical methods like robots for mechanical weed control, flaming and solar-energy based microwave generating devices are being experimented successfully in advanced countries. Use of such devices also needs to be promoted in India through custom-hire centers. Similarly, there is need to promote the use of power-driven mechanical devices in row-planted crops along with other methods as part of an integrated weed management strategy. Weed control through power-driven weeders including tractor-driven inter-row weeders in wide row spaced crops like maize, cotton, sugarcane, chickpea, mustard, soybean, etc. is required to be promoted, for which needed equipments could be subsidized.
7. There is an urgency to have a technical review of recent notification to ban seven herbicides, including the notification for restricted use of glyphosate. The sudden ban on herbicides without required technical justification and suitable alternatives may adversely

affect both the farmers and the Indian pesticides Industry. The recent directive on "Glyphosate use or any other product use by PCO" also needs to be reviewed on a scientific basis as well as practical feasibility for implementation.

8. There is need to generate data on adverse effects of herbicides under Indian conditions rather than relying on studies conducted in other countries. Also, a proper mechanism of consultative process involving key stakeholders to justify product utility and performance, before suggesting any herbicide ban or restrictions will be desirable to ensure transparency of the system involved.

9. Use of new technologies and innovation in weed management will have to be given priority attention. Appropriate policies and guidelines for the use for unmanned aerial vehicles (UAV) for pesticide spray need to be developed. For this, a separate approval mechanism for UAV based products would be highly desirable.

II. Herbicides for Improving Productivity – An Industry Perspective

10. As new molecules with new modes of action are likely to take time, it is imperative to retain already released herbicides and use them more judiciously and efficiently. In some countries, parasitic weeds have been controlled successfully through the use of herbicides. Such herbicides need to be imported for testing their efficacy and eventual use in India. Similarly, import, testing and fast track registration (even ad hoc) of bioherbicides should be our current priority for high level policy decision and implementation.

11. The effective weed management strategy in future should address: i) focus on season long weed management rather than critical period of weed management concept, ii) use of nano-encapsulated formulations for slow and steady release for season long weed control, iii) use of drones for herbicide spray for quick and more area coverage (5 minutes for one hectare spray), and iv) deactivating/ degrading the left over (residual) herbicides with the help of nanoparticles.

12. Greater attention is needed at the Government level to promote safe use of herbicides following the '5-R' principle of herbicide stewardship (right kind, right dose based on soil type, right time, right method of application and right place with appropriate nozzle solving many herbicide related problems and resulting in excellent weed control), and creating awareness among the stakeholders, especially the farmers to avoid both faulty and indiscriminate use. Efforts need to be made to reduce the herbicide load in the soil through integrated approach around conservation agriculture (CA), soil type, organic matter content, stage of weed growth, use of adjuvant and proper herbicide application technology. Awareness among farmers on weeds, safe herbicide use, and integration of other mechanical/cultural methods, including zero-till/no-till needs to be ensured.

13. Artificial intelligence is an emerging area that can certainly help in effective weed management. Weed populations need to be mapped through remote sensing mechanisms, viz., spectroradiometer, weed seeker, unmanned aircraft vehicles like drones, etc. enabling precise herbicide release on the targeted weeds. Hence, required expertise needs to be developed by training youth (both men and women) seeking the support of both public and private institutions.

14. To overcome the concern of harmful chemicals, the industry is already laying greater attention on developing biobased herbicides, which offer a clean solution for weed control, including the weeds that have developed herbicide resistance. Somehow, relatively low price of chemical herbicides is a deterrent for the growth of bioherbicides. Hence, concerted efforts are needed to develop cheaper bioherbicides. Also, policy consideration to subsidize these by the Government will help in accelerating the growth of bioherbicides in India.

15. The role of industry in production and promoting the use of herbicides in India through in-house production will be in line with Government policy of *'Atmanirbhar Bharat'*. Hence, a concerted effort by the private sector will greatly benefit the farmers and promote national agricultural growth faster. Also, the import of new molecules and use of combination herbicides will be highly beneficial. Further, greater thrust on use of safe herbicides will be much beneficial to the farmers. For this, adoption of herbicide rotation must be practiced to avoid herbicide resistance.

16. It will be desirable if the herbicides are sold by the trained youth having good scientific knowledge and requisite formal training. In this context, building skills of youth to provide custom-hire services for plant protection to the farmers is urgently needed. Obviously, pesticide industry could play an important role in using resources available under corporate social responsibility (CSR). Also, senior/ retired weed scientists/experts could be employed to train youth and act as mentors/advisors to promote safe use of herbicides in line with the adoption of IPM strategy at the national level. Thus "paid service providers" and "paid extension agents" will ensure proper pest/weed management at farm level. They may also be authorized to have an eye on market/sellers to avoid to a greater extent the practice of sale and use of poor quality or spurious herbicides.

III. R&D for Weed Management

17. There is also need for intensifying research on the discovery of new herbicides with new modes of action in public-private partnership (PPP) mode. Development of suitable technologies to tackle crop-weed competition due to increased atmospheric CO_2 concentration and subsequent global warming

is an emerging challenge to be addressed through intensification of research.

18. Greater thrust for IWM research in future needs to be given on: i) enhancement of herbicide efficacy, ii) assessment of on-farm losses caused by weed; iii) weed ecology, iv) interdisciplinary approach for R&D, v) on-farm assessment of available IWM options, and vi) need for knowledge-based decision-making tools. In view of the diversity of weed flora in different agro-ecosystems, appropriate technological support for weed management under organic farming, natural farming, hill farming and rainfed agriculture shall have to be provided.
19. There is an urgent need to intensify research on integrated weed management in rainfed cropping systems as well as in conservation agriculture (CA).
20. Breeding for herbicide tolerant and herbicide resistant transgenic crop varieties shall be intensified using resistant genes from various sources. Further, intensification of research to develop bioengineered plants for better nutrient mining, herbicide tolerance and weed suppression is highly justified, requiring additional funding support to ICAR to initiate an inter-institutional and inter-disciplinary network at the national level.
21. In-depth study is needed on design and development of energy-efficient weeding tools (for smallholders); sensor-based weeding tools and spraying equipments; small scale floating-cum-submerged weed harvester and dredgers. Also, there is need to develop nano-capsules/ nano-herbicides for slow release to ensure season long weed control, use of nano-biosensors for quick detection and quantification of herbicide residue in soil and crops, use of drones for herbicide application, socio-economic impact assessment, and the development of weed management portal for knowledge dissemination.
22. Biological control is an economical and practical option for the management of invasive weeds in forests, pastures and non-crop areas. There is an urgent need to promote research on biocontrol of major weeds and also introduce proven biocontrol agents from other countries. In Australia, *Parthenium* is being effectively managed by a consortium of 4-5 biocontrol agents. In fact, similar strategy can be tested and adopted in India. The ICAR-DWR in collaboration with ICAR-NBAIR could possibly introduce useful biocontrol agents from abroad and test them under varying agro-ecologies.
23. Continuous refinement of weed management technologies is essential to cut down crop production costs in the light of ever-changing socioeconomic conditions of the farmers and international trade policies. The rapid expansion of weedy rice infestation, evolution of herbicide resistant weeds, introduction of alien invasive weeds, lack of low-cost environment-friendly weed management technologies for water bodies and dryland farming systems are some of the burning issues requiring urgent attention.
24. Use of herbicides is rapidly increasing and hence the residue hazards and other environmental issues related to herbicides need to be suitably addressed. Since herbicide residue estimation through analytical method is tedious and time consuming, there is a need to develop sensors for *in situ* detection and quick quantification of herbicide residues.
25. Looking at the global trend and the national needs, greater emphasis on research and development (R&D) for better weed management is urgently needed. An IWM strategy around cultural, mechanical, biological and chemical methods would require much accelerated efforts at the national level. In this context, both ICAR and SAUs need to promote the use of safe herbicides, critical for increasing agricultural productivity while ensuring health and environmental security. Hence, a national 'Mission on Weed Management' is fully justified and thus be created under ICAR at the earliest possible.

5 Policy Briefs

Preamble

The TAAS has discussed and deliberated on six (6) important topics of thematic importance which culminated into policy briefs (Annexure VI). These discussions have been attended by subject matter specialists and other concerned stakeholders who deliberated on specific issues rather critically and came out with specific recommendations. Subsequently, all important recommendations have been sent to the concerned researchers, science managers and policy makers for required follow up/action. A brief account of these policy briefs is given below:

Policy Brief 1 : Efficient Nutrient Management for Improving Soil Health

(A National Dialogue: 28-29 September, 2015)

The 68th UN General Assembly declared 2015 as the International Year of Soils. The International Year of Soils aims to raise awareness among civil society and decision makers about the crucial role soil plays in food security, climate change adaptation and mitigation, essential ecosystem services, poverty alleviation and sustainable development. The major objectives include promoting investment in sustainable soil management activities to develop and maintain healthy soils for different land users and population groups; and support effective policies and actions for the sustainable management and protection of soil resources, at national, regional and global scale. Maintaining soil health while accommodating the increasing demand for food production is a continued and growing challenge for agricultural scientists, farmers, development agencies and policy planners in India and elsewhere.

A multi-pronged approach is required to address soil health issues in the realm of nutrient management in smallholder production systems. A scientific land use planning to help in location-specific cropping system optimization, balanced and adequate nutrient application to crops in an integrated manner, promotion of residue recycling, integration of legumes in cropping systems, and adequate policy support are some of the critical factors that may help us achieve sustainable food security in a healthy soil environment. The science, technology and policy aspects of maintaining a healthy soil would require the support of a robust extension mechanism for scaling and adoption of

Dr T. Mohapatra speaking during Inaugural Session

efficient nutrient management practices. The National Dialogue on "Efficient Nutrient Management for Improving Soil Health" intends to set the strategic pathways for ensuring a healthy soil environment through applications of farmer typology specific nutrient best management practices that can support future food demand and maintain our soil and environment resources for posterity of society with objectives, viz., trends in nutrient management practices and soil health in predominant production systems and ecologies; sharing experiences on recent advances in scalable tools, techniques and innovations for efficient nutrient management for improving soil health at landscape scale; creating evidence-based policy awareness for synergizing investments, institutions and innovations for scaling farmer typology specific nutrient management for soil health improvement; and developing "Roadmap" to implement efficient nutrient management and soil health improvement strategies.

Panel Discussion on Soil Health: Concerns and Opportunities

I. Efficient Nutrient Management a *sin qua non* of Sustainable Soil Health – Concept and Concerns

Scientific evidence built up over the last 5 decades confirms that institution of holistic fertilizer management practices is imperative to maximize fertilizer use by crops and minimize its waste. In

Dignitaries on the dais during the National Dialogue

pursuance of holistic fertilizer management, it is inevitable to: (i) make soil test and crop need based applications that not only equal crop removals, but also balance fertilizer treatment in proportions that adequately ameliorate all deficient nutrients, (ii) adopt efficiency enhancing fertilizer methods, times, sources and doses and (iii) include supplementary treatment with indigenous sources and resources. Besides, these basic elements of efficient fertilizer management, it is inescapable to exclude practices like standard/precise agricultural methods and smart use of pesticides, water and energy. Above all, it mandates to prepare expert human resource for transferring all-inclusive information on a right management package. Working in a participatory mode with all stakeholders will hasten the understanding prompting lasting adoption of holistic fertilizer management by the client farmers.

The role of holistic fertilizer management scheme is summarized below:

- For optimum growth and maximum productivity, crops need sufficient, but rightly-proportioned supply of 17 essential nutrient elements. Apparently, current focus of soil fertility management primarily on N and to some extent on P is misplaced for the purpose of sustainable productivity growth. Findings from fixed site long-term experiments elucidated need for correcting the imbalance by including K treatment. Contrary to that need, public subsidy policy favoring urea, continues to distort the necessary NPK use ratio. With time, rise in proportion of K deficient soils is the consequence of continuous mining without K supplementation. By and large, specifically in intensively cultivated regions, need for micro-nutrients - Zn and B and secondary-nutrient S came to the fore. Since facilities for soil testing in respect of these nutrients is almost non-existent, farmers remain in the dark whether or not and what nutrients to apply. Added to that is the insufficient expertize of technology transfer agents on instant ability to diagnose in-situ micro-nutrient disorders. With this kind of systemic weaknesses, farmers remain deprived of any real time credible source of advice to delineate deficient fields before cropping or take steps to alleviate the nutrient-specific hunger should their crops show deficiency symptoms after sowing/planting.
- Fertilizer use and management methods are divided into two categories – indirect and direct. The former class includes region- and crop-specific 'precise agronomic practices', like: land levelling and crop establishment, choice of variety, optimum seed rate/planting density and row orientation/ geometry, time of sowing, weed and pest control, smart water management, harvesting at prescribed physiological maturity and loss-free harvests. There exists an indisputable evidence that fertilizers alone fail to replace the yield loss caused by the non-adoption of any one technology constituting the package of standard agricultural practices. Once again, it is more necessary now than ever before that know-hows (scientists and extension functionaries) work hand-in-hand with the do-hows (peasantry).
- The expert fertilizer management scheme that directly influences FUE includes source, level, method and time of fertilizer application. Presently, these four practices are nicknamed '4Rs' (R stands for 'right' i.e., right source...) of fertilizer management. Guided by these 4 key elements (4Rs) of fertilizer management, a wealth of scientific information suggests that researchers were largely successful in demonstrating the strength of their findings even under farmer field conditions. Despite these well-meaning accomplishments, it is a paradox that level of NUE today remains what it was 50 years back. Pervading bleak scenario is an indication that either the scientist-suggested alternatives were not right for a vast majority of the farmers or farmers were unaware of these recommendations. Resultantly, easy to adopt,

albeit wasteful broadcasting method of surface spreading and general recommendations on rates/ proportions of application continue to dominate fertilizer management scene. New developments like site specific nutrient management (for example Nutrient Expert) or green sensors (GreenSeeker) or leaf color chart aided fertilizer dressings and role of sequencing fertilizer application with reference to irrigation seem to be aliens even to technology transfer agents. Emphasis on action research – scientists' facilitated, but farmers' led experimentation – needs to be revived by converging genuine commitment of ICAR institutes, State Agricultural Universities, State Extension Machinery and *Krishi Vigyan Kendras*.

- Another issue related to inefficient administration of fertilizers relates to relegated place of organic manures in soil fertility management. Organic manures undeniably are a store house of all essential nutrients, albeit in limited amounts. Besides, they have distinctive role in building soil biology, physical health and resilience - the contributory factors in sustaining tempo of productivity growth. In view of their insufficient availability compounded with the limited effective nutrient potential, organic manures have crucial complimentary role in maintaining soil health. On all counts, it appears that the integrated use of chemical fertilizers and organic manures is the most viable and practicable strategy to sustain productivity surge and mitigate rising concerns on soil health and climate change.
- Despite clear understanding on efficient management of fertilizers, improving FUE continues to be an enigma. One prominent explanation seems to be that scientific findings were perhaps not aligned to farmers' situation and/or the native biophysical soil attributes and limitations. In general, research objectives seldom provided space accommodating farmers' needs and views; particularly the constraints faced by the small and marginal (S&M) farmers. Rarely did scientists attempt to work hand in hand with this category of farmers to validate practicality of their findings on improving the conventional methods of fertilizer management. Incidentally, S&M farmers (land holding size <2ha) constitute a dominant category in India (~87% of the total ~138 M). They not only share sizeable part of the fertilizers consumed (53%), but the intensity of fertilizer use by them is also greater than the medium to large farm size groups (53 vs. 47 kg NPK/ha). Strangely, when it comes to transfer of technology, observed World Bank, small and marginal farmers remain the least preferred group to interact with. Likewise, on an overall basis, due to weak extension services even in 2012-13 round of NSSO, only 40 per cent of the surveyed land holders accessed scientific information from all available sources. Interestingly, in 2003-04 NSSO round also, only 2 out 5 farmers made use of all technology transfer sources to improve farming. Partial adoption of a technology package till date remains a patent source of persisting gulf between the potential yield and the yield obtained by the farmers. It is reasonable to believe that at least one half of the observed yield gap (up to 3 tons/ ha) can be assigned to inefficient use of fertilizers. It is reiterated, unutilized part of the fertilizers is potential source of pollution and contamination of soil, water and air. Need is to devise and induct a new look extension system, which besides being multi-agency, on the one hand will facilitate availability of inputs as per technological demands and on the other will offer advice on improved soil, water and input management including transfer of information on quality produce and nuances of markets and trade. Simultaneous launch of improved formal, non-formal and informal competence and capacity building HRD programs will be a fundamental necessity. It is seen to sustainably consolidate adoption and retention of efficient fertilizer use and management.
- While it is almost impossible to withdraw financial perks in the form of subsidy on fertilizers, an alternative could be to incentivize those who cooperatively save subsidy by leveraging practices leading to efficient use. One proposed option is to offer build-in efficiency in the freebies itself. For example, providing subsidy on the use of efficient nutrient sources, which otherwise are more costly. Another possibility is to reward efficient users of subsidized or free inputs. For instance, if farmers belonging to a village as a community reduce fertilizer use without compromising productivity levels, they as a group qualify to be rewarded. The sum of the incentive could be based on the amount of saved fertilizers, which otherwise would have been paid in the form of subsidy. Proposed incentive and reward scheme gives greater credence to inspire efficient use of inputs and helps protecting the environment rather than saving money for public exchequer. The investment on compensation for healthy environment for development is a win-win situation. It will both sustain food production and improvement in health of soils, water and climate. Effectivity or otherwise of this proposal can be tested on a pilot scale.

II. Soil Health: Monitoring Strategies for Smallholder Systems

Crop residue removal/burning in India is a serious problem, leading to wide spread problems of secondary and micronutrient deficiency, explaining why we have the "yield stagnation" scenario presented so often. The current challenge is addressing the issue of small land holdings and poverty amongst these farmers. Unfortunately, poverty has made crop biomass an attractive fuel for farm homes, and an additional source of income. As farm size increases, alternative cooking/ heating fuels will hopefully become more popular (gas/electricity) and crop biomass will no longer be in demand.

It was suggested that this challenge will evolve into a solution as current farmers' age, and in the absence of family members who are prepared to continue their meager lifestyle, land will be leased to those remaining farmers who are focused on agriculture as a family business.

- There is a need to move farmers from small holders to larger land holdings, supported by mechanization,
- There is a need to increase the understanding of engaged young farmers that there are economic benefits to production from improved soil quality, and
- There is a need to conduct detailed evaluation of soil quality on farms, asking the question what is the benefit that can come from this. Rather, it is suggested that any program on soil quality focus on those inputs which can be realistically sourced by small holders...such as livestock manure, crop biomass and farm yard compost. These amendments, when added to soils, can then be credited in any nutrient recommendation system that is properly designed to support soil quality improvement.

One more challenge which India faces, is the very wide diversity amongst farmers, ranging in education, land base, resources, technology use, etc. As a result of this, IPNI has focused their attention on current fertilizer users, supplying them with information which would help them in making better balanced fertilization decisions. The normal process of technology adoption and diffusion within a farming community requires that the "innovators" receive our attention to begin with, and associated information (radio and video) be directed at the larger, less innovative audience. The extension of publically good information must be tied to profitability on the farm. Failure to do this is destined to meet with failure.

III. Nutrient Mining in Indian Agriculture: Past Trends and Future Challenges

A continuous mismatch between nutrient removal and replenishment, even at the recommended levels of fertilizer application, was evident in the long-term studies on various cropping systems. The long-term rice-wheat experiments in the Indo-Gangetic Plain (IGP) under the All India Coordinated Research Project on Integrated Farming Systems reveal that additions of N and P in different locations were greater than their removal by the crops. On the other hand, negative K balances were noted in all the treatments at all the locations. However, the effect of negative K balance may not be visible on the plant available K content of soil owing to the relatively high K supplying capacity from the respective non-exchangeable K (NEK) pools of the illitic minerals-dominated soils of the IGP. Indeed, the assessment of the plant-available K in soils does not measure the NEK pool, or its depletion. However, continued (unnoticed) excessive depletion of NEK from the interlayer space of the illitic clays may lead to an irreversible structural collapse of these minerals, thereby severely restricting the release of K from such micaceous minerals. This would impair the long-term soil fertility in respect of K, and its restoration may require much higher and thoroughly unwarranted investment in future. Further, the estimates of apparent N balance, which was positive at all the locations, may not also mean a sustainable input-output relation either. In rice soils, the inclusion of N losses from rhizosphere by leaching, volatilization and denitrification in the nutrient balance calculation may render the N balances negative at all the locations. Thus, the current practices of nutrient management in cropping systems are exhaustive in terms of N and K withdrawals, leading to depletion of these nutrients from the native soil reserves.

It is apparent that well-documented soil-crop management practices are yet to address adequately the issue of nutrient mining from soil by the crops and cropping sequences, and the effect thereof on the long-term native soil fertility. There is thus a need for appropriate environmental auditing, concomitant with soil-crop management practices. Indeed, nutrient balance methodology, has been illustrated based on the QUEFTS (Quantitative Evaluation of the Fertility of Tropical Soils) model, for estimating the K balances in agricultural fields for single crop and cropping systems involving cereals. The essential components of such K balance calculations included contributions (input) from the retained crop residues, irrigation water and added organic matter, as well as the loss (output) of K from the system through leaching and export through the grain of the crops. These have been examined two options for rice to calculate the fertilizer K rates based on partial maintenance of soil K level with gradual drawdown or depletion of such native soil K. In one option with partial maintenance, fertilizer K requirement was calculated as a fraction of the full maintenance. The other option with partial maintenance allowed K depletion from the soil reserves up to a threshold limit, which is treated as an input in the nutrient balance. In such approach, the indigenous soil K supply to support the targeted crop yield was obtained from the corresponding omission plot data. However, a few scientists examined such n nutrient supply calculations of nutrient (N, P and K) contributions from the soil available pool (soil test data) and the appropriate nutrient use efficiency factors.

For addressing these issues, the nutrient input from irrigation water and losses through leaching would feature prominently in the nutrient balance equations that help estimate fertilizer requirement to achieve a targeted crop yield. A portion of the K and other basic cations added to the field through irrigation water, for instance, may also be lost via leaching from the highly permeable soils with adequate drainage and low CEC. Further, there are several researchable issues pertaining to the assessment of equitable distribution of crop residues among different competitive uses, such as between animal feed requirement and nutrient recycling in fields, thereby providing options for farmers to retain at least a part of the residues in the field. Critical estimation of the rate of mineralization of

crop residues with different (C:N) ratios under varying agro-climatic conditions and management scenarios would also be required for assessing the nutrient availability from crop residues in the nutrient balance and nutrient mining calculations. The availability of organic resources, having several competitive usages, for agricultural uses, along with their nutrient loading needs to be ascertained for reliable nutrient balance computations in the context of the integrated nutrient management options.

A national portal for soil data repository is a critical requirement for assessing nutrient mining from soil. Such a national-level initiative to develop and maintain a soil data repository will allow tracking of soil fertility changes in intensive cropping regions over time. At this point, such databases are fragmented and maintained by several organizations, which are unavailable in the public domain. Integrating the former into one national portal will help the overall assessment of the national soil resources and developing other knowledge resources, such as fertility maps for different soil nutrients at a finer scale. Once developed, such a database could be periodically updated with contribution from different organizations. However, the data querying from several disparate sources may cause concern for the appropriate reconciliation of the soil test data. Creating a national committee to oversee the data input, with particular reference to data sources and data quality could minimize such concerns. Developing a national portal of soil data will strongly fit into the current initiative of generating the "Soil Health Card" for millions of geo-referenced farm field soils. This would be a logical starting point for a "national soil data repository" for the posterity, and will be an extremely valuable resource to facilitate research, planning and implementation of the improved agricultural practices at the local, regional and country scale. Such a repository will also help reorient fertilizer management practices, based on agro-climate, soil type and management practices to minimize soil nutrient mining while sustaining the soil fertility levels.

Way forward included: i) nutrient mining in agriculture cannot be avoided altogether. Varying inherent buffer capacity and vulnerability of different soils, under similar cropping systems and comparable management practices are to be recognized. There is thus need for assessment of the allowable range of nutrient mining under variable climate-soil-crop-management domain at the regional scale. Multiple cropping systems and management practices further complicate the scenario; ii) the talk primarily intended to bring the nutrient mining issue in our collective consciousness as a threat to the quality of soil resources and the food security for now as well as for the posterity; and iii) the need arises for a national effort to address the nutrient mining issue in the Indian agricultural context.

IV. Improving Soil Physical Health: Challenges and Opportunities

In India, millions of hectares of land in both irrigated and rainfed ecologies produce very low crop yields and low efficiency of nutrients due to unfavourable soil physical conditions. Improving soil health under such conditions is crucial for sustainably increasing crop productivity and nutrient use efficiency. Efficient nutrient management is therefore essential not only for improving crop production and use efficiency of nutrients but sustaining soil health as well. Nutrient use efficiency may be measured either as the fraction of added fertilizer recovered by the harvested portion of the crop or as unit of economic yield per unit of nutrient applied. Regardless of the manner of expression, all factors that affect crop yield with a given amount of nutrient, influence nutrient use efficiency. In fact the inefficient use of nutrients is linked to their losses from the soil plant system. Therefore any practice that enhances nutrient uptake, maximizes yield, minimizes losses and leads to enhanced nutrient use efficiency. Mass flow and diffusion are the two major processes by which nutrient ions are transported to the root. Immobile nutrients are absorbed through root interception. Management practices which alter water availability and root growth in time and space are likely to influence these processes. The major soil physical constraints identified are low water retention and high permeability, slow permeability, surface and subsurface mechanical impedance and shallow depth of the soils, which either restrict crop growth or reduce efficiency of basic inputs, such as water, fertilizer etc.

Increasing input use efficiency and lowering cost of production is a big challenge to agricultural scientists. Limited availability and high costs of the three vital inputs in agriculture viz., water, fertilizer and energy demand their rational and sustainable use. Soil-water-plant relationships play an important role in determining the input use efficiency of these vital inputs and it is, therefore, important that the management practices that moderate and modify these relationships are evaluated and understood in great depth and dimensions. It is important to prepare an inventory and mapping of soil-water relations of different agro-climatic situations and soil types, water and nutrient losses and associated changes in physical properties in different land management practices. Models need to be developed/calibrated for better understanding of soil-water-tillage-nutrient-plant interactions with respect to input use efficiency of water, nutrient and energy. There is a need to evaluate crop specific conservation tillage (zero/minimum tillage with surface retention of available residues as mulch) technology with different levels of water and nutrients vis-à-vis methods of water and nutrients application to ensure resource conservation and high input use efficiency. Role of organic mulches and plastic mulching in resource conservation ensuring productivity and quality of the produce in higher water and nutrients requiring cash crops need to be evaluated. Indigenous moisture conservation and nutrient management practices blended with modern scientific knowledge need evaluation in developing location specific technologies to achieve higher use efficiency of costly inputs.

V. Conservation Agriculture and Soil Health vis-à-vis Nutrient Management: What is Business Unusual?

Traditionally, farmers in India as well as other South Asian nations apply fertilizer nutrients based on ad-hoc blanket recommendation for large area. Many farmers often use uniform rates of fertilizers that could be inconsistent from field-to-field and year-to-year depending on factors that are difficult to predict prior to fertilizer application and also no matter what crop management practices they have adopted. Also, farmers often apply fertilizer nutrient in doses much higher than the blanket recommendations to ensure high crop yields. Large temporal and spatial variability of soil nutrient supply restricts efficient use of fertilizer nutrients when broad based blanket recommendations are used even under contrasting management scenario. This leads to sub-optimal crop yields, low nutrient use efficiency, lower economic profitability and greater environmental footprints. Under such situations, in season site-specific nutrient management can effectively replace the blanket fertilizer nutrient recommendations for achieving high nutrient-use efficiency, economic profitability with lower environmental footprints. With 84 per cent or more operational land holdings in India having less than 2 ha (remaining 10-15 per cent up to 10 ha), it seems that high fertilizer nutrient-use efficiency can be achieved through field-specific fertilizer nutrient management considering both spatial and temporal variability in soil nutrient supply. However, quantifying the spatial and temporal variability of soil properties at scale using soil test based approach seems a wearisome task keeping in view of number of holdings and available resources in the region. However, the national mission on soil health launched by Government of India is welcome step in this direction. However, capturing temporal variability created due to contrasting management by the farmers and account that in fertilizer nutrient recommendations has to go a long way. Large studies on CA based system across a range of geographies suggest positive effects on soil health over a period of time and hence the fertilizer nutrient prescriptions have to be dynamic under those situations. Also, its just not only the rate of fertilizer nutrient application but method and time of application having congruence with soil moisture has to do a lot for improving efficiency as well as soil health. The changes in physical and biological properties of the soil associated with CA practices are expected to modify the direction and kinetics of the chemical and biochemical processes significantly affecting nutrient dynamics in the soil. Therefore, we need to have a paradigm shift in fertilizer nutrient management strategies (rate, time, method) under CA when we move from conventional tillage based management. In this paper, we attempted to provide evidence which suggests that we need a 'business unusual approach' for nutrient management when we move from CT to CA based production.

CA with layering of adapted component technologies especially nutrient and water relevant to local circumstances can serve the foundation for our goal of improving soil health for resilient farming and future food security. However, business as usual approach may not help us meeting the goals and warrants following strategies for capitalizing the synergies in positive role of different elements of CA on soil health and efficient nutrient management practices relevant to those circumstances.

- Take a stock of the available technologies/practices for CA and nutrient management adapted to different production systems and define their recommendation domains for scaling and impact on smallholder farming systems.
- The innovation platform on CA with component technologies for nutrient and water management should have a continuum of 'strategic-applied research-capacity development-delivery'.
- Capture farmer innovations on CA and align them with scientific validation and refinements through participatory action research on layering efficient nutrient (and water) management portfolios for CA based production systems, for example, aligning 4R nutrient stewardship with CA and microirrigation.
- Create evidence base on complementarity of CA based systems with efficient nutrient management as indicators of improved soil health, food security, income and livelihoods over conventional farming practices and define their recommendation domains.
- Analyse adoption pattern and behavioural change of farmers under different farm typologies to understand adoption of CA in isolation vis-à-vis layered with precision nutrient and water management.
- Strengthen institutional arrangements and enabling policy environments for scaling CA systems through establishing a 'Farmer Centric' consortium of active and complementing stakeholders.
- Enhance capacity of stakeholders especially rural youth and women.
- Develop and demonstrate CA system led business cases to engage rural youth for scaling CA based innovation.

VI. Fertilizer Policy and Nutrient Management: How to Connect?

The sale, price and quality of fertilizers is regulated under Fertilizer (Control) Order, popularly called FCO. With retention pricing scheme (RPS) implemented way back in 1977, fertilizer production and consumption increased significantly, although subsidy bill also increased simultaneously due to continuous rise in fertilizer production costs and relatively slow change in government controlled retail price of fertilizers. As there was abysmal investment in the fertilizer industry with less scope for any innovation, the need for policy reforms was badly felt. One of the major reforms took place in April 2010 with the introduction of nutrient-based subsidy (NBS), wherein the subsidy on P and K fertilizers was fixed annually, and the MRP was market-driven. Urea which constitutes more than half of the

total fertilizer products used in the country, however, continues to be out of the ambit of NBS. With the implementation of NBS, the fertilizer subsidy load on the exchequer got reduced significantly from Rs. 99.5 thousand crores in 2008-09 to 71.0 thousand crores in 2014-15. However, NBS had two apparent adverse implications. First, the retail price of urea (excluded from NBS) changed only marginally, whereas the prices of P and K fertilizers increased substantially during post NBS period, resulting in widening of fertilizer (N: P_2O_5: K_2O) consumption ratio from 4.3:2.1:1 in 2009-10 to 6.8:2.4:1 in 2014-15. Second, total fertilizer consumption as well as intensity of fertilizer use (kg/ha) has come down drastically. Fertilizer consumption was 28.1 mt (141 kg/ha) during 2010-11 which was reduced to 24.5 mt (126 kg/ha) during 2013-14. There has been some improvement in fertilizer consumption during 2014-15, i.e. 25.6 mt (136 kg/ha).

Implementation of fractured NBS is often argued as the major cause of distortion in fertilizer consumption ratio and fall in consumption; and bringing urea under NBS is advocated as the sole solution to these problems. It is said that farmers use urea in excessive amount due to its cheaper price. These arguments need to be analyzed in the light of fertilizer consumption statistics. During the period 2010-11 and 2013-14, the consumption of N increased by 2.8 per cent only, whereas P and K consumption registered a decrease of 24 and 29 per cent, respectively. This suggests the decrease in P and K consumption owing to exorbitant price as the major cause for distortion of fertilizer consumption ratio. Bringing urea under NBS may of course help narrowing the consumption ratio, owing to fall in N consumption (as happened in case of P and K). As Indian soils are universally deficient in N and also inherently low in N supplying capacity, the fall out of decreased N consumption on foodgrain production can be very well understood. The farm-level nutrient management should obviously consider both total amount of fertilizer use and ratio. Inclusion of urea in NBS may, therefore, be considered in a phased manner.

Neem oil coating of urea to the extent of 20 per cent of total production was introduced in 2010, and then up to 35 per cent in 2011. From 2015, neem oil coating has been made mandatory for 100 per cent of the indigenous urea production. This policy reform is likely to have far reaching effect on N management, as the advantage of neem oil coating on N use efficiency is well-documented. Besides, neem coating would also prevent any possible misuse of urea for industrial or non-agricultural purposes. New Urea Policy-2015, New Investment Policy (NIP)-2012, promotion of water soluble fertilizers and customized fertilizers, and coating/fortification with secondary and micronutrients are other important policies that directly or indirectly affect nutrient management.

The Road Map included: i) bring urea under NBS in phased manner only; also extend NBS to micronutrients; ii) enhance investment in fertilizer product research in order to develop sustained release/smart fertilizers with high nutrient use efficiency, and reduce dependence on conventional fertilizers, i.e., urea, DAP and MoP; iii) evaluate the significance/utility of customized fertilizers with respect to their grades, variation in soil fertility in recommendation domains and economic returns; iv) mechanism for inclusion of fertilizers in FCO needs a fresh look in view of availability of only few products in the market despite listing of more than 100 fertilizers in FCO; and v) ensure timely availability of required fertilizers in adequate amounts for balanced fertilization.

VII. Soil Test Crop Response: What Can Be Learnt?

Ensuring food security for burgeoning population necessitates the production of additional food grain from the same land without losing the production potential of the soil. This, in turn, requires extensive research to provide a scientific basis for enhancing and sustaining food production as well as soil productivity with minimum environmental degradation. Balanced nutrition does not mean the application of nitrogen, phosphorus and potassium alone in certain proportion through fertilizer, but it should ensure that the nutrients in available forms are in adequate quantity and in required proportion in the soil to meet the requirement of the crops for obtaining the desired levels of yield. Nutrients available in soil are rarely present in adequate amounts and in balanced proportion to meet the nutrient requirement of the crops. In order to attain this it is essential that the amount of nutrients removed from the soil should be replenished through judicious use of fertilizers and manures. This needs a more comprehensive approach for fertilizer use, incorporating components like soil test, field research and economic evaluation of the results. Soil test provides the requisite information about the amounts of nutrients available in the soil and their imbalances, while fertilizer recommendations aim at correcting the imbalances in nutrients according to crop requirements.

A new dimension to the value of the utility of soil testing has been added by the concept of fertilizer application for targeted yield demonstration in farmers' fields by choosing the yield target at such a level so that the cost of fertilizer requirement becomes more or less same as what was being practiced by farmers already. When fertilizer availability is limited or the resources of the farmers are also limited, planning for moderate yield targets which are, at the same time, higher than the yield levels normally obtained by the farmer provides means, far saturating mare areas with the available fertilizers and ensuring increased total production also.

New initiatives: Of late, STCR has developed algorithms of leaf colour chart, SPAD and fields cout CM 1000 meter values at three critical growth stages with yield in rice-wheat system; also developed fertilizer prescription equation for hitherto untouched secondary nutrient (sulphur). Besides, soil testing protocol for organic farming system including characterization and quantification of microbiologically exploited organic phosphorus-pools in organic farming systems has been developed.

Expert systems developed by AICRP (STCR): An expert system developed in collaboration with NIC, Pune which calculates the amount of nutrients required for specific yield targets of crops based on farmers' soil fertility. It is accessible on Internet (http://www.stcr.gov.in/). Also developed a Decision Support System for Integrated Fertilizer Recommendation for Tamil Nadu state encompassing soil test and target based fertilizer recommendations through Integrated Plant Nutrition System. Using this software, fertilizers doses can be prescribed for about 1645 situations and for 190 agricultural and horticultural crops along with fertilization schedule. If site specific soil test values are not available, data base included in the software on village fertility indices of all the districts of Tamil Nadu will generate soil test based fertilizer recommendation. Besides, farmers' resource based fertilizer prescriptions can also be computed. Way forward included: i) STCR recommendations for drip fertigation for enhancing nutrient use efficiency; ii) anomalous potassium response in Vertisols of India: Accounting contribution of non-exchangeable-K; iii) development of DSS by integrating GPS/GIS-based soil fertility maps with STCR prescription equations; iv) development of universal extractant/method and its calibration for target yields of different crops; and v) use of STCR prescription equation for development of customized fertilizers.

VIII. Advances in Precision Nutrient Management Decision Support: What are the BIGGains?

Scientists and policy-makers have time and again pointed out the significant decline in crop production per unit of fertilizer use in India. Conventional blanket fertilizer recommendation prevalent in the country, leading to imbalanced use of fertilizers and lower fertilizer use efficiency, has been identified as one of the main reasons. Its economic and environmental consequences are evident from long-term fertilizer experiments and other independent studies. Imbalanced fertilizer use has been associated with soil, air and water pollutions in numerous studies. However, connecting the soil nutrient status to soil health issues is less forthcoming. A recent study highlighted the extent of nutrient mining in production systems around the country, and identified it as a potential soil health issue that is aggravated by blanket fertilizer application. It was pointed out that the limitation imposed by inadequate nutrient status strips the soil off its "capacity to function or perform", and adequate availability of essential nutrients in the soil is critical for sustained soil health. Nutrient inadequacy and imbalance in the soils adversely affect the soil organic matter status, a critical soil health parameter. Besides it has a cascading effect on the air and water quality as a consequence of transformation and movements of nutrients that are essentially triggered by nutrient imbalances.

Way Forward

The 4R Nutrient Stewardship Principles of applying the right source of plant nutrients at the right rate, at the right time, and in the right place is at the core of the precision nutrient management approach. The 4R Nutrient Stewardship provides the scientific principles that are the basis of applying balanced and adequate amounts of nutrients to crops, and also connects the outcome of crop nutrient management to social, economic and environmental sustainability of production systems. The principles are equally applicable at the broad acreage farms where sophisticated machinery is used for precision application of nutrients or in smallholder systems where fertilizer is manually mixed and applied by farmers in their small fields.

In the context of precision, there are options to fine-tune the 4Rs to match the site-specific requirements of a particular production system. For example, the choice of fertilizer sources needs to match the soil characteristics; nutrient application rates should match the crop requirement while factoring in the indigenous nutrient supply and crop yield target; time of fertilizer application must match crop physiological requirement to ensure high efficiency and to reduce possibility of nutrient losses; while placement of fertilizer should ensure that crop roots have easy access to the nutrients. The 4Rs are thus highly crop and location specific to target social, economic and environmental benefits out of a nutrient management protocol.

On-farm evidences of the benefits of such site and crop specific nutrient management protocols are providing guidance for large-scale precision nutrient management in smallholder systems. Soil fertility maps developed from geo-referenced soil sampling and analysis has helped researchers and extension agents optimize nutrient use in landscapes with high field-to-field nutrient variability. Optical sensors have emerged on the agriculture scene in recent years as a means of making in-field adjustments of N application to crops as part of a split-N application program. While developed and implemented first under conditions of mechanized agriculture, the later low-cost variants of the optical sensors have been used effectively in smallholder systems to make split-N application decisions across variable landscapes. Significant advances were also made in the field of smallholder farm machinery that is providing better control over the nutrient application methods in small farms. However, optimizing only one 'R' of the '4Rs' often does not achieve the desired benefit or outcome. The Nutrient Expert® tools for rice, wheat and maize developed by the International Plant Nutrition Institute (IPNI), jointly with the International Maize and Wheat Improvement Center (CIMMYT) and in collaboration with several NARES partners, are providing guidance to optimize source, rate, and time of fertilizer application to ensure significant improvement in yield and economics, with decreasing environmental footprint of fertilizer use in disparate geographies in China, Southeast Asia and India. The Nutrient Expert® tools have been recommended by the Ministry of Agriculture, Government of India, as an ICT tool for site-specific nutrient recommendation in the centrally sponsored Soil Health Card Scheme (www.argicoop.nic.in).

The economic gain from precision nutrient management practices is quite obvious and apparent. Optimization of nutrient use either reduces the cost of production as in China, or increases production as in India and South East Asian countries, either way providing economic benefits to the farmers. We often, however, ignore its positive impacts on soil health through improved organic matter content and sustained soil fertility status that are critical for continued capacity of the soil to support plant growth. Experimental evidences have also shown that precision management of nutrients, through right source, rate, time and method of application can significantly reduce environmental footprint of agricultural nutrients.

IX. Micronutrients Management: A Way Forward to Food and Nutritional Security and Human Health

For sustainable agriculture, micronutrients should be looked with broad spectrum to "enhance soil productivity through a balanced use of local and external sources of plant nutrients in a way that maintains or improves soil fertility, environmentally friendly and can produce nutritious food. Another way of sustainable agriculture is to look for micronutrient efficient crops and/or their cultivars. Thus, the importance of micronutrients should be viewed in food systems context, as inclusion of micronutrients in balanced fertilization schedule would optimize micronutrient supply and availability in the entire food consumption cycle. The focus of improving the micronutrient quality of crops notes the density of bioavailable micronutrients in crops as consumed in order to take into account crop factors which increase or decrease the bioavailability of crop micronutrients. By considering the benefits of micronutrients in harvested plant products for human nutrition and in forages for animal nutrition, the benefits can be further extended beyond yield enhancement. Hence, a need has increasingly been felt to search best management practices and policies for managing the soil, fertilizer and manurial micronutrient resources more judiciously, efficiently, in balance amount and proportions for sustainable high agricultural productivity, nutritional quality of food to keep the national population hale and hearty and environmental pollution under check. It is presumed that malnutrition, including trace element deficiencies, is the result of dysfunctional food systems based in agricultural systems that provide the nutrients to feed the world. Thus, farmers should be thought of as nutrient providers. Unfortunately, agriculture has never had an unequivocal goal of improving human health and the nutrition and health communities have never used agricultural tools as a primary strategy to address malnutrition. This must change! The future requires that we closely link agriculture to human health to find sustainable ways to reduce micronutrient deficiencies. There is nothing more important than supplying all the nutrients required for good health, felicity, and longevity of the human race. The sustainable means to this end must come from agriculture

Way Forward

- The precise information and knowledge on extent of micronutrient deficiencies and their budgeting under different soil-cropping system/conditions in each agro-ecological region need to be created for correcting micronutrients deficiencies in soil through providing reliable soil testing advisory services and information on micronutrient technology to the farmers to achieve the target of producing 340 million tonnes of food grain by 2025 AD.
- Five (one each in north, south, east, west and central part of India) 'Advanced Micronutrient Testing Laboratory' for soil, plant, animal and human sample analysis need to be created to regulate/ monitor soil status, ensure quality of food and status of micronutrients deficiency in animal/human, with adequate funding and human resources so that information on trends of existing and emerging micronutrient problems impacting soil, crop, animal and human health may be generated.
- In the target areas with high incidence of micronutrient deficiency, fertilizer strategy should be applied nationwide to alleviate their deficiency in soil-cropping systems. Programs of genetic/ agronomic bio-fortification of cereal food grains with Zn and Fe needs to be launched in a mission mode to combat their deficiency in humans especially the poor section of the society unable to afford supplements or fortified foods with micronutrients.

X. Bringing Precision Nutrient Management to Smallholder Farmers Using Recent Advances in ICTs

In general, across India, fertilizer recommendations are generally made as blanket recommendations and do not reflect differences in indigenous soil fertility, prevailing crop management practices, yield responses, or attainable yield potential across sites or years. Existing approaches to improving this scenario through soil testing or STCR approach have proven too costly or difficult to extend to large numbers of farmers. Future gains in productivity and input-use efficiency will require soil and crop management technologies that are more knowledge-intensive and tailored to the specific characteristics of individual farms and fields. Site specific fertilizer recommendations approach manages the field to field variations in soil nutrient supply and crop responses to added nutrients. SSNM was a general concept for optimizing the supply and demand of nutrients according to their variation in time and space. However, for scaling SSNM approach, new ways need to be identified and developed.

IRRI in partnership with CIMMYT and NARES has developed a web- and mobile phone based application/ software' Crop Manager', which uses SSNM principles, to calculate a field specific nutrient management recommendation based on information provided through a farmer's interview about field and crop

management. The tool is being tailored to specific local conditions. The tool includes both web-based and mobile Android application with a simple, user-friendly interface providing personalized fertilizer guidance for small-scale farmers and extension workers. The farmer has to provide information about their fields by responding to a set of 12-15 brief questions about field location, planting method, seed variety, typical yields, choice of fertilizer, method of harvesting and other factors. The Crop Manager was adapted, evaluated, and verified for cereal based systems in Bihar and eastern UP, Odisha and Tamil Nadu through support from the Cereal Systems Initiative for South Asia (CSISA), funded by the Bill and Melinda Gates Foundation and the U.S. Agency for International Development during 2012 to 2015. Till date a number of nutrient omission plot technique (NOPT) trials and RCM evaluation trials have been conducted in several districts of the states. The data is being used to update SSNM-based approach and algorithms to enable rapid development of field-specific K and P management recommendations. Initial results have shown comparative advantage of using Rice Crop Manager as a tool for providing site-specific nutrient and crop management advisory to the farmers. Initial field trials conducted across seasons and crop in South Asia indicated that the field- and farmer-specific management recommendations generated through the developed 'Crop Manager' tools can increase yields by about 0.4 t/ha for wheat and up to 1 t/ha for rice, while increasing income by US$ 97 per ha for wheat and by US$ 188 per ha for rice. In some cases where farmers already use high levels of fertilizer, cost savings and yield enhancements can be achieved while reducing overall applications rates of fertilizer and rebalancing what is applied to better match crop requirements.

Way Forward

The mobile phone and internet penetrating fast in rural India. India has 110 million mobile internet users of which 25 million are in rural India – these ICT-based tools, especially in future, will serve as a useful platform to take knowledge to the farmers easily and at the time when they need it. Initiatives like Digital India and Soil Health Scheme lay a big opportunity for these tools as medium of transferring site specific fertilizer management information and knowledge to farmers at the desired time using mobiles and web based advisories.

XI. Strategies for the Last Mile Delivery of Efficient Nutrient Management

In India, intensive agriculture powered by improved varieties of seeds, application of fertilizers and assured irrigation has resulted in impressive growth in food grain production. The fertilizer consumption is increasing quantitatively and hence the corresponding yield increase per unit of nutrient has diminished over the years. High disparity between nutrient applied and nutrient uptake by harvested products is a serious threat to long term soil health, crop productivity and sustainability of agriculture. This is mainly because nutrient recommendation for crops are based upon crop response data averaged over large geographic areas and do not take into account the spatial variability in indigenous nutrient supplying capacity of soils. In general, blanket fertilizer recommendations are followed for N, P & K which rarely matches soil fertility need, and often ignoring secondary and micronutrients, in various cropping systems. Many farmers use uniform rates of fertilizers based on expected yields (yield goal) that could be inconsistent from field-to-field and year-to-year depending on factors that are difficult to predict prior to fertilizer application. Also, farmers often apply fertilizer nutrient in doses much higher than the blanket recommendations to ensure high crop yields.

Way Forward

Imbalanced application of fertilizers is under prevalence due to lack of timely, accurate and reliable information on nutrient management and crop cultivation practices. Yield and profitability can be increased by effective last mile delivery for adopting SSNM. Various tools, techniques and decision support systems are available to develop site-specific nutrient management plan. There is urgent need for enabling innovative extension policies and institutional and agri-industry framework for wide-scale adoption. ICTs/ mobile phone growth over last few years have made it a ubiquitous device and can help reach out farmers in remote and far flange areas. Farmers still need to attain greater level of awareness on managing practices and ICT based technologies can be the vehicle to support last mile delivery of the technologies to the stakeholders.

XII. Estimates and Analysis of Nutrient Imbalance and Subsidies in Indian States

Fertilizer has to play larger role in growth of agricultural output in future as other resources like land and water are facing serious stress. This requires a policy favorable for attaining optimum application of plant nutrients. Over time, emphasis of fertilizer policy has been to reduce share of N and raise the shares of P and K in total use of fertilizer in the country. This has been based on the axiom that ideal combination or composition of N, P and K is 4:2:1 and any deviation from this norm constrains growth in productivity and also causes adverse effect. We opine that there is no scientific rationale to support the existing NPK norm in current situation and such norms are meaningful only at disaggregate level and in a situation where plant nutrients are used in adequate quantity. Thus, the shift in fertilizer policy towards balanced use of N, P and K based on inadequate and outdated norm, will not yield desired results. Second, the approach towards balanced use of fertilizer based on aggregate of the country is totally irrelevant as the optimum ratio of N, P and K differs significantly across states according to the types of crops grown and soil fertility status and other factors.

In nut shell, the common and strong view held in the country that balanced fertilizer use requires three major plant nutrients namely, N, P and K to be used

in the ratio of 4:2:1 and that deviation in fertilizer use from this norm was constraining growth in crop productivity. This perception, which has been officially accepted, has led to wrong policy on fertilizer because the so called norm of balanced use is based on outdated and inadequate experiments conducted during the early 1950s. The study demonstrates that balance use of fertilizer comes into picture only when different plant nutrients are applied in adequate quantity and it differs widely across states. It pleads for a policy to address deficit and excess in use of N, P and K rather than chasing the imbalance in fertilizer use. It is estimated the actual and normative quantity of N, P and K for each state of the country corresponding to the current cropping pattern. Contrary to the notion of excess use of Nitrogen in the country, it was found that 13 major states of the country use less than the required level of N. The country faces large deficit in use of P and K compared to optimum level. It calls for curtailing use of N in one third of the states and raising it in the remaining two third states.

XIII. Organic Resources for Agriculture: Availability, Recycling Potential and Strategies to Convert Waste to National Resource

The nutrient needs of crops and associated nutrient losses of Indian agriculture are so large (and growing each year) that no single source, be it inorganic fertilizers, organic manures, or crop residues can meet them by itself. Indian soils are still estimated to be losing close to 9 Mt N + P_2O_5 +K_2O (NPK) annually even after harnessing currently utilizable organic resources plus input through BNF on a gross basis. It is projected that in the year 2050, the food grain production (estimated at 457 Mt) would remove about 58 mt of NPK with an addition of 48 Mt of fertilizer nutrients if the current linear trend in fertilizer consumption observed over the last twenty years is continued for the next 35 years. This would result in a negative gap of 10 Mt per annum of NPK. At the present NPK consumption in India is 25.53 Mt. Divergent assumptions are made by various workers regarding nutrient use efficiency and nutrient inputs from organic sources which is a major problem while working out net nutrient balances. The negative nutrient balance may be a potential threat to the soil quality and sustainable agriculture. This gap can be bridged by the recycling of the huge of quantity of organic wastes and municipal solid wastes (MSW) because these can serve as valuable sources of plant nutrients if recycled in agriculture through proper technology. Similarly, a vast amount of human excreta is generated in the country but not recycled in proper manner to benefit agriculture.

Improving nutrient balances, improving crop yields and maintaining soil quality call for conscious moves for managing organic sources. Organic nutrient sources have widely varying composition and differ in their nutrient availability. The INM has a great potential to offset the heavy requirements of chemical fertilizers in crops, to achieve maximum yields and to sustain the crop productivity on long term basis. With detailed information on the quality of the organic material and our improved understanding on the decomposition processes, we may nevertheless be able to predict nutrient release with higher accuracy. Post-harvest residues should be utilized to the fullest extent. However, to accomplish this objective, feasible technologies are needed for *in situ* recycling (e.g. use of Turbo Happy Seeder)/rapid composting of on-farm residues and wastes, in addition to extension efforts to change the mindset of the farmers. There are a number of gaps in our knowledge for developing quantitative estimates on different aspects of integrated nutrient management for specific environments.

Priorities for future research are as under:

1. Preparation of inventory of organic sources and recyclable wastes under different farming situations and estimations of nutrient from organic sources. Studying decomposition and nutrient release patterns from diverse sources of organic materials under simulated field conditions.
2. Proper storage, composting and application techniques of manures are needed to avoid nutrient losses and conserve maximum nutrients.
3. Technologies for *in-situ* recycling of crop residues (e.g. use of Turbo Happy Seder) need to be popularized.
4. Research on developing cultures of microorganisms and techniques which hasten the process of composting in order to produce good quality of compost will be useful.
5. Nutrient supply packages with optimum application rates of all the sources of organic manures and inorganic fertilizers should be developed. Economic evaluation of the each integrated nutrient management technology and identification of constraints in the adoption of new technology.
6. Evaluation of long term benefits of organic materials on soil quality, heavy metal accumulation and climate change mitigation by C sequestration.
7. Develop technologies to manage agro-industrial/ municipal wastes for nutrient supply and quality assessment of waste waters and their recycling.

Policy options

The availability of organic manures in adequate amounts and at costs affordable by the farmers is a major problem. Subsidizing biogas plants to meet fuel needs of the farming families as an alternative to burning of cattle dung cake can provide some FYM for recycling in agriculture. Subsidizing the high- quality compost to farmers who bring urban waste to the composting plant is one option, though this would require support from the municipal authority. Similarly, subsidizing machinery needed for managing organic sources (e.g. Happy Seeder for managing rice residues) will help in scaling the technologies. The development of source separation schemes for MSW, where households divide their garbage into organic and inorganic materials, is one of the key approaches needed to be adopted in

many Indian cities to reduce solid waste management problems. The scope for decentralized composting plants in India could be explored, particularly through NGOs and civil society organizations.

XIV. Legumes in Cropping Systems: Soil Health and Human Nutrition

Indian farming is dominated by cereal based cropping system and about 85% of the total cropping system followed in India are cereal-cereal systems e.g., rice-wheat (9.8 mha), rice-rice (5.9 mha) pearl millet-wheat (2.3 mha), sorghum-wheat (2.3 mha) and maize-wheat (1.9 mha) etc. On the other hand, glory of green revolution is under stress as continuous cereal-cereal cropping system have also led to several new challenges like decline in factor productivity, degradation of land and water resources, diminishing biodiversity, depletion of ground water table, degrading soil health, increase in environmental pollution and resultant climate changes. Under such situations, diversification has assumed paramount importance in areas where a specific cropping system, more particularly cereal-cereal system are being followed continuously for several years.

Opportunities for diversification/intensification through legumes

- Legume as summer/catch crop
- Legume as substitute crop
- Legume as intercrop
- Legume in fallow lands and new niches
- Legume inclusion as break crop

The discussion clearly reveals the assured advantage of inclusion of legume in continuous cereal based systems. Although substitution of a crop in intensively cultivated areas is quite difficult however, attempts should be made to harness the advantages of legumes in bi-exploiting one or the more avenues indicated in these studies. The inclusion of legumes as summer forage or as break crop may be more promising in the areas where cereal-cereal systems are pre-dominant staple food grain crops.

XV. Biofertilizers: Current Scenario and Future

Unscientific agricultural intensification, intensive tillage, non-return or diminished recycling of organic residues etc. lead to reduction in soil organic matter, loss of soil health and fertility. Consequently, there is a renewed emphasis now on conservation agriculture, organic farming and microbial inoculants. A wide spread consensus has emerged that sole dependence on chemical input based agriculture is not sustainable in the long run and only integrated plant nutrient systems (IPNS) involving a combination of fertilizers, organic/green manures and biofertilizers are essential to sustain crop production, preserve soil health and soil biodiversity. This is especially important for India where soil organic matter content is low; cost of chemical fertilizers is high and the use efficiency of applied chemical nutrients is poor. This also becomes important in the context of climatic aberrations imposing severe abiotic and biotic stresses on crops. Considering the high import cost of fertilizers, it is imperative to reduce a part of chemical fertilizer inputs by biofertilizers. In India, where ~70 per cent lands are under dry farming, where average pulse yields are only ~700 kg/ha, biofertilizer technologies have to be given a high priority and any neglect would be detrimental.

Application of organic manures is required in very high quantities to meet nutrient demand of crops; chemical fertilizers are becoming increasingly expensive. Biofertilizers are thus attractive as they are applied in small quantities, are cheap and when used along with small doses of organic manures and reduced dose of chemical fertilizers, give synergistic benefits on productivity, nutrient use efficiency, crop quality, soil health and disease suppression. By using biofertilizers farmers most commonly report earlier germination, more greenness, greater tillering and healthy crop stand. About 10% higher yield and 25% nutrient savings have been widely observed. In addition, significant improvement in use efficiency of applied nutrients has been observed in hundreds of experiments. Biofertilizers also improve quality in terms of phyto-chemicals and are contributing to improvement of nutritional security, particularly among those cultivating vegetables. Increased emphasis on organic farming, horticulture and commodity crops will require increased supply of quality biofertilizers.

There are many success stories of biofertilizer usage all over India e.g., Azospirillum for rice in Tamil Nadu, Rhizobium for soybean and phosphate solubilizing bacteria (PSB) all over the country. Biofertilizer adoption is easy in vegetable growing and very successful since farm yard manure is invariably applied and good irrigation regimes are maintained. This leads to improvement of the quality and shelf life of the produce, and improved nutrient use efficiency. These success stories need to be replicated more widely. The production of biofertilizers and usage is more in southern and western India but is now also picking up in eastern India. The main issues pertain to selecting the best suited and most efficient microbial strains for a crop/soil/region; use of certified mother cultures supplied by R&D laboratories for industrial production, using only sterile methods of production and maintaining high quality at all stages – production, storage and till its supply to the farmer. It should be mandatory for the industry to disclose details of strain used and its source in the registration certificates and inoculant literature.

Way Forward

- Greater attention on rhizobial research to boost pulses production: Improve strategy for selection of superior rhizobia in various agro-climatic zones by assessment of proportion of nitrogen fixed by legumes using stable isotope methodology.
- Improved fermentation technology for inoculant production by industry, sterile methods of manufacture, employing qualified personnel,

creating brand equity as part of corporate social responsibility.

- A further 10-fold improvement in BIS quality standards of microbial inoculants both for solid and liquid biofertilizers; establishment of high-grade quality control laboratories in all states, strictly monitor quality control.
- Improved application technology of liquid and granular biofertilizers in mechanized faming.
- Promote supply of quality biofertilizers, spread awareness on microbial inoculants and soil health through mass media and greater diffusion of technology through mass demonstrations.

The constraints to fuller implementation of biofertilizer technologies in Indian agriculture are not scientific, but largely organizational and logistical. There is a need to develop an integrated strategy to replicate the success stories and raise the general awareness about the benefits of biofertilizer usage to a level where it is implemented as a normal package of practice by the farming community to improve yields and benefit soil health.

Overarching Strategies for Better Soil Health through Nutrient Best Management Practices

Ensuring soil health in the vast tracts of agricultural lands in our country is easier said than done. Implementation of nutrient best management practices in the smallholder systems of India and beyond is also a challenging task. The National Dialogue on "Efficient Nutrient Management for Improving Soil Health" provides an opportunity to bring into fore the knowledge and dissemination gaps in efficient nutrient management that influences the health of our soils, and prioritize them as pre-requisites for sustained future food security. The group work in the National Dialogue was designed to allow all participants to share their rich experiences on key issues that are critical for soil health to help develop the roadmap and formulate future policies for scalable fertilizer best management practices not only to improve soil health but efficiency, productivity and farm profits while reducing environmental footprints.

The following topical issues have direct connects with the theme of the national dialogue and have been chosen for elaborate discussion by the participants during the group work:

Organic recycling in agriculture: what, how much, where, how?

India has vast potential of organic waste resources, recycling of which is vital for supplementing plant nutrients and maintenance of soil health. Organic recycling in agriculture is limited in our country because of several competitive uses of crop residues, animal waste etc. This group will discuss the synergies and tradeoff in recycling organics and the realistic potential of organic resources that could be recycled back to the farmland to improve soil physical, chemical and biological health.

Soil health card and beyond

The Government of India has undertaken a massive effort to provide soil health cards to all farmers. How best the soil health information could be used to provide rational fertilizer recommendation on both spatial and temporal scales to the farmers ensuring sustained soil health while we try to feed the burgeoning population would be the key discussion point in this group.

Soil pollutants and soil degradation

The hazards of soil degradation and presence of pollutants in the soil adversely affect the soil health. This issue needs to be addressed on a priority basis to save our farmland's capacity to produce food, feed, and fuel for the growing population. Are there proven strategies or mechanisms that needs to be prioritized, and what are the performance indicators that could be used to identify the reversal of soil degradation/ soil pollution etc., are some of the discussion points in this group.

Fertilizer nutrient use trends, scalable technological innovations and tools for improving nutrient use efficiency

Balanced fertilization, a prerequisite of high nutrient use efficiency, has been in discussion for a long time. However, the acceptance and adoption of balanced fertilization at farmers' level is far from the expectation. One of the major issues that restricted the adoption of balanced fertilization is the lack of easily available and usable tools that can allow farmers and their advisors to implement balanced fertilization quickly in their fields. This group will discuss some of the scalable approaches that might help large-scale implementation of balanced fertilization in farmers' fields to improve nutrient use efficiency.

Institutions, policies, partnerships, scaling strategies and capacity for a healthy national soil resource

A healthy national soil resource will require strong policy support, institutional mechanism and capacity development of stakeholders to implement strategies that promote soil health. What policies need to be in place to help scaling of strategies that has the overarching influence on efficient nutrient management leading to soil health improvement will be discussed in detail in this group.

For more precise information, please consult the Citation: Jat, M.L.; Majumdar, K.; McDonald, A.; Sikka, A.K. and Paroda, R.S. 2015. Book of extended summaries. National Dialogue on Efficient Nutrient Management for Improving Soil Health, September 28-29, 2015, New Delhi, India, TAAS, ICAR, CIMMYT, IPNI, CSISA, FAI, p. 56.

Policy Brief 2 : Efficient Potassium Management in Indian Agriculture

Potassium (K) plays an important role in supporting many metabolic functions of plants that ensure high yields and quality of produce. However application of

Dignitaries on the dais during Inaugural Session

adequate rates of K to crops and cropping systems is continuously being ignored because of a belief that Indian sols are well supplied with. This undermined the fact that soils once rich in decades ago could not sustain the continuous supply from native sol reserves unless replenished with external application. Also, recent evidence based on large soil testing initiatives under the National Soil Health Card Program has revealed that areas where soil test levels were high are now showing low K fertility. Therefore, unless addressed proactively, decreased fertility of Indian soils can seriously jeopardize our food security and soil health.

Maintaining soil health, while meeting food demand is a major challenge. Hence, implementing right strategies of management needs immediate attention. To be effective, K application must follow the 4R Nutrient Stewardship Principles of selecting the Right Sources of K, applied at the Right Rate, at the Right Time, and at the Right Place. In addition, science-based application of K also provides opportunities to address both biotic and abiotic stresses, which are on an increase, due to climate change. Inadequate K availability in soils also have a direct bearing on human nutrition and health. Potassium use in India contributes to less than 10% of the total fertilizer nutrient consumption. Moreover, in past fertilizer policies have had a strong influence on K fertilizer use. On farm scientific evidence across large geography and production systems suggest that present K fertilization practice is unsustainable. Accordingly, the policy decisions that directly influence on-farm implementation of balanced fertilization must be based on agronomic evidence Else it may adversely affect future goals of sustainably producing more and quality food doubling farmer income, and improving soil health.

In view of this the International Plant Nutrition Institute (IPNI), The Fertilizer Association of India (FAI), Trust for Advancement of Agricultural Sciences (TAAS), International Maize and Wheat Improvement Center (CIMMYT), Indian Council of Agricultural Research (ICAR), and ICAR-Indian Agricultural Research Institute (ICAR-IARI) jointly organized an international Conference on 'Advances in potassium research for efficient soil and crop management" at NASC Complex, New Delhi, India on 28-29 August, 2017. The conference discussed the advancements in K science, frontier technologies, research gaps and extension needs. A panel discussion was part of the conference that discussed the need for evidence-based agronomic support on K fertilizer policy formulations. The two-day conference broadly addressed the three thematic are as follows: i) advances in potassium research, ii) advances in potassium: Science to practices; and iii) panel Discussion on potash fertilizer policy and evidence-based agronomy. In all, 165 national and international delegates participated, representing researchers, policymakers, extension specialists and fertilizer industry people. The deliberations had culminated in specific recommendations for improving food and nutritional security through science-based K management in agriculture, as well as to ensure mitigation of adverse effects of climate change.

Recommendations

A. Needed Policy Interventions for efficient K management

- There is an urgent need to maintain price discipline for potash fertilizer through Government intervention in order to ensure affordability and accessibility of K fertilizer to farmers to improve their crop productivity, double the income, and sustain soil health. Frequent price fluctuations significantly impact potash consumption, negating all extension efforts to increase awareness.
- Bring Urea under the Nutrient Based Subsidy (NBS) policy so as to promote balanced use of P and K fertilizers, improve N use efficiency, and to reduce loss of N to the environment through greenhouse gas emission.
- Ensure last mile delivery of K fertilizers to the farmers, and effectively engage the existing two lakh strong fertilizer dealer/retailer network with the public extension system to create awareness among farmers on economic and long term social benefits of applying fertilizer.
- Formulate policies to promote the use of K based on existing soil maps and the national soil health card database by delineating K deficient areas of the country. Also ensure timely supply of fertilizer in those areas, and promote K use through concerted extension efforts with fertilizer industry.
- Bring Sulphate of Potash (SOP), an important source of K, under the NBS policy to ensure manufacturing the water-soluble fertilizers, besides other direct benefits to the farmers.

B. Efficient extension system to improve on-farm K management

- There is a definite need to revise k recommendations for crops and crapping systems, based on spatially explicit crop responses and information based on the soil health card database, and disseminate the same effectively both to public and private extension systems in each state.

- Develop and use soil fertility maps for K based on the soil health card database for increasing awareness at the grass-root level, and for policy planning towards allocation of K fertilizer.
- Integrate the Nutrient Expert fertilizer decision support tool with the national soil health card database to provide site-specific/farmer-specific balanced fertilizer recommendations.
- Promote split application of potash using the seed-cum-fertilizer drill to increase K use efficiency. This should be ensured through policy intervention to provide subsidy on seed-cum-fertilizer drill.
- Develop an effective engagement between the fertilizer industry and researchers to strengthen K fertilizer development and use research, and for rational use by the farmers.
- Educate farmers, dealers and the retailers of fertilizer industry with consistent message on the specifics of K use through public and private extension efforts and researchers' interventions, so as to avoid confusion arising through multiple source messages.

C. New dimensions of potassium research

- There is an urgent need to initiate a review of K research conducted so far in India. It is also important to develop a network on K research at national level to see what we have not yet addressed, and what new research is needed both in the current and future context. Some specific research needs defined are:
  a. Update the current fertility ratings of "low", "medium," and "high" of available to accommodate the needs of intensive cropping systems as well as spatially and socially variable yield targets. Develop a rapid method of measuring non-exchangeable K and integrate that information in the K recommendation process.
  b. Initiate systematic research on the right source, rate, time and method combination of application in major crops and cropping systems in India for different agro-climatic zones. Revise K recommendations for modern cultivars especially of plantation and horticultural crops for improving both productivity and crop quality.
  c. Develop scientific understanding on k dynamics in conservation agriculture (CA) systems for quantifying Kinputs, particularly for cereal based cropping systems.
  d. Explore the potential of alternate potash sources, such as low-grade potash-bearing minerals, e.g. glauconite deposits polyhalite deposits, mica wastes coupled with potash-solubilizing bacteria, crop residues etc for partial substitution of potassic fertilizer.
- Study the physiological role of K in enabling crops to cope with heat, low temperature, drought, and pest and disease stresses, and at elevated ambient Co, which are evident effects of climate change, through joint efforts of soil scientists, agronomists, plant physiologists and molecular biologists to develop K recommendations for managing biotic and abiotic stresses.
- Initiate multidisciplinary research involving agronomists, geneticists, soil scientists, biotechnologists, economic botanists, and others in a consortium mode to understand Genotype × Environment × Management (G×E×M) interactions under various K regimes.
- Understand the role of K in addressing non-communicable diseases, such as cardio-vascular diseases, diabetes and osteoporosis, affecting Indian population, through collaboration with medical institutions/researchers.
- Research on precision K management using modern tools and techniques is needed. Use of modern machine learning techniques and big data analysis to characterize landscapes based on K stocks, expected K use efficiency, and the yield goals for predicting responses under specific soil-management- environment combinations, is the need of the hour.

Policy Brief 3 : Scaling Conservation Agriculture for Sustainable Intensification in South Asia

Preamble

Realizing the importance of conservation agriculture (CA) and its scope in South Asia (SA), a high-level policy dialogue on scaling Conservation Agriculture for Sustainable Intensification (CASI) was jointly organized by the Australian Centre for International Agricultural Research (ACIAR) and the Trust for Advancement of Agricultural Sciences (TAAS) on 8-9 September 2017 in Dhaka, Bangladesh. The CIMMYT and the sustainable and resilient farming system intensification (SRFSI) project of the Australian supported Sustainable Development Investment Portfolio (SDIP) in South Asia facilitated its organization. In all, 64 participants, including high-level policy planners,

Dignitaries on the dias during Policy Dialogue

senior NARS leaders, research leaders and senior scientists of the CGIAR centres, research institutions, development officials, private sector representatives, NGOs, donors and some progressive farmers, from 5 out of 8 countries from South Asia contributed in drawing useful recommendations from this Policy Dialogue.

The Policy Dialogue was the first opportunity in many years to exchange information on CASI across the whole region for assessing regional priorities and for defining a roadmap for scaling CA based sustainable intensification in South Asia. The primary goal of the dialogue was to review the progress and the state of the CASI in South Asia and to explore way outs to move forward on scientific, institutional and policy fronts to catalyze transformative actions on scaling the CASI. Based on the formal presentations on the scientific developments on the CASI, specific deliberations on the development and policy-related issues and also the panel discussion on possibilities of scaling CASI, a Road Map has been suggested for its effective implementation.

The Regional Scenario

The South Asia is an agriculturally vibrant region. It has witnessed Green, White and Blue Revolutions in the recent-past. The region is home to many influential civilizations. It is endowed with rich agro-biodiversity, but is exposed to recurring incidences of natural disasters, like droughts, floods and cyclones. South Asia is also the most populous (1.87 billion) and densely populated region of the world (330 persons/km^2) (www.worldmeters.info). Despite these odds, it enjoys a high rate of economic growth. But the region still reels under the scourge of extreme poverty (42%) and malnutrition (21%), which are among the important agenda of the sustainable development goals (SDGs). Policy Brief Scaling Conservation Agriculture for Sustainable Intensification in South Asia

In South Asia, there is hardly any scope for horizontal expansion of farm area. Yet the region would need 70 per cent more food by the year 2050 to meet the projected demand. In fact, the future food security in South Asia has twin challenges of degrading natural resources and decelerating productivity growth of food grains. The challenges are exacerbated further owing to sharp rise in the cost of inputs, including energy, depleting water resources, soil degradation, indiscriminate and imbalanced use of chemical fertilizers and above all adverse effects of global climate change, which are likely to affect crop yields by 7-10%. Therefore, deployment of tools, techniques, practices and strategies aiming at increasing agricultural production and using technologies, which would address degradation of soil, water and environment and ensure their rational use, are essential for sustainable growth of agriculture in the region.

Dr R.S. Paroda expressing his views during Policy Dialogue

The Core Issues-Soil, Water and Environment

Despite the success of Green Revolution (GR), the larger challenge of feeding an increasing population from non-expandable arable land is putting tremendous pressure on and is resulting in overexploitation and degradation of natural resources. Intensification of agricultural production through cereal after cereal cycle is no more sustainable. The productivity growth rates of both rice and wheat have declined almost to one half of the initial peak rate during the last two decades in South Asia. This drop is a consequence of deterioration in soil -health and input- use efficiency, drying of aquifers, rise in greenhouse gas (GHG) emissions and global warming, and fall in soil-organic carbon (SOC). Additionally, spread of nutrient deficiencies of Zn, Mn, B and K, unknown earlier, has depressing influence on the crop productivity. Over the last 6 decades, besides deterioration in the ability to act as sink for carbon (C) and a storehouse for nutrients and water, the ability of soil has also been dented in regulating the climate. Apart from a faulty soil management practice like intensive tillage, increase in crop residue burning lately has also become a major contributor to CO_2 emissions. Additionally, this senseless incineration weakens soil physical, chemical and biological quality attributes.

Influence of the above listed adversaries fueling unsustainable intensification is maintained because of: existing imperfections in public policy on subsidizing agrochemicals, power and tillage, exclusion of natural resources conservation and role of stakeholders from the development agenda, and prevalence of institutions and scientists conducting component-based individual researches in place of system-wide multi-partner holistic enquiry in real-life farms, farmers and farming situations.

A priority condition would be the holistic management and more efficient resource use to protect health of soil, quality of water and condition of environment on which the growth of the human-beings depends.

Options for Sustainable Agriculture

Sustainable intensification, as well as contributing to food security, optimizes productivity with efficiency and competitiveness. Apparently, sustainable intensification requires a holistic approach around the following:

- **Conservation agriculture (CA):** CA is characterized by three linked principles– continuous minimum mechanical soil disturbance, permanent

Participants attending the Policy Dialogue

organic soil cover and diversification of crop species.

- **Integrated nutrient management (INM):** INM comprises right management of fertilizers and biological processes such as organics, mulching and microorganisms to provide and recycle nutrients to sustain productivity growth without adverse ecological consequences.
- **Integrated pest management (IPM):** IPM reflects an integrated approach for containing pests (diseases, insects and weeds) below the economic threshold using cultural methods, resistant varieties, habitat manipulations and minimal pesticide use.

Hence, CA aims at yield optimization in a more sustainable way, while reducing cost on inputs like energy, water, labour, nutrients, etc. According to FAO (http:// www.fao.org/agriculture/crops/core-themes/theme/spi) estimates, GHG emission with CA cutback was equal to savings in fuel by 40-70 per cent; input manufacturing like biological processes replacing functions of machinery by 50 per cent; fertilizer use by 30-50 per cent; and pesticides use by 20 per cent. Adoption of all elements of CA is necessary to have economic and environmental benefits.

Initiatives on Conservation Agriculture (CA)

The concept of CA to save land from adverse consequence of erosion was adopted in the USA as early as in 1930s. Thereafter, the concept spread to Brazil, Argentina and other parts of the world. In South Asia, the concept of CA got attention during mid-nineties when the Rice-Wheat Consortium (RWC) for the Indo-Gangetic Plains was launched, involving India, Pakistan, Nepal and Bangladesh. It was initiated in a collaborative mode by the World Bank, involving all the four National Agricultural Research Systems (NARS), and was facilitated in turn by the ICRISAT, CIMMYT and IRRI. Being a unique ecoregional program, additional funding support was also provided by the USAID, ACIAR and ADB to the RWC. Through facilitation by the RWC by 1999-2000, zero-till wheat was practiced in about 10,000 ha. In 2002, RWC and its collaborators helped introduction of second generation zero- till seed drill. This development stimulated adoption of CA further, and contributed to rise in area under CA to 2.2 mha in 2004-05. Of late, CA spans on an area of 5.0 mha in South Asia; ~75 per cent in India, ~20 per cent in Pakistan and remaining 5 per cent in both Bangladesh and Nepal. Additionally, emphasis on the laser land levelling strengthened significantly the impact of CA practices. Impressed by the success of the RWC across South Asia region, as a unique ecoregional program in South Asia, the CGIAR conferred upon it the prestigious King Baudouin Award.

Concerns on Slow Spread of CASI

Despite impressive growth in acreage, barely 2 per cent of the arable land (210 mha) in South Asia is presently under CASI. Moreover, there are very few instances of acceptance of full CASI practices; mostly it was the adoption of 'zero-till' practice and that too confined to wheat and lately to maize. The practice of puddled rice remains a big hindrance, since surface presence of crop residue inconveniences cultivation of a submerged field (puddling). On the other hand, despite the proven superiority of CASI in rainfed areas (around 60% area in India), it continues to be grossly underutilized in South Asia. Majority of the South Asian farming community persists with the clean cultivation, and hence is reluctant to believe in the efficacy of sowing in a straw-mulched land surface. Even the extension functionaries have limited knowledge on scientific, economic and environmental benefits of CASI. As a result, CASI rarely forms part of the packages of practices. Moreover, CASI demands farmers'

participatory research approach, which remains largely neglected. Resultantly, CASI thus far did not get the needed attention for R&D funding and policy support that it deserved despite the availability of credible evidence on the economic and environmental benefits of CASI practices. Also, CASI research in the past was mainly focused on ricewheat irrigated system. The present need is for diffusion and adoption of CASI in irrigated upland and rainfed ecologies. Above all, CASI is more than a costcutting technological option, as it leads to sustainable intensification, while providing environmental services as national public good. Notwithstanding, CASI spread continues to be rather slow and thus requires a major policy thrust and that too in a Mission Mode.

Road Map for Scaling CASI

- Conceptually, CASI is not a single technology. It is an innovation for sustainable farming, assimilating effective germplasm/crops, integrated nutrient/pest management, minimal and efficient farm mechanization, and efficient soil and water management practices. Therefore, it requires application of farming system' related coherent interventions that would increase both income and adaptive capacity of farmers for diversified as well as resilient agriculture. Additionally, its infusion is seen to sustain ecological services and in providing greater environmental benefits to the countries of the region. Hence, CASI being a national/regional/ international public good, it needs to be outscaled to reap multidimensional benefits.
- Farmers in South Asia are predominantly small and marginal with a limited risk taking ability. Hence, outscaling of CASI principles has to adopt farmers' participatory approach, requiring on-farm research, validation, refinement and faster adoption methodology.
- Noticeably, the complexity of scaling CASI related innovations calls for inter-disciplinary and inter-institutional collaboration. Thus, it necessitates combined action by the drivers of change – farmers, scientists, development officials, NGOs, entrepreneurs and the policy-makers. For this, a 'Mission Mode' program/ approach is warranted urgently for joint regional action to have the needed impact on scale.
- Given the intricacy of the process to effect change in soil and crop management practices, scientists, engineers and extension workers (both public and private) would need to impart knowledge to practitioners (farmers) regarding CASI principles and practices without any dissemination losses. This calls for greater emphasis on translational research and transformational action for scaling CASI in South Asia, which has so far lagged behind other regions (South America, USA, Canada and Australia).
- Convincing farmers, which goes beyond filling knowledge gap, would require linking science to society. In pursuance of this, a paradigm shift from routine component based short-term research to innovative, result-oriented, system-wide long term research is warranted. From organization standpoint, forging alliance of innovators, social scientists, public development officials, policymakers, NGOs and the private sector would ensure faster and desired impact of conservation agriculture for sustainable intensification (CASI). Perceptibly, smallholder farmers adopting CASI are contributing towards ecological services that are inherent to the land biosphere. In recognition furthering the cause of environmental services, the resource poor farmers be compensated/ rewarded suitably. Besides cash dividend, they be provided with tools and tackles facilitating application of CASI technologies, Extending incentive for not burning straw, free custom hiring of zero till machinery and cheap credit are the three examples of this genre. Such bold policy decision would inspire farmers ensuring faster scaling of CASI in South Asia.
- Political commitment and much needed policy support will be necessary to make CASI an integral part of: (i) country's development agenda aiming at resilient agriculture, adoption of improved technologies such as: efficient crop, water, nutrient, energy use, etc. and (ii) action plan to fulfil obligations under international treaties and conventions such as: climate change, desertification, Convention on Biological Diversity (CBD), SDGs, etc. Guided by the quality of native biophysical resources and socioeconomic situation of farmers, the policy instrument, hence, would have to be region/country-specific.
- Irrefutably, increased budgetary provision (almost four times), supporting CASI application, is urgently needed for sustaining farm profitability and national food and nutritional security, conserving available natural resources and containing GHG emissions. Primarily, a national funding promise such as "National CASI Mission" would be the need of the hour to scale CASI practices both in rainfed and irrigated areas. CASI can also be made an integral part of the on-going public funded schemes of the Governments. Like in India: RKVY-*Rashtriya Krishi Vikas Yojana* (National Agriculture Development Scheme); in Nepal: Prime Minister's Agricultural Development Program; and in Pakistan, aligning CASI with commitment for Paris Agreement on Climate Change. Yet, complementary international funding would be essential to scale-out innovations around CASI. To catalyze donors and policy- makers, it would be desirable to organize a 'Funders' Forum' to ensure scaling of the CASI in South Asia.
- Though the positive ecological outcomes of CASI are perceived to be local, these do spill far beyond the boundaries of a nation and even the region. Moreover, what a country does to its natural resources influences greatly environment of its neighbours as well. Although local legal measures are necessary to nip the on-site generation of adverse outputs (like smog from burning of straw), yet to contain the off-site spread, application of CASI principles and practices would essentially require a

"South Asia Regional Platform for the Conservation Agriculture for Sustainable Intensification (SARP 4 CASI)" through an effective collaboration and a firm commitment of all national leaders, institutions (NARS), donors and the CG Centres actively engaged in promoting CASI in South Asia.

- Such a platform, (SARP 4 CASI) once established on the principles of earlier rice-wheat consortium (RWC), to share knowledge/success stories, technological options/innovations, expertise, etc. would require effective NARS partnership. It could be facilitated by one of the CG Centres actively involved in research and development on CASI practices, such as the CIMMYT through its two major regional programs: CSISA (funded by BMGF and USAID) and SRFSI (funded by ACIAR). Involvement also of other CG Centres and institutes like IRRI, ICRISAT, ICARDA, ILRI, ICRAF, BISA, etc. and the National/Regional Fora such as APAARI, SAARC, TAAS, etc. would strengthen further the initiatives on the CASI, so essential for achieving SDGs in the region.

Policy Brief 4 : Incentives and Strategies for Scaling-out Innovations for Smallholder Farmers

(Policy Dialogue; 30-31 October, 2017)

Background

In India, agriculture plays a pivotal role in ensuring food security, reducing poverty and malnutrition, and promoting overall economic development. Innovations and their dissemination contribute significantly in acceleration of agricultural development and in realization of the Sustainable Development Goals (SDGs). Therefore, greater emphasis has been given on scaling-out agricultural innovations. Since industrialization, agricultural innovations in the developing countries were predominantly developed by the public sector. Private sector, including multinational companies (MNCs), has entered in this arena quite lately. With the economic liberalization of agricultural sector in India, private investments in agricultural innovations have increased. A number of national initiatives in policymaking (e.g. IPR policy) and in flagship programs (Make in India, Skill India, Start-up India, Digital India) have been started to foster innovations.

Dr RB Singh expressing his views during Inaugural Session

Dr R.S. Paroda speaking on innovation for smallholder farmers

The National Agricultural Research System (NARS) had undergone many policy reforms in research, intellectual property rights (IPRs) and technology transfer. Appropriate seed money was also given for producing basic material to spread the technology and to promote the innovation in the technology-delivery system. Later in 2006, the Indian Council of Agricultural Research (ICAR) prepared guidelines for the management and commercialization of intellectual property (IP). The guidelines outlined the incentives and rewards for outscaling innovations and for resource generation through commercialization of IPs. A very large number of agricultural innovations have been commercialized earlier. In order to address the vital issues in agricultural sector in near and distant future, innovations in various fields are the need of the hour. Challenges of food insecurity, climatic change and low profitability of farms are some of the issues where the country needs innovations.

Role of private sector, though well realized and appreciated in inputs development and delivery (seeds, fertilizers, pesticides, cold storage/ chain solutions, etc.), still needs to be examined and extended to other nonconventional research and development (R&D) areas like basic research and for long gestation technologies under the public-private partnership (PPP). The business environment, on the other hand, is becoming more and more complex and technical with the passage of time. To be globally competitive and moving on the journey towards curtailing trap of middle income, this is the right time to develop innovations and upscale them, and promote agri-IPR management activities in the national systems. Hence, there is an urgent need to revisit technology dissemination and commercialization mechanisms and associated policies to draw a road map for enabling policy environment and incentives and rewards for the innovation process.

In this context, a policy dialogue on "Incentives and Strategies for Scalingout Innovations for Smallholder Farmers" was jointly organized by the Trust for Advancement of Agricultural Sciences (TAAS) and the Indian Council of Agricultural Research (ICAR) at the NASC Complex, New Delhi on 30-31 October, 2017. The

Participants attending the Policy Dialogue

dialogue was attended by participants from public, private and Consultative Group on International Agricultural Research (CGIAR) systems.

Recommendations

Innovations have played and will continue to play important role in agricultural transformation globally. The innovation process involves multiple stakeholders and the right policy environment to innovate and its outscaling for impact in the broader national agricultural perspective.

- Agricultural research must move from commodity centric to 'systems approach,' and all stakeholders (farmers, private sector, NGOs, etc.) should be part of the research and innovation continuum. Hence, institutional/innovation platforms are essentially needed to encourage much needed scientist-farmer, and public private partnerships.
- To achieve an innovation-driven agrarian economy, innovation capacity of the research and development systems, civil society organizations, and farmers should be developed. For this purpose, intensity of public investment would have to be enhanced considerably. Also, greater attention would be needed towards capacity development of people responsible for scaling out innovations and their successful commercialization.
- There is an urgent need to strengthen existing technology transfer system within the NARS (front-line extension, Agri-Business Incubator, Agrinnovate India Ltd.) and to establish technology parks for commercialization both in ICAR and SAUs. Also, it requires placement of adequate manpower, financial resources and freedom to operate. Convergence of technology and diversification of extension and other service systems are also critical for outscaling innovations.
- The available innovations, including those that are farmer-led, must be assessed for validation, refinement and prioritization, based on their commercialization potential. This should also entail identification of suitable partners for initiating successful ventures. Financing, risk management and incentives for outscaling innovation are necessary to encourage potential entrepreneurs.
- An Innovation Platform would help accelerate scaling-out innovations, and therefore, an 'Agri Innovation Board' should be established urgently in the Ministry of Agriculture and Farmers Welfare. This Board must be headed by an eminent agricultural scientist and its members should be selected from different Ministries, including Finance, Commerce and Industry.
- To begin with, the Board should have a minimum of Rs 1,000 crores for financing activities to scale-out agricultural innovations. This can be from the existing funding support for innovation (Start-up India, Atal Innovation Scheme), or a separate funding mechanism such as the National Innovation Fund, initiated by the Council of Scientific and Industrial Research (CSIR).
- Concerned ICAR institutes and SAUs must ensure providing skill-based certificate training for entrepreneurship, and in addition should provide much needed backstopping services so critical for successful scaling-out of innovations. The manpower so trained can work as para-innovators or technical service providers. Also, to link with the industry, ICAR would need to develop an effective partnership with organizations, such as the Federation of Indian Chambers of Commerce and Industry (FICCI), the Associated Chambers of Commerce and Industry of India (ASSOCHAM), Confederation of Indian Industry (CII), etc.
- Farmer Producer Organizations, self-help groups, cooperatives, producer companies, etc. could effectively be involved for out-scaling innovations. These organizations should have easy access to technology, financial services, including credit, and hand-holding from public organizations for promoting demand-driven innovations in the broader national interest.

Participation of private sector in R&D and upscaling and outscaling of innovations need an enabling policy environment and access to public technology and other resources. To facilitate this, the Government should move from "directive" to a "facilitative" role. This may also require revisiting of existing regulations to provide a "predictable and enabling" regulatory framework. Also, incentives and rewards to the innovators should be put in place to sustain their interest in outscaling innovations and providing much needed technical backstopping.

Policy Brief 5 : Agricultural Policies and Investment Priorities for Managing Natural Resources, Climate Change and Air Pollution

Agriculture is an engine of inclusive economic growth as a major source of livelihood for millions of smallholder farmers and other rural residents in India. Having made significant strides in food production,

Dr R.S. Paroda discussing with other experts during the Round Table Dialogue

through the Green, White, Yellow, and Blue Revolutions, Indian agriculture is now at a cross road. Deterioration in the quality of natural resources (soil, water and air) together with the adverse effects of climate change pose significant threats to the sustainability of agricultural production and farmers' incomes. The situation in the Green Revolution corridors of India is especially daunting with severe problems of hydrological imbalance, soil degradation, and water pollution. In addition, the problem of air pollution from crop residue burning has emerged as a major cause for national and international concern because of its enormous environmental and health costs across the Northern plains of India. These worrying trends have led policy-makers to recognize that past strategies adopted for agricultural growth need to be re-adjusted, with the benefit of the same far-sighted vision as in the case of Green Revolution, to address these emerging complex challenges, fully exploit the potential opportunities for inclusive but sustainable growth, and promote rural prosperity.

The Round Table Dialogue

To outline an action plan and priorities for investments that address the key challenges holistically, a one-day round table dialogue on "Options and Investment Priorities for Conserving Natural Resources, and Addressing Climate Change & Agricultural Pollution" was organized on 9 April 2018 at NASC Complex, Pusa, New Delhi. The dialogue was jointly organized by the Trust for Advancement of Agricultural Sciences (TAAS), International Maize and Wheat Improvement Center (CIMMYT), Indian Council of Agricultural Research (ICAR), the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), and the World Bank Group. A total of 50 senior policy planners from NITI Aayog, Ministry of Agriculture & Farmers' Welfare (MoA&FW), Department of Agriculture Research & Education (DARE), Chairpersons of Farmers Commissions of Punjab and Haryana, senior policy planners from the state governments, research leaders from ICAR, State Agricultural Universities, CGIAR Centers (CIMMYT, IFPRI, ICARDA, ICRISAT), Advanced Research Institutions, NGOs, agricultural experts, and the potential donor organizations including World Bank, NABARD, IFAD, ACIAR, participated in the Round Table Dialogue and deliberated upon issues that addressed the following objectives:

Participants during book release

- To consider the potential options and investment priorities for sustainable intensification and resilient growth in Indian agriculture in accordance with the Paris Agreement and the UN Sustainable Development Goals (SDGs).
- To identify the areas of analyses for articulation of the strategies, policies and technology options with potential tangible benefits that address the agriculture-water energy-environment nexus, and specifically the urgent problem of air pollution.
- To identify opportunities for scaling conservation agriculture for sustainable intensification through partnerships/networking.

The Challenge

The land available for cultivation has no scope for further horizontal expansion in India. With continued rise in population, current agricultural practices are severely stressing the natural resource base, with rapid declines in soil health, water availability and quality, loss of biodiversity, and rising air pollution. The natural resources in India are estimated to be 3-5 times more stressed compared to the rest of the world. The extent of land degradation is alarming (114-145 million ha). A large fraction of agricultural soils in the Green Revolution belt now considered to be practically infertile, with their native productive capacity declining below the estimate threshold level for sustainable agricultural production. India ranks at the top in the world in terms of withdrawal of fresh water from aquifers (761 km^3 per year). And with a replenishment rate well below the withdrawal rate, especially in north-west India, many districts have experienced a decline in the water table of over 0.50 meters per year, reaching critical levels. Inefficient use and mismanagement of land, water, energy, and agro-chemicals jeopardize soil fertility, and adversely affect the quality of both water and the environment. It is well recognized that existing policies to provide free water and energy, subsidized fertilizers, and the continued reliance on the food distribution system promote inefficient use of inputs and resources, and drive the environmental degradation. Further, climate change and agriculture are closely interrelated, and the projected impacts of climate change-induced weather variability are a serious threat to agricultural production, food security, and livelihoods of farming communities in all agriculture dominated economies.

Participants attending the Round Table Dialogue

While adaptation to climate change is necessary to ensure food security and protect livelihoods of farmers, mitigation of greenhouse gas (GHG) emissions is critical to lessening the future impact of climate change. It is also evident that improved agricultural practices can help mitigate GHG emissions without compromising food production goals. India is the third largest GHG emitter in the world, and agriculture is responsible for 18 per cent of it's total emissions. India's Nationally Determined Contributions (NDCs) to United Nations Framework Convention on Climate Change (UNFCCC) pledges to reduce emission intensity of its GDP by 33-35 per cent by 2030 from 2005 levels (http://www.moef.nic.in/climate-change-docs-and-publications). Accordingly, India has rightly identified agriculture as one of the priority sectors to reduce emissions in its Nationally Determined Contributions (NDCs). This requires a clear strategy and action plan to address specific aspects of the agriculture water-energy-environment nexus. A number of scientifically robust, climate-smart, sustainable agricultural intensification technologies and practices are available, which need to be scaled-up urgently with the adoption of appropriate policies and strategies backed by appropriate investment options.

Technological Options

A number of technological innovations exist for more sustainable management of natural resources, build resilience to climate change, and dramatically reduce agriculture sourced air pollution. Among these, conservation agriculture (CA) with the principles of zero tillage, soil cover using organics, and diversified crop rotations are well developed and validated with proven multiple benefits. The scope for scaling–up CA-based systems in both the irrigated as well as rainfed cropping systems is vast. For agricultural diversification, low water-use crops are available that provide higher farmers' incomes while having a positive effect on natural resources.

Similarly, technical options are available to address the problems of indiscriminate use and over pumping of ground water, which results in the rapid depletion of water resources threatening agricultural sustainability. Efficient water management systems such as pressurized irrigation systems (sprinkler and drip irrigation) as well as automated irrigation management systems can lead to substantial saving of water. Even in flood irrigation systems, the traditional methods of land-preparation cause significant loss of water, which in turn leads to poor crop establishment, reduced efficiency of inputs, and lower agronomic yields. The laser-assisted precision land-leveling is a proven technology with significant potential for scaling-up.

Balanced application of nitrogen and other fertilizer nutrients can optimize food production while reducing GHG emissions. Efficient and appropriate use of fertilizer nutrients in smallholder farming systems is possible with decision support tools, sensors, and precision management methods that can be adopted and applied with significant potential benefits. Increase in fertilizer-use efficiency combined with improvement in soil health and soil organic carbon (SOC) concentration can substantially reduce use of fertilizers and decrease emissions of GHG, while increasing and sustaining agricultural production.

Finally, several options are also available to reduce agriculture biomass burning, which has emerged as a major contributor to air pollution and soil degradation. The best option to address this consistently with the goal of sustainable agriculture, though improved soil health, is to utilize the crop residues on the field itself. The Happy Seeder technology coupled with Super Straw Management System (SMS) mounted combine harvesters is an innovative and potentially scalable solution to achieve this. For increasing farmers' profits, conserving natural resources and building resilience while attaining food and nutrient security, science-based integrated farming systems must be developed,

validated and scaled-out on priority for their large-scale adoption.

Based on a pan-India study by CIMMYT-CCAFS-ICAR University of Aberdeen, it is roughly estimated that the technical mitigation potential of Indian agriculture is 85.5 Mega tons CO_2-e which represents a significant share (approx. 20%) of the total emission from agriculture. To achieve this, technical mitigation potential, supportive policies and investments are needed to promote viable solutions and widespread adoption by farmers.

Policies and Investment Priorities

The concerns of sustainable management of natural resources (soil health, quality of water, air, etc.) need urgent attention. The current status and trends in soil health, water availability and air quality are far below desirable standards to nurture and sustain healthy lives. Soils in the Indo-Gangetic Plains are severely degraded with soil per cent, which is far below the critical threshold of 1.5 to 2.0 per cent needed for healthy soils. If this declining trend is not checked and reversed on a priority basis, the implications for food security and environmental quality may be catastrophic in terms of productivity decline. Looking at investment opportunities, the technological options indicated above need to be scaled-up through supportive policies, institutions and incentive structures that would help reduce agriculture's environmental footprint, conserve natural resources, and ensure sustainability of food production. Among these, the following policies and investment priorities merit consideration:

- The current focus on doubling farmers' incomes marks a paradigm shift in India's approach to agriculture, which requires to be more productive, sustainable and resilient. This can be achieved by scalingup conservation agriculture practices, promoting appropriate and competitive agricultural diversification, and adopting an integrated farming systems approach that considers socio-economic and bio-physical trade-offs, and promotes climate-smart agriculture.
- Efficient use of water and nitrogen will help to simultaneously attain higher productivity and reduce agriculture's environmental footprint. A policy decision to ban flood irrigation and broadcast application of fertilizers in a phased manner should receive immediate attention of the government. Also, there is an urgent need to reconsider policies, especially on incentives and subsidies that promote the overuse of water and nitrogen, and discourage the uptake of tools and practices (microirrigation-cum-fertigation, minimum tillage, laser land leveling, mechanical drilling/banding of fertilizers, sensors and decision support tools for automation of nutrient and water application, etc.) that will promote greater resource use efficiency on farms.
- Restoring soil health at scale requires a focused national initiative on soil carbon sequestration. This initiative would necessitate strengthening the capability, efficiency and infrastructure of laboratories undertaking soil health analysis for desired nutrient and water management. Therefore, as a part of the carbon farming initiative, setting-up of state-level automated referral laboratories is urgently needed. Also, state level soil health reports for farmers should be prepared on a five-yearly basis to facilitate the adoption of corrective measures on farms.
- Mining of clay for brick making needs to be restricted to appropriate sites with deeper soil depths and strongly discourage the use of top soil from agricultural lands. The site selection for mining clay can be decided with the support from the Bureau of Soil Survey and Land Use organic carbon (SOC) content estimated at or below 0.5 Planning along with the Department of Geology at the state level.
- An effective solution to control open burning of crop residues is to promote in situ recycling and management of crop residues. The current design of mechanical harvesters (combines), the narrow window of time available for planting the subsequent crop, and the high cost of labor create the incentives for farmers to burn the residues. In situ management would not only control air pollution but provide much-needed organic matter to restore soil health. A technical solution to this problem is the concurrent use of Straw Management System (SMS) with combine harvesters, followed by Happy Seeder for planting the next crop. Wider use of these machines needs a viable business model and a careful assessment of the farm level constraints (and trade-offs) to its scalingup.
- Investing in climate-smart agriculture (CSA) is a high priority not only for restoring soil and conserving natural resources but also to achieve the goal of doubling the farmers' income. There is large untapped potential for increasing productivity under rainfed agriculture by bridging the yield gaps through Natural Resource Best Management Practices (NRBMPs).
- Investments in "Scale Appropriate Farm Mechanization" should be promoted all along the agricultural value chain, i.e., planting, harvesting, processing, and marketing, within a broader sustainable farming systems perspective. Viable business models to scale-up such technologies and services need to be promoted by motivating and attracting youth in agriculture (MAYA). This requires skills development, entrepreneurship training, and leveraging financial institutions. Government initiatives on small farm mechanization need to be complemented with efforts to overcome the farmers' information gaps and induce behavior change for faster adoption of mechanization by farmers.
- The whole process of technology development, adoption, and scaling needs to be made more socially inclusive to ensure relevance and acceptance under farmers' own circumstances. Concerted

efforts are also needed to re-orient knowledge management and sharing digital technologies and artificial intelligence can be used for better, faster and more cost-effective identification and dissemination of natural resource management (NRM) and climate-smart solutions at scale. A key element for building climate resilience in agricultural management decisions, better manage climate risks, improving production efficiency and conserving natural resources is near real-time, targeted and actionable dissemination of weather/agriculture advisories to farmers. Since NRM calls for the concerted approach at the landscape level, mobilizing social entrepreneurs/stimulants/village jankars to stimulate the necessary community action and achieve scale for impact will be needed.

- The current system of subsidies can be repurposed to promote sustainable practices that restore our natural resource base. A suitable incentive mechanism for rewarding farmers for provisioning of ecosystem services and in the larger national interest of environmental stewardship, therefore, merits serious consideration. In this regard, quantification and payments through a mechanism like carbon trading, as practiced in advanced countries, would help in faster scaling of innovations of conservation agriculture based sustainable intensification (CASI). Accordingly, for adoption of CASI technologies, incentives in the form of payment for environmental services that are mainly in the national interest, has to be in place. In this context, to promote an estimated SOC sequestration of 0.33 metric tons per hectare per year, payment for environmental services to farmers at the rate of Rs. 2,500/hectare/year need to be considered. A "National Initiative on Payments for Ecosystem Services to Farmers" need to be established.
- Studies on the economic returns to investments in major soil health and natural resource management technologies should be undertaken to draw implications both at the micro level (to assess their financial attractiveness for farmers to adopt them), and at the macro level (to assess the socio economic trade-offs), including positive and negative environmental externalities. Maximizing the impact of investments necessitates a focus on technologies with multiple benefits, with high priority on those providing triple wins (in terms of farmers' incomes – through improvement in productivity and efficiency; sustainable use of natural resources for better climate adaptation; and creating co-benefits in terms of mitigation.
- Since agriculture is a state subject in India, the investment needs so carried-out by the State Governments should be met on priority either by Central/State initiatives or by seeking funding support, from Overseas Development Agencies (ODAs). Accordingly, the policy support should be seen as a bottom-up initiative that is geographically differentiated and flexible in its implementation to address the problems relating to agriculture and beyond.
- Strengthening the technical, institutional and financial capacities of farmer producer groups, farmer producer organizations and agri-entrepreneurs with a focus on women farmers can necessitate farm-based collective action towards effective implementation and monitoring of eco-friendly solutions.

Policy Brief 6 : Framework for Increasing Private Sector Investments in Agriculture and Enhancing the Global Competitiveness of Indian Farmers

(Roundtable Discussion: 4 December, 2019)

Background

India has emerged to be a vibrant economy. The reasons had been: enabling policy and regulatory environment, increased capital investment for critical infrastructure, good institutions, competent human resource and the global partnership for access and scaling of innovations. As a result, India could achieve household food security and a significant decline in poverty. It also attained diversified agricultural growth through White, Blue, and Rainbow Revolutions, etc. Equally impressive had been the achievements for agricultural exports now touching almost US$ 40 billion.

Despite these, second generation problems of Green Revolution such as factor productivity decline, depletion of natural resources (soil, water, biodiversity, etc.), decline in the income of farmers, etc. have emerged as major concerns. Also, meeting the sustainable development goals (SDGs), especially the concerns of poverty, hunger and environmental sustainability, and the adverse impact of climate change are the additional challenges to be addressed on priority not only by the Government alone but by all stakeholders.

In this context, the private sector holds key to accelerate further the present agricultural growth, which is around 2.9 per cent, by enhancing investments

In-depth discussion among senior level officials

Ashish Bahuguna expressing his views

in R&D as well as in infrastructure and to ensure desired efficiencies in agricultural value chain through timely service delivery and linking smallholder farmers to market. The public-private partnership (PPP) is also critical to harness diverse talent (especially youth, including women) and modern technologies, backed by resources, corporate work culture and new business skills in pursuing sustainable development goals.

Currently, there are various challenges facing the Indian private sector engaged in agriculture. Some of these are: i) meeting nation's household food and nutritional security (food demand of about 350 million tons by 2025), ii) changes happening in the consumer preferences towards healthy foods (5-6% CAGR of fruits & vegetables and pulses), iii) increased stress on agri-production due to decline in resources (decreasing size of land holdings, decline in soil health and water availability, agri-labour migration to non-farm jobs), iv) expected adverse impact of climate change (54% of India faces high or extremely high water stress), v) food wastage across the value chain (fruits & vegetables up to 37% and cereals up to 25%), (vi) lower profitability for the farmers, vii) lack of rural infrastructure to support on-farm and off-farm activities, viii) existing yield gaps in many important crops, ix) lack of interest among youth in agriculture, and x) adverse impact of agriculture on environment, especially on soil health, water, quality of air and on food safety.

Further, under the current scenario, an urgent reorientation of agricultural policies, research priorities and advisory services defining a comprehensive framework is urgently needed, which defines clear goals for the stakeholders (farmers, scientists, government, private sector: both agri-input and output industries, and NGOs) to be achieved. The needed key policy interventions in Indian agriculture include: i) making agriculture attractive, remunerative and globally competitive with better opportunities for employment in and around agriculture, ii) enhanced marketing options (both domestic and global), and iii) reduced pricing risks. Accordingly, the private agri-input industry has a major role and responsibility for: i) investing in developing and popularizing science based agronomic practices that are climate-smart and financially viable for the farmers, ii) creating and respecting intellectual property that is legally tenable and ethically sound, iii) providing effective technical advisory services to the farmers to adopt good agronomic practices (GAP) around sustainable intensification, and iv) producing and making available various products of high quality meeting the expectations of farmers.

India is the first country in the world to make corporate social responsibility (CSR) mandatory, following an amendment to the Companies Act, 2013 in April 2014. The inclusion of CSR is an attempt by the Government to engage private sector businesses with the national development agenda. As per the Act, every company (private limited or public limited) which either has a net worth of Rs 500 crore or a turnover of Rs 1,000 crore or net profit of Rs 5 crore, needs to spend at least 2 per cent of its average net profit on CSR activities relating to agricultural research, education, extension and development. The private industry working in agriculture, covering both inputs and outputs, has a significant expenditure on the CSR activity. In this regard, the private sector participation in the national agricultural extension system to provide good knowledge and for skill development, especially of youth, could be of great benefit.

For developing strong public-private partnership (PPP), there is strong need to build mutual trust between the Government and the industry. Private sector can provide support in areas like rural infrastructure, training and capacity building, establishment of agri-clinics, value chain development, linking farmers to markets and in technology development involving youth (including women) for increasing farmers' productivity and profitability through secondary and specialty agriculture. Therefore, for future growth acceleration, the private sector has to play a proactive role in creating much needed 'Agri-Youth Innovation Corpus Fund' and enhance rural employment through special projects. Such an effort would enhance rural

Delegates participating in the Roundtable Discussion

employment opportunities through small agri-business start-ups, public-private as well as private-private entrepreneurship. The private sector can also help in providing soft loans and in mentoring programs for the rural youths to become agri-entrepreneurs, input dealers/suppliers, technical service providers and paid extension agents.

In order to discuss threadbare the above critical issues, a roundtable discussion on "Policy Framework for Increasing Private Sector Investments in Agriculture and Enhancing the Global Competitiveness of Indian Farmer" was organized by the Trust for Advancement of Agricultural Sciences (TAAS) at Taj Palace Hotel, New Delhi on 4th December, 2019. A total of 37 eminent experts, administrators, policy planners, farmers and the industry stakeholders participated.

Recommendations

The Road Map For increasing the private sector investments in agriculture and enhancing the global competitiveness of Indian farmers, there is an urgent need for policy reorientation. To ensure having a sound strategy and action plan for timely implementation, the following Road Map is proposed based on the Roundtable discussion:

I. Policy framework for increasing private sector investment

1. There is an urgent need for a paradigm shift from production oriented policies to market driven policies which will attract private investment in agriculture. These include:
   - The Essential Commodities Act in its present form is no longer relevant as India has moved from a shortage economy to a surplus economy concerning agricultural production and hence this Act needs to be revisited and modified suitably to avoid restrictions on movement of agricultural produce.
   - APMC Act needs to be amended to facilitate better price realization by the farmers. All the restrictions on the farmers/producers, especially for sale of perishable vegetables and fruits, as well as for price fixation need to be removed. Assessment of quality parameters by buyers should be made professional with accurate measurement systems. All the mandis need to be modernized with improved infrastructure and use of new age digital technology. Also, the mandis need to be privatized on the pattern of airports, for better efficiency, transparency and greater private sector investment.
   - An effective rural based primary value chain needs to be developed to reduce post-harvest losses and avoid the distress sale. Farmer selfhelp groups (SHGs), cooperatives and farmer producer companies (FPCs) be incentivized to aggregate agri-production and ensure effective linkage to markets. The markets need to be opened to private sector, including progressive farmers and the youth (including women).
2. Priority attention needs to be given to liberalize important factors of production like land, water and seeds through:
   - Establishing open land lease markets to attract greater private sector investments for setting-up high value agriculture around secondary and specialty agriculture. Reviewing Land Ceiling Act and liberalizing provisions for consolidation of land holdings, while ensuring minimum farm holdings not less than 1.0 ha. Also, private sector involvement is critical to make farming operations more efficient through adoption of modern technologies and farm machinery.
   - Promoting micro-irrigation in a mission mode and allowing private industry to compete through bidding and investing in the irrigation projects. Also, there is need to open up water ways for development and use by the private sector in order to ensure efficiency.
   - Creating a supportive and time bound regulatory/policy environment to apply modern science and technology for the production of quality seeds including the use of GM crops, new plant breeding innovations like gene editing and other modern technologies such as: geographic information system (GIS), artificial intelligence (AI), robots, drones, big data, etc.
   - Regulatory procedures and protection of intellectual property (IP) for innovations around various agriinputs need to be improved in line with global standards. An integrated IP policy needs to be in place and has to be implemented ruthlessly by the Government. Enforcement of IP laws by the Centre and States is critical for attaining greater success.
3. Greater thrust needs to be given to increase non-farm income. This could be done through generation of energy (biofuel, solar or wind energy) or by enhancing input-use efficiency, postharvest management and value chain that would generate additional income for the farmers.
4. There is need to create a few world class food and agricultural education institutions/universities with provision for equal shareholding by the Government, domestic /global private sector with their autonomous governance. Such institutions will bridge the gap between farms and markets and will create high quality human resource through quality education in agriculture starting from secondary and higher education levels. Some of the premier institutions like Indian Institute of Management (IIM), Indian Institute of Technology (IIT), etc. could be good models in making agriculture both efficient and profitable to the farmers as well as consumers.

5. Increasing private sector investments in agricultural research, innovation and development through various ways is extremely important:
   - There is need to promote research programs/ projects of ICAR in collaborative mode and even devolve research initiatives like hybrid research in selected crops to the private sector for conducting research. Government should clearly identify and announce areas of priority for private sector investments with longterm enabling policy framework. Also, Government policies need to be reoriented to eliminate unsustainable practices by the farmers – like water consumption, power consumption, fertilizer use, etc.
   - Government has to seriously think about bringing disruptive changes in the functioning of agricultural sector so as to ensure transformational change that will incentivize private sector to invest heavily in the agriculture sector. Government policy should promote R&D and innovation – by having clear policy on intellectual property (IP) protection, creating large public-private partnership based research projects, and creating a national innovation fund of Rs 10,000 crore to encourage innovation and entrepreneurship. The scope and guidelines for use of innovation fund needs to be developed. There is also a need to provide incentives for scaling innovations both by the national and international private sector R&D organizations, for which an enabling environment through quick release of national license to R&D companies, IPR for innovations, joint venture between public and private sector institutions, etc. shall have to be created at the soonest possible.
   - Specific policy support needs to be provided for increasing the role of science and technology in agriculture, especially to counteract the negative perception created by the vested interests. The scientists working with Government institutions should be encouraged to support science and technology initiatives by the private sector in the larger interest of the county and the farmers. For this, there is need for creating confidence among general public through awareness programs (example: nano technology and artificial intelligence in fertilizers and pesticides, GM technology in seeds, etc.).
   - Large scale promotion of nutri-crops rich in minerals and micronutrients is required to improve nutritional and health standards of our people. Also, the policy environment be created to support contract cultivation, corporate cultivation and price discovery mechanisms to facilitate their large scale cultivation. This will also help in addressing the concern of existing micronutrient deficiency among Indian population.
   - All subsidies being given by the Government need to be converted into incentives and the process is restructured to promote efficiency through sustainable practices by farmers and to ensure value chain creation through greater collaboration between public and private sectors. In this context, the recommendations of Paroda Committee submitted to the office of Principal Scientific Adviser (PSA), GoI be considered for implementation at the soonest possible.
   - Government may set-up an appropriate institutional mechanism to facilitate regular policy consultations with the private sector and build much needed confidence among them in order to increase their investments in creating infrastructure, modernizing markets, primary processing and value addition, creating rural infrastructure, improvement of rural sanitation, education and health, peri- urban agriculture, etc.
   - It is high time that Government starts thinking comprehensively as to how to facilitate taking farmers out of agriculture gradually to other livelihoods for better economic growth. For this to be a reality, needed capacity development initiatives shall have to be strengthened.
   - There is vast opportunity to promote agri-exports from India, which requires large scale private investments in contract production, quality management, processing and packaging technologies, value addition, storage and other links in the value chain. For this, the Government shall have to create a long- term and enabling policy environment for export.
6. Schedule 7 of Companies Act concerning use of Corporate Social Responsibility (CSR) funds needs to be revisited and amended to categorically include the investments by the corporate sector so as to accelerate the growth of Indian agriculture. This has to be ensured through:
   - Greater capital investments in agriculture by the corporate sector, as envisioned in the National Agricultural Policy (2000)
   - PPP projects for research on new innovations that help agricultural production and profitability of smallholder farmers
   - Developing and popularizing science based good agronomic practices (GAP) that are climate-smart and financially viable
   - Establishing infrastructure and conservation assets that will help the farmers in practicing sustainable agriculture
   - Creating venture capital fund such as: National Agricultural Innovation Fund for motivating and attracting youth (including women) in food and agri- enterprises and for establishment of Agri-Clinic Centres in all KVKs

as recommended by Paroda Committee to the Government. Farm mechanization, storage and other infrastructure needs to be covered in the schedule for use of CSR funds

- Any investment that has an end use in food and agri-sectoral growth need to be included under the CSR use category
- Promoting large scale agri-waste management including in situ paddy straw management (e.g. Punjab and Haryana) and also converting agriwaste into biofuels for wealth creation by the farmers
- Extending required financial and risk mitigation support such as: insurance of crops, animals, human life, assets and protection against natural calamities
- Promoting the use of CSR funds for knowledge dissemination as a single window system and also for post-harvest management and value addition especially in peri-urban agriculture.
- CSR funds could be effectively used in creating water-shed management assets in the villages which will help considerably in increasing the competitiveness of the farmer.

7. Urgent attention is needed to strengthen public-private partnership through:
   - Greater trust needs to be built between public and private sector through an effective facilitation and dialogue mechanism and follow-up action on strengthening partnership for accelerating agricultural growth.
   - There should be special recognition and incentive mechanism for the efforts made by the private sector in research, production, extension and marketing of agricultural products. As an incentive, the national level research based agri-input companies could be considered for a special status in the licensing system.
   - Collaborative research projects between the public and private sector need to be developed in underutilized/orphan/minor crops and open pollinated (OP) crops. Also, there is need for undertaking contract research by both the sectors, with clear policies on sharing of IP rights, and through needed security of the products.
   - Government could declare specific areas where public-private partnership (PPP) will be promoted as a national priority and encourage private industry to come forward with higher investments for new innovations. For scaling out innovations, the involvement of smallholder farmers, self-help groups (SHG), and the FPOs, through trade oriented capacity building, could be a win-win scenario.
   - There is a strong need for creating an institutional mechanism for knowledge sharing with farmers involving existing KVKs. A commercial network of digital platforms for both production and postharvest management and value addition needs to be established by bringing young men and women farmers and the private industry together.

II. Enhancing the global competitiveness of Indian farmers

1. There is an urgent need to study the relative cost of production per kg indifferent crops grown by the Indian farmers with those of other competing countries and identify options for reducing the costs and also improve yields to become globally competitive. This will help in making focused efforts to improve relative competitiveness.
2. The farmers who cultivate nutr—crops rich in minerals and micronutrients should get premium price so that they can be encouraged to grow these crops. This will also lead to enhanced income to smallholder farmers.
3. A comprehensive and collaborative approach needs to be taken-up between the Central Government and the State Governments to take appropriate policy measures to improve global competitiveness of Indian farmers. For this, following aspects need attention:
   - An end to end approach needs to be adopted for each crop. Critical review of technologies to be used as inputs, agronomic practices that can increase yield and quality, postharvest management to minimize losses in storage and transportation, etc. and the strategic policy support required to deploy the cutting edge technologies in each of the agroecologies would help smallholder farmers significantly. Private sector has to play an important role in scaling of innovations like expanding area under single cross maize hybrids, hybrid rice, conservation agriculture, microirrigation, protected cultivation, and vertical farming, etc.
   - There is also an urgent need to promote primary value addition at the village level involving youth including women, for which appropriate mechanism and enabling policies need to be in place. The value chain needs to be built for each crop in a comprehensive way in order to ensure full value for the farmers – reduce the role of unnecessary middlemen – create digital networks of farmers and value chain players to bring a seamless integration. This will need specific policy reforms in a much focused way. This has to be extended across sectors like crops, livestock, fisheries, etc.
   - As per current cost structure, almost 40-50 per cent of the cost is on account of labour. This has to change if we wish to make the farmer competitive and his farming remunerative. Farm mechanization strategies to reduce considerably the dependence on labour such

as: field preparation, transplanting, weeding, pest management, harvesting, post-harvest operations etc are to be promoted through adequate policy support and incentives by the Government.

4. Improving the export competitiveness of the Indian farmers has to be given high priority. In order to enhance India's global trade of agricultural commodities to achieve at least 10 per cent of the share would require special attention on: A long-term import/export policy of agricultural commodities should be announced by the Government, which should be reviewed periodically (5 yearly intervals). This will assure farmers and associated organizations to plan required agricultural production for export purposes.
   - The policy framework has to reduce red tape, improve ease of doing business, provide integrated facilities from farm to fork, build warehouses near the ports, and establishes dry ports, etc. Further, helping private companies to meet export schedules without delay, financial support like credit, insurance, etc. will be critical components to be covered under the export framework.
   - Contract farming, collective farming and corporate farming are the key elements of the strategy to increase farmers' income for which required support is needed. Enforcement of contracts, eliminating Government/ bureaucratic interference will be crucial for their success.
   - Motivating and attracting youth (including women) in agriculture, especially towards secondary and specially agriculture and for export of value added products will be highly rewarding and thus be pursued vigorously.
5. The other important areas that need to be addressed on priority are:
   - Risk management is a big challenge for farmers in India and we need to develop instruments that mitigate the risks in farming. In this context, for strengthening the existing insurance system, we need to set-up robust future markets in India.
   - Concerted efforts need to be made for human capital development. Agrientrepreneurs, knowledge, input and service providers need to be trained and supported in rural areas to improve diversified farming practices and to link farmers with markets. A suitable policy framework for human resource development along with provision and easy access to funds needs to be created.
   - Promoting Farmer Producer Organizations (FPOs) is extremely important for the required aggregation of agricultural produce, its processing, value addition and storage for collective bargaining and better income. Capacity building among FPOs through training, institutional backstopping and mentorship require urgent attention to make their business commercially viable.

III. General issues relating to policy, coordination and monitoring

For effective implementation of above recommendations, it is critical that some important issues related to policy, coordination and monitoring mechanisms, as recommended by Paroda Committee, and re-emphasised below are implemented urgently:

1. The National Agricultural Policy (2000) and the National Policy for Farmers (2007) shall have to be revisited as these are more than a decade or two old. Moreover, as stated earlier, new challenges have emerged needing bold policy orientation and new directions. New challenges have emerged in Indian agriculture which need innovations to make a difference. Now it is not only production but post-production management and value addition that demand a paradigm shift from 'Farm to Fork', production to processing, including value chain and traditional to new efficient and sustainable farming. Therefore, business as usual will not do. Agricultural growth will have to be accelerated beyond 4 per cent per annum. Hence, a comprehensive "National Agricultural and Farmers' Welfare Policy (NAFWP)" must be reformulated in order to achieve SDGs through secure and sustainable agriculture. The new policy must reflect foresight and clear action plan to make India a developed nation through accelerated growth and development in agriculture. In the process, a thorough review needs to be done to see which of the goals set in the earlier two policies have not been implemented and what reorientation is critical now to make agriculture both a profitable and respectable business for the millions of smallholder farmers.
2. Since agriculture is a state subject, there is great need for coordination and convergence between the Centre and States especially for the policy alignment to enhance ease of doing business and debottlenecking several processes and constraints. Also, there is a need for a change in the mind-set of politicians and planners to enhance private sector participation. Policy should promote health and safety through establishment of uniform standards of food safety, farmer safety, crop quality, etc. The data on soils, rainfall patterns, crops, costs, yields, etc. needs to be collected and analyzed and the results are to be made accessible to both private and public sectors to construct products like credit, insurance, technical advice, market linkages, etc. An integrated approach across relevant ministries including the end user ministries like textiles, food processing, chemicals & fertilizers, marine products, etc. in addition to the agriculture ministry is to be drawn up and implemented. Establishment of a National Agricultural Development and Farmers' Welfare Council (NAD&FWC) under the chairmanship of

Prime Minister, on the lines similar to GST Council, is urgently needed for an effective coordination and convergence mechanism.

3. Experience has shown that due to lack of effective implementation and assigned responsibilities for supervision, monitoring and evaluation, the Government programs are either delayed or they do not achieve their desired goals and objectives. Hence, invariably various initiatives/ investments are not able to yield desired results. It is, therefore, suggested to set-up an independent "Planning, Monitoring and Evaluation Unit" to review all missions, programs and important national schemes related to agriculture and allied fields. Such a unit should be established under NITI Aayog to ensure independent functioning and timely implementation. This Unit should be headed by a senior agricultural executive and should have provisions to invite experts for technical evaluation and monitoring. Also, the causes of poor implementation will have to be identified for taking corrective measures periodically, including the closure of non-performing schemes/ programs.

6 Strategy Papers

Preamble

The Trust for Advancement of Agricultural Sciences (TAAS) has brought out 20 strategy papers on topics of considerable importance (see Annexure VII). These papers do provide crucial information on each subject and have been authored mainly by Dr. R.S. Paroda, Chairman, TAAS, Former Director General, ICAR and Secretary, DARE, Government of India. He is an accomplished plant breeder and geneticist and is known for his analytical thinking as well as vision on agriculture related matters. His vast experience at national, regional and global level is reflected in these strategy papers which TAAS has been fortunate to publish and disseminate widely. A few strategy papers were attempted by other imminent research managers as well. The detailed strategy papers are also available on the TAAS website www.taas.in whereas the gist of these papers is provided below:

Strategy Paper 1 : Strategy for Increasing Productivity Growth Rate in Agriculture

(Dr. R.S. Paroda; August, 2006)

To attain a sustained growth rate of 8 per cent during XI Five Year Plan, India must accelerate the pace of agricultural growth from the current around 1 per cent to at least 4 per cent. Hence, a Mission-mode Program for Accelerating Productivity Growth Rate in Agriculture is called for as a matter of priority. It would need a dynamic approach oriented towards focused strategy which is well planned, coordinated and monitored. Business as usual will not work. Concerted efforts would be required for meeting the targets that are achievable but were not so well addressed in the past in a holistic manner.

Following are the ten strategic areas along with proposed action plan that need to be pursued rigorously on agricultural front:

(i) **Increased Capital Investment in Agriculture:** Capital Investment in Agriculture needs to be enhanced from present less than 10 per cent to at least 15 per cent. Investment on infrastructure in rural areas such as roads, markets would accelerate faster growth in agriculture sector.

(ii) **Supply of Growth Oriented Inputs at Farmers' Doorsteps:** Growth oriented agriculture would demand following inputs:

- **Supply of quality seeds:** It is extremely important to provide better quality seeds to the farmers
- **Supply of fertilizer:** It is necessary to accelerate the annual mineral fertilizer consumption rate to at least 5 per cent. Also, target of at least 5per cent for biofertilizer use has to be achieved in the XI plan.
- **Supply of biocontrol agents and biopesticides:** Supply of biocontrol agents and biopesticides for enhanced use in crops such as vegetables, pulses, rice, maize, sorghum, sugarcane, cotton etc. will need special emphasis.
- **Use of farm machinery:** Increased use of efficient and cost-effective farm machinery and equipment has to be promoted through large scale fabrication.

(iii) **Improving Productivity:** India is much behind China and Brazil in productivity which has to be increased through efficient management of natural resources. Some concrete action would be needed in the following areas:

- **Adoption of well-planned strategy for increasing production:** India can become No. 1 (surpassing China) in near future if an aggressive and well planned strategy is adopted for increasing wheat production – using both area expansion and enhanced productivity approach
- **Stabilizing area and production of rice:** A new strategy needs to be evolved by which area, especially under rainfed rice (having low productivity), could be reduced with simultaneous increase in yield using hybrid rice, integrated pest management (IPM) and conservation agriculture technologies.
- **Enhancing maize production:** Yield potential of maize can be enhanced significantly by promoting single cross hybrids.
- **Sugarcane for biofuel:** In view of spiraling prices of petrol, it is high time to have a policy reorientation towards use of sugarcane for biofuel production by increasing sugarcane productivity in the northern states of India, which is quite low at present despite large

acreage.

- **Increased productivity of pulses:** Improved short duration, disease resistant varieties are to be popularized. Short duration varieties need to be promoted in new areas such as chickpea in south, urdbean in rice fallows, in coastal region of Andhra Pradesh, Orissa and West Bengal, pigeonpea in the north-west (Haryana, Gujarat and Rajasthan).
- **Increasing oilseed production:**
  - *Soybean* - Soybean could become No. 1 oilseed in India provided a major effort is mounted in this direction. Another important policy related issue is regarding use of GM soybean
  - *Groundnut* - Use of improved varieties, higher rate of seed replacement, use of sulphur and plastic mulching, besides IPM, can result in significant improvements in states of Andhra Pradesh, Karnataka, Maharashtra and Madhya Pradesh.
  - *Rapeseed and Mustard* - Expansion of area in eastern States (West Bengal, Assam, Bihar) and north eastern states would help in higher production. Hybrid technology could be exploited in the northern and western states.
  - *Hybrid Castor and Safflower* - Promoting use of improved hybrids and, wherever possible, use of one irrigation would make all the difference. Good hybrids are now available for large area coverage.

(iv) **Making Gray Areas Green:** In order to achieve Evergreen Revolution, there is a strong need to lay special emphasis on rainfed agriculture

(v) **Emphasis on New Area Approach:** New area approach can lead to faster progress on account of quick adoption of technological package. Examples are: hybrid rice in eastern India, soybean in eastern and NE region, sunflower in the north etc,

(vi) **Major Thrust on Horticulture:** Right policy decision, technical guidance and funding support for initial establishment can make all the difference. Opportunities for linking farmers to markets, processing and value addition are all critical for the growth of horticulture sector.

(vii) **Promoting Inland Aquaculture:** This would require special thrust, both, on research and development side – including support for the production and supply of quality seed, rural based fish processing, packing, and cold storage facilities and transportation as well as export promotion.

(viii) **Capitalizing on Livestock Sector:** India has the largest cattle and buffalo population, second largest population of goats and the third largest of sheep in the world. India is also the largest milk producer (187.75 mt) in the world today. Yet, it has not been possible to compete globally in the export of milk products. There is need to link farmers to market. In some areas, such as Rajasthan and Maharashtra, major thrust should be on silvi-pastoral practices using agro-forestry and use of rangeland pastures and legumes. Also, there is need to protect and improve the local breeds

(ix) **Improved On-farm Efficiency and Precision Farming:** Most critical factor for faster growth in future will be the input use efficiency. It would demand integrated natural resource management and precision farming through adoption of small scale farm machinery/tools (such as zero till drill, planters, seed and fertilizer drills, sprinklers etc.)

(x) **Critical Policy Interventions Needed:** Enabling policy environment is critical for future growth and development. It is, therefore, necessary to continue having appropriate policy interventions in future as well.

Strategy Paper 2 : Overcoming the World Food and Agriculture Crisis through Policy Change, Institutional Innovation, and Science

(Joachim von Braun; March, 2009)

The world is currently in a deep economic recession, which follows in the footsteps of an international food price crisis. To understand the impacts and overcome these crises, it is critical to address some key questions: What is the role of agriculture in mitigating economy-wide effects and poverty? What should be done to strengthen the potential role of agriculture and the small-farm sector in reversing the decline of economic growth? And with respect to both these questions, how to act?

Today's world food situation is shaped by volatility of food prices, low growth in agricultural productivity, and severe constraints to access of investment capital for agriculture in many countries. The sharp rise in global food prices in 2007–08 severely undermined the nutrition security of the poor, provoked social and political instability, and increased competition for limited natural resources. The crisis, however, also renewed the focus on food and agriculture on national and global agendas, after decades of policy neglect and underinvestment in agricultural science, rural infrastructure, and institutions. India has responded strongly to the challenges in the world food system with policy actions that will be discussed here in a global context.

Throughout the world, policymakers and the public long for simple solutions of these complex problems, but unfortunately, there are none. At the same time, some misguided policy actions have deepened the crises by threatening the open exchange of ideas, information, services, and goods. The globalization of the agrifood system which—in other words, the integration of the production and processing of agriculture and food items across national borders through markets, standardizations, regulations, and technologies - could

be reversed. Borders have been closed, for example to the trade of food in 2007-08, and ears have been shut to reasoning by dogmatic forces. However, we should remember the good words of Mahatma Gandhi "...I do not want my house to be walled in on all sides and my windows to be stuffed. I want the cultures of all lands to be blown about my house as freely as possible...".

As policymakers consider options for overcoming the crises and reviving agriculture development, the following patterns of consensus, and lack of consensus, are evident:

- First, there is wide agreement that innovations in agricultural practices and science have crucial roles to play in boosting agricultural growth, coping with and recovering from the current world food crisis, as well as preventing similar crises in the future.
- Second, there is also broad agreement that science alone cannot change the world food situation, but that institutional innovation and change must facilitate farmers' profitable use of science and technology by reducing the transaction costs of gaining access to innovations. Institutions in this context are understood as the "rules of the game," and include laws and regulations, not just organizations.
- Third, however, there is little agreement about the best designs of these institutional arrangements. These relate for instance to the institutions that define scale in farming and food industries; contract and cooperation choices; roles of public and private sectors along the food value chains; market and trade arrangements; taxation, subsidies, and pricing; public sector functions in agriculture at central versus local government levels; and civil society's roles.
- Fourth, while there is underinvestment in food and agricultural science and technology—innovation in institutional arrangements are lagging behind even more, and hinder progress in the uptake and use of technology and in reducing hunger through public and market-based actions.

An international perspective on these issues is taken here, with some focus on South Asia's rich experiences. The discussion of these issues is connected to a policy proposal to overcome the world food and agricultural crisis, composed of three sets of needed complementary actions:

(1) promote agricultural growth,

(2) reduce market volatility, and

(3) expand social protection and child nutrition action.

Each of these policy actions needs to be enhanced by science, by institutional innovations, and by evidence-based policy advice. Policy, in turn, needs to define strategies and implementation pathways to spur the needed innovations and fill information gaps.

I. The Food Price Crisis and Its Impacts

Driven by rapid growth in food and energy demand, agricultural supply constraints, and speculation, the world price of almost every agricultural commodity sharply increased in 2007 and 2008. At their peaks, world rice prices increased fivefold and wheat and maize prices tripled compared with their levels at the beginning of 2003. At the country level, these global food price changes have been transmitted to different degrees owing to domestic policies and market structure. In many developing countries, including the countries in South Asia, food price increases led inflation dynamics because of the large share of food in the consumption basket. Upward pressure on overall inflation had adverse macro-economic effects and increased uncertainty. Some countries, such as India, used subsidy, trade, and tariff policies to absorb much of the shock in global food prices. Indeed, wholesale rice and wheat prices in India increased by 30 percent from the beginning of 2003 to October 2008 (Ministry of Commerce and Industry of India 2009). Many least-developed countries, however, had fewer resources to respond in a similar manner and many were hard hit by measures such as export restrictions on agricultural commodities of major producers. Indeed, countries that imposed export restrictions may have reduced their own risk of food shortage in the short term, but they hurt import-dependent trading partners and made the international market smaller and more volatile. Slowing demand and higher production have now eased the food price spike. International cereal prices have fallen by about 40 to 60 percent from their peaks, but they remain high compared with a couple of years ago. In some regions, such as East Africa, prices have actually not declined much.

Impacts on the poor and hungry

Even before the food crisis hit, roughly 160 million people were living in ultra-poverty, on less than 50 cents a day (Ahmed et al. 2007). The number of undernourished people in developing countries has been increasing and is largest in South Asia. The 2008 Global Hunger Index (GHI)[1] shows only a slight improvement in the overall world hunger situation since 1990. When Indian states are compared with the 88 countries in the GHI, their rankings range from 34th (Punjab) to 82nd (Madhya Pradesh). Child under nutrition in India is particularly grave. India is home to 40 percent of the world's malnourished children and 35 percent of developing countries' infants born with low birth weights. According to preliminary estimates of the Food and Agriculture Organization of the United Nations (FAO), the number of undernourished people increased from 848 million to 963 million between 2002–05 and 2008, largely because of the food price

[1]The GHI is a combined measure of three equally weighted components: (1) the proportion of undernourished as a percentage of the population, (2) the prevalence of underweight in children under the age of five, and (3) the under-five mortality rate. The 2008 GHI is based on data until 2006 – the last year with data available at the time of publication.

crisis. Food price hikes have also worsened micronutrient deficiencies, with negative consequences for people's nutrition and health, such as impaired cognitive development, lower resistance to disease, and increased risks during childbirth for both mothers and children. In Bangladesh, for example, a 50 per cent increase in the price of food is estimated to raise the prevalence of iron deficiency among women and children by 25 per cent. Indeed, food crises affect women more deeply and for longer because they more often lack the income and assets that could help them cope with the crisis than men. With the cost of food and other essentials increasing, people have taken to the streets in protest. Social and political unrest has occurred in more than 60 countries since the beginning of 2007, with some countries experiencing multiple occurrences and a high degree of violence. The protest frequency by month shows a high correlation with international grain prices, especially the price of rice.

The global financial crisis and recession are now adding to the burden on the poor. Wages are lost as jobs are cut around the globe. Many small farmers who took advantage of rising agricultural prices to invest in agricultural technologies find themselves unable to pay off their debts. Compared with previous crises, the recent financial crisis has affected many more of the poor in all corners of the world, because a large share of the most vulnerable people is dependent on wages. Also, given that children's under nutrition affects their physical and cognitive development and has implications for their earnings as adults, the crises will have long-lasting negative implications for people's economic prospects long after prices come down and the credit crunch is resolved. If the recession is not overcome quickly and investments in agriculture are not accelerated, the consequences could be severe.

IFPRI estimates that recession and reduced investment in agriculture would raise international grain prices by 30 per cent and push 16 million more children into malnutrition in 2020 compared with continued high economic growth and maintained investments. At a global scale, the decline in investments leading to cuts in agricultural supply seems to be stronger than the demand decline due to the recession. These trends might soon put again strong upward pressure on food prices.

Impacts on agriculture and natural resources

Underinvestment in public goods—such as agricultural research, science and technology, rural infrastructure, and information and monitoring—has impaired agricultural productivity and production growth as demand for food has risen rapidly. Indeed, annual world cereal yield growth has declined from about 3 per cent in the 1960s and 1970s to less than 1 per cent since 2000. Total factor productivity (derived from the ratio of total output growth to total input growth) in developing countries grew by 2.1 per cent per year from 1992 to 2003 on average. In some regions growth was higher, averaging 2.7 per cent in East Asia and Latin America, but in South Asia, the annual rate of growth was even lower—only 1 percent (Table 1). In India, public investment in agricultural research equals only about 0.5 percent of agricultural gross domestic product (GDP), which is lower than the 0.7 per cent average for developing countries and the 2–3 per cent average for developed countries. In 2005–07, cereal yields in India grew on average by 2.5 per cent a year.

High food prices in 2007–08 and favorable weather provided incentives for agricultural expansion, but most of the increase in output has occurred in developed countries. Many developing countries have been unable to generate the desired production response. If Brazil, China, and India are excluded, total cereal production in the rest of the developing countries actually fell by 1.6 percent in 2008. In India, the grain harvest was particularly good—213 million tons in 2007–08 compared with 194 million tons in 2006. Now, however, as capital becomes more expensive and scarce, plans for investment in agriculture across the globe are at risk of being postponed or scaled back.

Pressures on natural resources, combined with increasing distrust in the functioning of regional and global markets in the wake of the price crisis, have led to increased new forms of government-to-government foreign direct investment in agriculture. A number of countries, many with severe natural resource constraints but rich in capital, have turned to overseas investment in agriculture to secure domestic supply. According to news reports, Qatar, Jordan, Kuwait, and the United Arab Emirates have invested in Sudan; India and Kuwait have invested in Myanmar (Burma); China has invested in Mozambique, the Philippines, and Zimbabwe. These agreements help reduce underinvestment in agriculture, but recipient countries need to negotiate contracts wisely and establish an enforceable code of conduct, including rules about sustainable management of natural resources, engagement of local producers, and respect for customary property rights.

II. India's Response to the Food Crisis

After reaching impressive rates of 9–10 percent a year in 2006–07, economic growth in India slowed to 7 percent in 2008 owing to the recent world food and financial crises and is projected to decline to 5 percent in 2009. As further recession challenges arise, agriculture has an increasingly important role to play in India's economic development. Agricultural growth has been low on average, with annual growth in 2004– 06 at below 3 per cent, and average farm size in India has been decreasing. To overcome the crisis, agricultural growth needs to be revived, with the active involvement of the small-farm sector.

India's quick and comprehensive response to high world food prices and its good grain harvest in 2007–08 made the immediate impact of the crisis less drastic than in other countries. Indian policymakers saw that at a time of high global food prices, cereal

productivity growth in India had been slowing down. In response, India imposed export restrictions on major grains; expanded subsidies on crude oil, fertilizers, and food; and sustained safety net programs such as the Public Distribution System (PDS) and the National Rural Employment Guarantee Scheme (NREGS). Some of these responses, such as export controls on rice and wheat and withdrawal of these cereals from the futures markets, actually bumped up global prices, especially for rice. India must reverse this protectionist trend in order to avoid threatening the domestic benefits of its liberalization of agrifood markets in the 1990s and to prevent harm to importing partners. Unlike other countries, India accumulated large grain buffer stocks both before and during the crisis. With grain stocks of more than 35 million tons in 2008, India has already surpassed its estimated stock norm by 10 million tons and is projected to increase its stocks further to 39 million tons this year. An institutional arrangement is needed to govern the appropriate level of stocks and their timely release to reduce food market volatility. In terms of stocks, India is now a potential global food player, and can have a significant role in a new policy regime of coordinated grain reserves policy (see Section IV).

As a step in the right direction, the government of India increased its investment in agriculture and social protection by 24 percent in its 2008 budget (MoF, GoI 2008). To enhance food security, it established a National Food Security Mission in August 2007 with the goal of sustainably increasing agricultural productivity and production. Focusing on the eastern part of the country, the scheme aims to raise production of rice by 10 million tons, wheat by 8 million tons, and pulses by 2 million tons by 2011–12. Given that productivity on irrigated land is almost double that on rainfed land, the government plans to substantially improve irrigation systems. In its 2008 budget, the government raised the allocation to irrigation by 80 percent. This irrigation investment needs to be accompanied by institutional and price reforms. Further, India has maintained and expanded its safety nets in the context of the food price crisis. Food and fertilizer prices have remained constant in nominal terms and declined in real terms. Issue prices are now almost half of the open market prices. In addition, the NREGS introduced in 2006–07 was scaled up substantially. In February 2009, the scheme's allocation was increased from US$ 3 billion to $6 billion. Although these programs have cushioned some of the negative impact on the poor, they come at a high cost. The PDS food and fertilizer subsidy, for example, increased to almost $20 billion, raising the budget deficit[2]. The targeting mechanisms, coverage, and cost-effectiveness of many safety net programs are not always optimal and need to be revisited. Child malnutrition issues in particular need to be addressed with institutional innovations.

[2]Discussion based on information from Ashok Gulati, February 2009

III. The Role of Science and Institutional Innovation in Responding to the Food Crisis

Technological breakthroughs, and their adoption on a large scale as in the Green Revolution in Asia in the 1960s and 1970s, have been critical in preventing Malthusian outcomes. Yet agricultural growth in many developing countries continues to be hampered by lack of appropriate agricultural technologies, immense institutional constraints, and serious problems with the organization and management of agricultural systems.

Agricultural technology, with only a few exceptions, is not an easy candidate for leapfrogging, and it requires substantial joint investments in areas such as rural education, infrastructure, and extension services. Thus, innovations in technology need to go hand in hand with innovations in policies and institutions that can boost growth. Innovations are critical for improving the livelihoods of smallholder farmers and reducing poverty and hunger in general. These include innovations in

- organizations for agricultural research, extension, education, input supplies, marketing, and collective action;
- technologies along the whole food value chain;
- institutions, including laws, regulations, traditions, customs, beliefs, and norms; and
- public policies affecting all of these organizational, technological, and institutional arrangements.

New institutional arrangements should be actively designed to help reduce the cost of scientific research, add value to research by facilitating innovation, and enhance the impact of research on smallholders and other marginalized groups in developing-country agriculture. Institutional innovations can also play important roles in strengthening markets for commodities produced, bought, and sold by smallholders: reducing transaction costs; managing risk; building social capital; enabling collective action; and redressing missing markets. It is increasingly clear that the institutional infrastructure to facilitate market exchange is a critically important policy area to countries recently experiencing the shortfalls of market liberalization, specifically for smallholder agriculture. When market information and markets themselves are not accessible to the rural poor, farmers capture little of the value that they create, demand and supply are highly unstable, and distribution costs for rurally produced goods are very high. Simply put, markets often do not work very well for the poor as producers, and market volatilities and risks fully confront the poor as consumers.

But how would appropriate and timely institutional innovations come about? Initially, it was thought that institutions would improve as a consequence of individual self-interest and therefore take care of transaction costs and information asymmetries. Reality, however, has shown that the presence of coordination failure, innovation failure and authority failure are behind the failure of institutions to emerge efficiently.

The high risks of production and cycles of oversupply and price depression create financial risks throughout the distribution chain that inhibit investment and access to capital. Monopolistic practices, corruption, and excessive regulations also add to the burden of the rural marketplace. The high costs, risks, and "friction" in rural agricultural markets prevents markets from achieving sufficient scale for efficiency and similarly prevent the low-cost and reliable supply of production inputs such as seed, fertilizer, and other goods to farmers. Poor farmers also lack the political power, market knowledge, and business knowledge to address these market roadblocks. Thus poor farmers lack the capacity to improve and influence the markets upon which their lives depend. But some of these capacities can be developed through effective organization, technical training, and means for assembly and communication.

It has been shown that changes in technology and the relative prices of factor endowments can induce institutional change. Today, the conditions exist for inducing innovation in public research institutions. Prices of food, land, and water, have been on the rise. Political and macroeconomic stability are increasingly at risk, and have provided incentives for risk reduction. Priorities for agricultural research have started to shift, and there are calls for increasing investment in research and development. To carry this trend forward and respond to the food crisis, the theory of induced institutional innovation is a useful paradigm to consider, but induced innovations come about too slowly and this causes frictions in food systems.

Examples of successful institutional innovations include public-private partnerships, farm cooperatives, and social networks for the adoption of innovation. Farmers' transaction costs have been greatly reduced by decreasing information asymmetry through information and communication technologies. Institutional innovations have also assisted smallholders in reaching new, higher-value, markets. Public-private partnerships and organized producer groups have been successful tools for helping smallholders comply with higher food safety requirements and reduce transaction costs. A recent study in Maharashtra, India, shows not only that social networks are crucial mediators in the process of technology adoption, but also that increased involvement of women enhances collective action.

Going forward, it is important that innovations include smallholders, women, and disadvantaged groups. And the rural education system is to be an essential part of the way forward with a strong role of institutional innovation, as that pathway is quite knowledge intensive. Let us be reminded of the words of Rabindranath Tagore about his ideal of "the true school in India", which he described as follows: "The school will make use of best methods in agriculture, the breeding of livestock, and development of village crafts. The teachers, students and people of the surrounding country side will be related to each other with the strong and intimate ties of livelihood." Throughout much of the developing world a new approach to rural education and extension is needed today.

IV. Policy Actions to Overcome the Crisis

The danger posed by the global financial crisis and recession is the contraction of investments needed for rural poverty reduction as cost of capital increase and access to capital decreases. Alarmingly, the rich are bailed out before the poor in this crisis. To overcome the world food and agriculture crisis and assist the poor, a comprehensive set of complementary policy actions is needed: (1) promote sustainable agricultural growth, (2) reduce market volatility, and (3) expand social protection and child nutrition action. In all of these areas, science and institutional innovations are needed to complement and enhance the effectiveness of policies.

Promote sustainable agricultural growth

To enhance agricultural productivity, investments should be scaled up in the areas of R&D, rural infrastructure, rural institutions, and information monitoring and sharing. For smallholders, it is crucial to provide viable policy options and institutions to ensure improved access to finance (e.g. rural banks and microfinance), expansion of risk management (e.g. crop insurance), access to inputs (e.g. quality seeds, fertilizers, feed, veterinary drugs), access to services and extension, investment in rural infrastructure (e.g. rural roads, electrification, water and irrigation).

A recent study by IFPRI shows that if investments in public agricultural research were doubled, agricultural output would increase significantly and millions of people would emerge from poverty. If these investments were targeted at the poor regions of the world—Sub-Saharan Africa and South Asia—overall agricultural output growth would increase by 1.1 percentage points a year and lift about 282 million people out of poverty by 2020. Not all investments, however, are equally worthwhile. International agricultural research projects with substantial payoffs for a large number of beneficiaries should be given investment priority. The "best bets" identified by the centers of the Consultative Group on International Agricultural Research (CGIAR) include innovative programs to revitalize yield growth in intensive cereal systems in Asia, increase small-scale fish production, address threatening pests like virulent wheat rust, breed maize that can be grown in drought-prone areas, and scale up biofortified food crops that are rich in micronutrients such as vitamin A, zinc, and iron. Institutional innovations such as public-private partnerships, social networks, and participatory research can greatly help in the transfer and adoption of innovations by smallholders and in adapting innovations to farmer's needs and capacities. Rural services need to be revitalized to facilitate technology transfer, and rural borrowing is a critical component for that.

Reduce market volatility

Lack of information can lead to market inefficiencies and reduce the extent of mutually beneficial exchanges. The spread of new information and communication technologies has significantly

improved market information and welfare. Reforms and innovations are now needed in commodity markets. India should promote futures trading to minimize market risks and promote further investment in commodities. At the global level, two collective actions are needed to protect the poor, improve market efficiency, and strengthen long term investment incentives in agriculture. First, a small physical reserve must be created to facilitate smooth emergency response. The physical reserve could be managed, for example, by the World Food Program. Second, an international coordinated grain reserve scheme should be established, with India's participation. Third, a virtual reserve and intervention mechanism must be created to help avoid the next price spike. The organizational design of the virtual reserve would include a high-level technical commission that would intervene in futures markets and a global intelligence unit that would signal when prices head toward a spike. Usually, intervention would not be necessary, and the signaling mechanism would be sufficient to divert speculators.

Expand social protection and child nutrition action

To protect the basic nutrition of the most vulnerable and ensure food security for more of the world's population, sustainable pro-poor agricultural growth and reduced market volatility should be accompanied by social protection and child nutrition actions. Protective actions are needed to mitigate short-term risks, and preventive actions are needed to avoid long-term negative consequences. Protective interventions include conditional cash transfers, pension systems, and employment programs. Preventive health and nutrition interventions such as school feeding and programs for improved early childhood nutrition should be targeted to vulnerable groups and strengthened and expanded to ensure universal coverage. To aid the poor, these programs should go beyond social assistance and provide social development opportunities by building up physical and social assets. Tying cash or food transfers to school attendance has been a successful institutional innovation in social programs. Mexico's large-scale conditional cash transfer program for poor rural households, increased the years of educational attainment by 10 per cent and raised median caloric acquisition by 11 per cent, among other benefits. Bangladesh's food for education program increased school participation rates by 20–30 per cent and girl's lifetime earnings by 33–35 per cent. India's nutrition programs, such as the ICDS should utilize and adapt these experiences, as they are currently not achieving the desired results.

The handling of policy, technology action, and institutional change would define policy failure, policy neglect, and policy success in combating the world food and agriculture crisis. For success, R&D acceleration should be combined with a solid strategy for institutional innovation. The design of national agricultural strategies must be country-driven and country-owned, with country-specific priorities and sequencing. Given that prioritization, sequencing, transparency, and accountability are crucial for successful implementation, policy and governance practices in many countries must be strengthened. At the same time, new partners should be involved on a greater scale in policy design and implementation. The private sector and nongovernmental organizations are becoming increasingly interested in and involved. India's rich experience can play a significant role for strategic policy change in agriculture and for food security at the international scale. In doing so, India could be a main driver of good globalization.

Strategy Paper 3 : Imperatives of Global Climate Change for Agricultural Research in Asia-Pacific

(Dr. R.S. Paroda; November, 2009)

Major challenges in the twenty-first century are the rapid increase in the world population, degradation of agricultural land and other natural resources and emission of greenhouse gases that contribute to climate change. Hence, there is growing threat of food insecurity. Emissions of greenhouse gases, like carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), resulting from human activities, are substantially increasing the average temperature of the earth's surface.

Rapid increase in population implies increased demand for food in the region. It is estimated that by 2020, food grain requirement in Asia would be 30-50 per cent more than the current demand which will have to be produced from same or even less land that too with inferior quality of other natural resources. Alleviating poverty and attaining food security under adverse environmental scenario due to global climate change would be a major challenge in the 21st century.

These facts draw attention for global concerns and urgency to address the options by which threats to Asian agriculture, due to climate change, can be addressed successfully in the near future. On positive side, the agriculture sector also provides significant potential for the greenhouse gas mitigation and adaptation to climate change effects. This would demand reorientation of agricultural research.

Drastic changes in climate are affecting agriculture considerably through their direct and indirect effects on crops, soils, livestock and pests, and ultimately the global food security.

Extreme events including floods, droughts, forest fires, and tropical cyclones have already increased in temperate and tropical Asia in the last few decades. Runoff and water availability are projected to decrease in the arid and semi-arid regions of Asia. The issue of climate change and its imperatives for agricultural research was deliberated in an International Symposium organized jointly by APAARI and JIRCAS. Thirty countries came out with agricultural research priorities for adapting agriculture to climate change in the form of "Tsukuba Declaration"

The salient features of "Tsukuba Declaration on Adapting Agriculture to Climate Change" are given below:

- Water is a key constraint in the region for attaining food production targets and will remain so in future as well. Steps are, therefore, needed by all the stakeholders to prioritize enhanced water- use efficiency.
- It was fully recognized that increasing food production locally will be the best option.
- New genotypes tolerant to multiple stresses, viz., drought, floods, heat, salinity, pests and diseases, will help further increase food production.
- A reliable and timely early warning system of impending climatic risks could help determination of the potential food insecure areas and communities.
- Appropriate policies and institutions are needed that assist in containing the risk and to provide protection against natural calamities.
- Governments of the countries in the region should collaborate on priorities to secure effective adaptation and mitigation strategies.
- It was recognized that adoption of scientific soil and crop management practices, improving degraded lands, enhanced fertilizer- use efficiency, and large scale adoption of conservation agriculture will be necessary.
- Coping with global climate change is a must and for that there are two strategies
  - (i) adaptation through learning to live with the new environment (e.g., time of planting, changing varieties, new cropping systems, etc.), and
  - (ii) mitigation through offsetting the causative factors such as reducing the net emission of greenhouse gases.

Impact of climate change on agricultural production in the Asia- Pacific is real. Hence, immediate action at national level to understand and address the issues of climate change becomes a priority. Strategy around both adaptation and mitigation is called for, which would require research reorientation and major policy interventions. Regional and global collaboration would help in addressing these concerns and for building both institutional and human resource capabilities being the two cradles for sustainable agriculture.

Strategy Paper 4 : Intensive Efforts Needed for Food and Nutrition Security

(Dr. R.S. Paroda; November, 2009)

After Green Revolution, we thought that we had achieved self-sufficiency and solved our problem of food security. Somehow, the things have changed and there are many challenges and concerns that require our immediate attention. In this context, I draw your attention to the "Vision Statement" adopted by all the science academies in India and released by the Hon'ble Prime Minister Atal Bihari Vajpayee during the Indian Science Congress held in January, 2001. It's theme was on food, nutrition and environmental security. We need to continuously discuss this issue as we move along. In India, the ever increasing population in fact nullifies all our efforts. Every year we add one Australia to our population needing additionally 4 to 5 million tons of food grains. Many countries don't have such challenge, even China is now better off in that context. We have 16% of total population sustaining on only 2.8% of global land. It is anticipated that we may even surpass the population of China by 2020. We have to realize that India also has almost half of the livestock population than that of our human population. No where else this type of pressure per unit land is being faced currently.

Over the years, per cent GDP from agriculture sector is declining. This indeed is a good sign since industrial growth in the country is showing upward trend. However, it is well established that unless we have 4% growth rate from agriculture, expected 8% industrial growth would not be possible. So, agriculture is the backbone for India's overall development. In rural India, almost 60% of our people are dependent on agriculture alone. Dr. Swaminathan, Father of Green Revolution has often highlighted the importance of agriculture for national food security.

In mid 60s, India was considered a basket case. We seemed to have progressed considerably, thanks to the science based Revolution such as: changing the plant type concept, by making them respond better to higher inputs and giving higher productivity. We had also been fortunate to have the holy alliance of the NARS (National Agricultural Research System) supported well by the policy makers, International Agricultural Research Centers such as CIMMYT and IRRI, and above all our highly intelligent and hardworking farmers. The green revolution enabled us to feed our population, which is still increasing @ 1.6 per cent. At one time, we were importing more than 10 million tons of foodgrains under PL-480. During past 50 years, we have witnessed unprecedented progress, increased agricultural production at growth rate of 4.5 per cent. Yet the concern is of economic and ecological access to food. Unfortunately, we have not been able to increase buying power, which is why the poverty issue is of major concern.

In the past five decades, there had been steady rise in the prices of most of the industrial products. On the contrary, in agriculture, prices of foodgrains have shown a declining trend, which made the life easier for our people. We have also been able to reduce poverty by 40 per cent. At the same time, life expectancy got doubled from 32-64 years since we became independent. We are aware that despite all these achievements, there are new concerns globally. MDGs (Millennium Development Goals) have drawn our attention towards eradication of poverty and environmental sustainability. Unfortunately, the extreme poverty resides in South Asia. We cannot feel proud on this account despite having done much better on food front. We need to ensure better income for our people and see that they are above poverty line and have easy access to food.

The present global concerns are about 180 million children severely underweight for their age, over 800 million chronically undernourished children, 400 million women of child bearing age being anemic and over 200 million children being vitamin A deficient. Thus, nutrition security has become a major concern which need to be addressed. Also the poverty concentration is maximum in the South Asia. Yet the donor organizations appear to be laying major emphasis on Africa. Asia is not taken seriously just because we had witnessed Green Revolution. Though around 200 million people are still below poverty line (getting less than dollar a day), yet our per capita calorie consumption is higher than many countries in Africa and parts of Latin America. At the same time, we need to move forward from present availability of around 2000 kcal per person to a level of about 2500 or 2800 kcal. This would demand an expansion of our food basket so as to reduce dependence on cereals. We have also been experiencing factor productivity decline on account of second generation problems of Green Revolution such as: salinity, lowering of water table and increased incidence of pests and diseases.

Lately, due to policy changes, the buffer stocks have also depleted. From over 58 million tons in 2002, our buffer stocks went down to almost 15 million tonnes. Due to global decline in production of foodgrains, the prices per ton of wheat and rice had touched all time high ($400 for wheat and $900 for rice) by late 2008. This has obviously affected the consumers badly. Lately, the foodgrains are also being diverted as feed, thus making their availability even more difficult. We in India are fortunate due to being vegetarian. Our protein demand is mainly through pulses, vegetables and fruits and not meat. Lately, USA is diverting its maize production to the level of 33 per cent towards bio-fuel production, which appears to be ethically wrong.

Climate Change is also affecting us. It is known that from 1920 to 2000, average global temperature has risen by almost 1 degree, which is expected to rise by another 4 degrees if no corrective measures are taken. Imagine what will happen if that really happens. Impact of climate change is now real. Emission of green house gases (GHG), leading to global warming, more intense tropical cyclones, faster wind speeds and heavy precipitation are all a reality. Contraction of Himalayan glaciers by almost 17 kms in the last 10 years is another reality. As stated earlier, the world cereal production has also been affected adversely in the recent past due to drought in Australia, Canada, US and other developing countries. Recent studies predict that 2250 million tons of cereals will be produced this year but most of this increase is going to be from the developed countries.

In India, the prices are going up, buffer stocks are depleting and imports from developed world are on rise. We must, therefore, think seriously to remain self-sufficient. As such, the subject of this seminar to have self-sufficiency at the national level is indeed very important. We had to import wheat in 2007-08, for the first time after Green Revolution period. We produced around 4 to 5 million tons of wheat each year for over a decade upto 2002. Somehow, during the last 6-7 years, our production has remained stagnant. Fortunately, the minimum support price (MSP) for wheat was increased from Rs. 750 to Rs. 1000 per ton in 2007, which resulted in increased wheat production by almost 3 million tons just in one year. So, the issue of sufficient production and self-sufficiency depends on right policies. In recent years, demand for other commodities is growing much faster than cereals, which is a fairly good sign.

We need to reorient our research for development strategy through twin pillar approach. This will require a paradigm shift of not only having germplasm improvement (good varieties and hybrids) but also improved natural resource management. Also we need to consider socio-economic aspects and policies around diversification of agriculture. It is a matter of concern that over the years, the use of germplasm for breeding new varieties of different crops has gone down. This trend is rather global and that's why a global initiative on plant breeding has been initiated by FAO through the support of Gates Foundation with the aim to reverse this trend. It is apparent that some complacency in plant breeding has come. It is because people thinks that biotechnology can solve all the problems. It is important to understand that biotechnology can supplement but can not replace plant breeding efforts. In eighties and nineties, Indian wheat program recorded an annual genetic gain of one per cent per annum. Lately, this is stagnating since release of variety PB-343. The challenge is how to improve the yield further. The same challenge is also now with The International Maize and Wheat Improvement Center (CIMMYT). In this context, advances through hybrid technology are encouraging. Our scientists both in public and private sector came forward to give hybrid technology first in to the world in cotton, pearl millet, castor and pigeonpea.

In case of rice, China was first to release hybrids which now covers 53 per cent area giving more than 58 per cent rice production. An yield gain of 1 t/ha could be achieved through this technology. Now China is developing super hybrid rice targeting yield level of 15 t/ha. This kind of effort is needed in India where rice productivity is still below 3 t/ha. Private sector can play a major role, since public sector has not been able to deliver expected output in case of hybrid seed production. We have 42 million hectare area of rice but hybrid rice area is only 1.2 mha. Hence, we need to move forward. In the USA, single cross hybrid maize technology provided higher productivity (7 to 8 tons). The Bt hybrid maize can now yield upto 12 tons/ha. Hence, through new technologies are available yet there is need to make available the seeds of these hybrids to the end users.

It was for this reason that a mission project on hybrids was initiated under the National Agricultural Technology Project (NATP), which resulted in the release of single cross hybrids of maize for the first time. As a result, our maize production doubled in last one decade. However, the area under hybrid maize, particularly

single cross and quality protein maize (QPM) hybrids, is much low. Why can't it be 70-80 per cent? Why is it still 25%? We need to understand the reasons and move forward. For this, we need to strengthen Public Private Partnership (PPP).

PPP is essential for future growth in agriculture. For this, we need to provide enabling environment and government should come out with proper policies and incentives to be put in place for those who perform. There is an obvious need for building mutual trust. This is indeed a grey area for which we need to sit across the table and discuss successful models of PPP and have better understanding. Currently, total acreage under GM crops is around 140 m ha. Presently in India, we have only Bt cotton. In Philippines, Bt corn has already been released as a food crop. Recently, in India, both Bt brinjal and Bt corn have been permitted for field tests. In future, I do not know whether there will again be a resistance for acceptance of transgenic technologies. In any case, these technologies are required in country's interest. Even the Europeans are importing Bt cotton, soyabean and corn for use as animal feed. I don't know why there should be any concern for release of GM food crops in India, if testing procedures are in place. Partnership of Mahyco with Monsanto coupled with enabling environment created by ICAR (Indian Council for Agriculture Research) and DBT (Department of Biotechnology) both for testing and release led to release of Bt cotton in India. In last 5 years, area has increased from no where to around 8 m ha under Bt cotton. In my opinion, there is no better example than this for such a faster adoption anywhere in the world. As a result, the cotton area increased, production almost doubled and productivity also increased. Currently, cotton export alone is fetching India worth 1.4 billion dollars per year. Before Bt cotton technology, we practically had no tangible cotton export.

There is another approach for enhancing food and nutrition security. This is new area - new crop approach. We all know that both rice and sugarcane were not grown before in the north. Groundnut was not grown in Gujarat, which is currently number one state. Potatoes were not grown in the Indo-Gangetic plains before. Maize in eastern India now gives more than 8 to 10 tons of productivity. Chickpea, a crop of North India, can now be grown in Tamil Nadu because of short duration varieties. So, the research has led to a number of achievements in different commodities and crops. For example, pigeon pea is being grown in North and West, due to release of hybrids and short duration varieties. Niche for soybean could be found in Madhya Pradesh which is now number one oilseed crop in the country. Dr. Barwale raised a very pertinent point as to why we are exporting soybean which can otherwise help in ensuring nutritional security. Therefore, until we make use of it as a food source, we better continue with current export of soybean meal worth over US$ one billion per annum.

Finally, we need to move forward and do research in up-stream areas of strategic importance. We have to make sure that our knowledge gets translated into products that can benefit the end users. This is what we call translational research for which we need to work with the farmers in a participatory mode, as was demonstrated through Integrated Pest Management (IPM) in rice in Indonesia. This led to increased rice production and decline in pesticide consumption by 50 per cent within 5 years. We have to understand the problems of our farmers and integrate their traditional knowledge with that of the scientific one. We have to make sure that they are able to use their resources judiciously; just alternate furrow irrigation in cotton can reduce water use by 30 per cent. We need innovative technologies. A decade ago no one thought that in rice-wheat production system one could use zero-till drill and have conservation agriculture. Today, over 2 mha area in the Indo-Gangetic plains is under zerotill. This success could be extended to a potential area of 8 m ha under rice-wheat in India. My mention of all these is to convey that we should look for newer options such as precision farming, which is possible through efficient farm mechanization. Farmers are even adopting lazer leveling to improve water use efficiency (WUE). Thatis where again private sectors role becomes important. Somehow, over the years, our extension system has also become weak. The dissemination losses are higher due to less competent people involved in extension services. In this context, private sector can again play an important role. For example, establishment of agri-clinics through creation of technology agents who can provide much needed them vocational training for much needed custom hire services to the farmers is an important aspect. The role of NGOs is also to be encouraged in this regard.

It is indeed heartening that recent World Bank report has clearly brought out that there can not be sustained and inclusive development unless high priority and required funding support is given to agriculture. Fortunately, therefore, agriculture has come again up-front despite being neglected in the recent past. We definitely need more capital investment in agriculture, as we did soon after independence. We created a lot of good infrastructure like highest dam, longest canal, best fertilizer factories in the cooperative sector, markets/ mandis and so on. This could be possible since almost 18 per cent of our GDP was spent for capital investment. Unfortunately, over the last 2 decades, this support has declined to almost 9 per cent. Now we expect the private sector to come forward in building the much needed infrastructure. For this, Government has also to provide enabling environment to catalyse the private sector.

India is also blamed for providing subsidy to our farmers. It must be understood that agricultural subsidy in India is linked to productivity, whereas in the developed nations much higher support is provided for storage, marketing and also the export. Our subsidy is currently, around 6.5 per cent, whereas, upto 10 per cent is acceptable limit by the World Trade Organization (WTO). Hence, needed support to resource poor farmers must continue in the overall interest of our nation. Let me conclude by stating that we need not be complacent.

We need to continue scaling up our efforts both up stream and out stream. We have to see that technologies reach quickly to the end users. We must build stronger partnership among public and private institutions to ensure this goal. For this, we need policy makers to provide enabling environment and needed support to catalyze the process as a matter of high national priority. All these will help in accelerating much needed productivity growth in agriculture to achieve both food and nutrition security on a long term basis.

Strategy Paper 5 : Revitalizing Indian Seed Sector for Accelerated Agricultural Growth

(Based on NSAI Foundation Day Lecture by Dr. R.S. Paroda; October, 2010)

India recorded an unprecedented growth in agricultural production during the last 50 years. The first phase of agricultural growth was on account of 'Green Revolution' during the late sixties and seventies, with the introduction of semi-dwarf high yielding varieties (HYVs) of wheat and rice. As a result, substantial increase in food grain production from 50.3 mt in 1952 to 88.1 mt in 1971 was realized. During this period, significant role towards quality seed production of HYVs was played mainly by the public sector seed organizations viz., NSC, SFCI, State Farm Corporations, Indian Council of Agricultural Research (ICAR) Institutes, State Agricultural Universities, etc.

A significant policy decision of the ICAR to share freely the parental seeds of hybrids with the Private Sector catalysed the process of increased productivity as well as cropping intensity (from 118.6% in the early seventies to 133.8% in nineties). Subsequently, Government enacted the Protection of Plant Varieties and Farmers' Rights Act (2001) to ensure faster growth of our seed sector. All these initiatives helped Private Seed Sector in India to play much bigger role.

Vegetables are the fastest growing sector. The hybrid vegetable seed market in India is of about Rs 1500 crore. There was an increase of 194 per cent in vegetable hybrid seed market during 1998 to 2008, and it is expected to grow further. Public research institutes played a key role in establishing the vegetable variety improvement and seed production. However, the R&D in vegetables is also very active in the private sector. Out of about 110 vegetable hybrids released 60 per cent have been developed by the private sector. With the rapid pace with which biotech innovations are being tested, the market share of vegetable hybrids is expected to rise. However, as stated earlier, a decelerating productivity growth rate, increasing prices and demand of food grains, shrinking natural resources and the emerging challenge of climate change have emerged lately as major concerns for the policy makers and the scientists. To attain a national GDP growth rate of 8 percent, it is necessary that agricultural growth rate is raised from 2 to 4 per cent. Best way to achieve this is through greater coverage under HYVs and hybrids.

This paper highlights the key role of seed industry in accelerating agriculture growth. A process of revitalization is needed urgently to accelerate the pace of seed production. It is with this objective in mind, the following suggestions were made:

- Seed replacement has to be linked with new variety replacement too.
- For achieving desirable levels of seed replacement rate, adequate seed needs to be produced first.
- Production of hybrid seed needs to be promoted aggressively to improve crop productivity.
- Complementarity of the public sector policy and infrastructure and the private sector dynamism can be maximized through appropriate Public- Private Partnerships (PPP).
- The success of partnership lies in trust, openness, and transparency. This can be built by regular interactions and dialogues, and appropriate policy framework.
- Good models and success stories on PPP existing in the NARS and the CGIAR system, such as that of ICAR-IARI, ICAR-NIPB, ICAR-IIHR, ICRISAT, IRRI, etc., can be replicated or further refined, as needed, by other institutions/universities.
- There is an urgent need to build crop-based / institution-based Technology Parks / Incubators.
- Seed quality assurance requires considerable investment in terms of proper infrastructure, equipment and competent human resource.
- There is an urgency to have the Seed Bill enacted soon.
- Re-structuring and revamping the public sector seed producing undertakings is also required for product diversification/ upgradation and for improving their governance, core competence and competitiveness.
- Specific interventions through active involvement of National Seed Association of India (NSAI), to boost our seed exports, need urgent consideration.
- A National Mission on Seed needs to be launched by the Central Government so as to provide an enabling environment for faster and an efficient quality seed production program.
- The national germplasm collection available at the ICAR-NBPGR, needs to be made available more freely on request,
- The share of Private Sector investment in plant breeding and seed development area has increased in recent years and needs to be further enhanced.
- For crisis management, there is a strong need to establish Regional Seed Banks as a contingency measure.

Also, a serious effort is needed to revitalize our national seed sector, for which a missionary zeal is warranted to accelerate the pace of Indian agriculture.

Strategy Paper 6 : Implementing the International Treaty to Address Current Concerns about Managing Plant Genetic Resources

(Dr. R.S. Paroda; January, 2012)

For strengthening national capacities to implement the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is essential in order to promote the participation of countries in the multilateral system. For the effective implementation of the multilateral system of access and benefit-sharing at country level, there are a number of core requirements to be fulfilled, according to the needs of each country.

Three important things about genetic resources are to be kept in mind. First, that genetic resources are the building blocks for improving productivity; Second, that genetic resources are the common heritage of mankind; and Third, that genetic resources are to be freely exchanged for human welfare.

The Convention on Biological Diversity envisioned that genetic resources were to be conserved for posterity. It was realized that conservation is not only required for 'posterity' but also for 'use'. The Food and Agriculture Organization of the United Nations (FAO) has begun a Global Initiative to build required capacity for enhanced use of genetic resources.

We are greatly concerned with agricultural crops, which are immediately necessary for the food and nutritional security of humankind. Thus, a dialogue was initiated under the auspices of FAO to revise the International Undertaking on Plant Genetic Resources. The deliberations culminated in the development of the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). At that time, there was a general consensus that only plant breeders should have rights, the definition of farmers' rights was not known. While chairing the FAO Working Group on Farmers' Rights, it was realized that not only plant breeders but also the farmers should have rights over their landraces and varieties.

The ITPGRFA came into force in 2004, and in 2006 its governing body adopted the standard material transfer agreement (SMTA) under the ITPGRFA. In India, it was envisioned that there would be a bilateral system of germplasm exchange under the CBD, and multilateral exchange under the umbrella of the ITPGRFA. The Government of India enacted the Protection of Plant Varieties and Farmers' Rights (PPV&FR) Act in 2001, to provide for the protection of plant varieties, the rights of farmers, plant breeders and researchers.The food basket in India today would have been entirely different had there not been free exchange of genetic resources.

A large amount of germplasm of Indian origin was acquired by international genebanks. This germplasm is being globally exchanged continuously through the ITPGRFA. It is paradoxical that India has yet to agree upon a mechanism under the ITPGRFA to implement the multilateral exchange of crops, while most of our germplasm is already held in the global multilateral domain. Asia-Pacific Association of Agricultural Research Institutions (APAARI) has played a significant role in creating awareness about the enhanced use of genetic resources through multilateral exchange using the SMTA. The farmers are the custodians of many traditional varieties and landraces. Currently, their rights are being protected through the PPV&FR Act.

In order to harness the benefits of these protocols and treaties, a national strategy is urgently needed for the convergence and coordination of all relevant issues/ legal requirements to make a step forward so that a targeted section of our society is benefitted.There is an urgent need for a coordinated effort at the national level, to put in place decisions through regular consultations involving all relevant organizations. It was decided that the Department of Agricultural Research and Education in coordination with the National Biodiversity Authority, must take immediate steps towards providing access to the germplasm of crops under the multilateral system as per the provisions of the ITPGRFA.

Furthermore, there is also a need for the harmonization of different protocols/treaties. I am a strong advocate of the concept of benefit-sharing, and in view of this, I have been urging the Chairman, PPV&FR Authority to garner government support for the creation of an Indian Gene Fund of around Rs. 50 crore (US$ 10 million), which seems to have been included in the 12th Five Year Plan. There is an urgent need for partnerships amongst all stakeholders, including public and private sector, NGOs and farmers.

India is richly endowed with a wealth of genetic resources, which it used to nurture. We have been debating and making a good case for effective and rather urgent implementation of farmers' rights and benefit-sharing with local communities. This process has to be initiated without further delay. Today, there are over 400,000 accessions, of which 200,000 were collected in just five years. This was achieved through a participatory approach. However, this enormous wealth of germplasm must now be systematically characterized, evaluated and shared for effective use.

Germplasm must be shared more freely in India through the multilateral system, under the ITPGRFA, using the SMTA. There are serious challenges before us. Hence, we need to put all our energy and actions together and have a clear road map before us so as to address both the national as well as international concerns more effectively for the benefit of humankind.

Strategy Paper 7 : Indian Seed Sector: The Way Forward

(Based on special Lecture by Dr. R.S. Paroda; February, 2013)

In order to bring about the 'Change' that our agriculture needs today horizontal expansion is no more a choice. Vertical expansion is the only best option to move forward. For this, improving productivity through good quality seeds of improved varieties/hybrids is the best possible alternative.

In order to meet the demand of our increasing population, likely to be 1.7 billion by 2050, we shall need to double our food production. This can only be possible by bridging the existing yield gaps through enhanced productivity and integrated natural resource management. Hence, the second Green Revolution would need much faster growth of seed sector. For this, a Mission on Seed Production is urgently needed. The seed sector grew steadily with the establishment of several private seed companies. Growth of private sector began in early nineties when ICAR took a bold decision of providing breeder seed of parental lines of public bred hybrids and varieties freely to the private sector. This enabled private seed companies to grow much faster. Liberal policy of importing seed and planting materials of best varieties resulted in substantial private investments in the seed sector.

Technology-Led Growth: The enactment of the PPV&FR Act and rapid expansion of Bt cotton production area has enhanced the demand for Bt cotton hybrid seed by 220 per cent. India could turn into a net exporter of cotton from being an importer. In this case, the private sector took the lead in accessing the technology. This led to higher growth of Indian seed industry around US$ 2,000 million. For raising the agricultural productivity, seed is recognized to be the most critical single input. Use of good quality seeds can result in as much as 15-20 per cent yield increase. The availability of quality seed is sufficient to meet the current requirement. However, many a time the seeds of new improved varieties are not available to the farmers. The subsidy linked to certified seed of field crops of large volume and low value has proved counter-productive to the variety replacement rate. Extending the scope of government subsidy to truthfully labeled seed of promising hybrids, produced by private companies, would be yet another bold policy decision.

Varietal Denotification: It is high time that we denotify on priority such old varieties that have no demand or relevance in the present context. Continued production of seed of old varieties by many State Corporations is rather counterproductive.

Need for Enhance Replacement Rate: For achieving the desired levels of seed replacement rates, adequate seed of good varieties need to be produced first. In the last two decades, the ICAR institutes and SAUs have made significant progress in meeting fully the breeder seed requirement. States must ensure production, multiplication and replacement of seed progressively, especially in respect of regionally important varieties. The state departments may consider procuring quality seeds of improved crops varieties through a Contract Seed Production system. This will ensure timely availability of sufficient quantities of seed of the desired (new improved) varieties.

Good Future Prospects: Advantage of diverse agro-climatic conditions, developed institutional infrastructure and availability of skilled human resource can certainly make Indian seed business globally competitive. India's seed export can be increased many fold from current US $ 400 million There is need to have an aggressive approach and develop strategy to capture seed markets abroad in a well planned manner.

Investment Towards Innovation: The seed sector had been quite active to outscale new innovation in agriculture. Such innovation encompasses development of superior hybrids, transgenics and advanced seed treatments. Acceleration of hybrid seed production in these crops both by the Public and Private Seed Companies is the need of the hour. Better climate resilient hybrids and varieties in all major crops need to be developed both by the public and private research institutes.

Role of Biotechnology: There is need for greater focus on the application of biotechnology to develop new improved varieties with special traits, particularly to provide effective and durable solutions against abiotic and biotic stresses. It will be appropriate to generate much needed awareness among farmers, civil society organization and the policy makers about the potential of plant biotechnology as well as its safe application. Research is needed to meet the growing demand for high quality seeds of improved varieties/hybrids with high productivity higher proteins, minerals and vitamin contents. The Golden rice, QPM and Fe and Zn enriched millets are some such examples.

Investments in AR4D: It is encouraging that for advancement in research and technology development in agriculture, the ICAR got enhanced plan allocation almost 2.5 times in the XII Plan period. The private seed sector is also expected to make significant investments in the AR4D. it is presumed that private sector is currently spending on R&D about 10-15 per cent of the total turnover.

Promoting Hybrid Technology: More public-private funding is needed to develop HYVs/hybrids for varying agro climatic regions. The increased investments made by the private sector have resulted in better innovations and technology development over the years. It is encouraging to note that the contribution of the private sector has been quite remarkable in the expansion of the vegetable basket.

Building Public Confidence: The private sector has shown its confidence and interest in the national system by applying for the protection of their plant varieties with the PPV&FR Authority. Out of 4267 applications received by the PPV&FR Authority, 1796 were from the private sector. To fulfill the social commitment, the private sector also needs to release and promote high yielding OP varieties of crops where hybrid technology is yet not feasible.

Partnership for Prosperity: India is a country of diverse agro-ecosystems and cropping preferences. It is predominantly rainfed (~60%) and size of the farm holdings are rather small (~67%). The wide gaps reported between the potential and realized productivity in most of the crops can be bridged to a large extent by using the seeds of improved varieties. A recent study has shown that the use of HYV seeds was one of the

key factors for an impressive increase in production. The fact that even today nearly 70-75 per cent of the total seed requirements is met by the farm-saved seed, should also be seen new opportunity to expand and meet the diverse needs of our smallholder farmers. It is beyond doubt that public-private-partnership in seed sector is critical for future growth of Indian agriculture.

Germplasm Exchange: The ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR) acts as a national repository of plant genetic resources, but also acts as an apex organization facilitating germplasm conservation, access and exchange for research purposes, which can be of great significance in plant breeding programs. However, as these resources represent our invaluable national asset, utmost care is needed to develop guidelines on access and benefit sharing (ABS), on lines of standard MTA of the ITPGRFA, with necessary safeguards.

The Way Forward: We must accelerate pace for seed development by defining a clear "Road Map" for future.

Strategy Paper 8 : Managing our Water Resource for Increased Efficiency

(Dr. R.S. Paroda; May, 2013)

India with 2.4 per cent of the global geographical area and only 4.5 per cent of water resource supports about 17 per cent of the human and 11 per cent livestock population of the world. Per-capita availability of land for producing agricultural commodities has declined from 0.48 ha in 1951 to 0.15 ha in 2,000 AD and it is expected to decline further. Availability of fresh water for agriculture is expected to decline from current level of 80 per cent to about 70 per cent by 2050 AD. Global-warming will further reduce availability of fresh water to agriculture. Population growth, declining land and water quality, coupled with challenge of climate change, has created much greater concern to feed our ever growing population. Thus, the challenge has to be addressed with strategic approach utilizing innovations in science and technology.

Emerging Challenges

(i) **Declining Water Resource:** In India, currently about 80 per cent of available water is consumed for agricultural production, whereas, this share will be reduced to about 70 per cent by 2025 due to increasing demand of water for industry and drinking purposes. Although, India has the largest irrigation system in the world, its water- use efficiency has not been more than 40 per cent. If it continues like this, the water crisis would result in reduced production and productivity, which would affect our food and nutritional security. Currently, only 38 per cent of cultivated area is irrigated. More efforts are needed to cover additional area to enhance productivity. Studies have shown that improving water productivity by 40 per cent on rainfed and irrigated land could reduce the need for additional withdrawals over the next 25 years to zero.

(ii) **Challenge of Climate Change:** Enhanced CO_2 concentration may enhance photosynthesis in C3 crop species but increased temperature may increase water use and hasten the process of maturity. Innovations and strategic approaches may convert weaknesses into the opportunities. Adaptive mechanisms like time adjustment and productive use of water shall reduce the negative impact. These challenges could be addressed through identification of genes tolerant to high temperature, flooding and drought. Adoption of conservation agricultural technologies could be important. This would need reorientation of research agenda to address emerging challenges.

Crop Management Options

(i) **Water Productivity and Water Use Efficiency:** Water productivity denotes the output of goods per unit volume of water. However, productivity of water could be enhanced either by saving water use or by increasing the productivity. Relocation of water from low value to higher value uses would generally not result in any direct water savings but can directly increase the economic productivity of water. Suitable water application methods, varieties and management practices will have to be evolved. In agriculture, water use efficiency at the field level will amount to crop output in physical terms i.e. crop yield per drop.

(ii) **Water Productivity through Crop Improvement:** The productivity of water irrespective of environment will be governed by those factors which minimize water losses from the soil system and improve the transpirational water use by the crops. Water productivity with respect to evapo-transpiration varies considerably for different crops. Modern rice varieties have about a three-fold increase in water productivity. Similar is the case with modern dwarf wheat. Potential production rate of C3 plants is around 200 kg dry matter/ha/day and those of C4 plants between 200- 400 kg dry matter/ha/day. In some succulents, when stomata remain open during the night and close during the day, such adaptations are important from carbon and water economy point of view. To mitigate the impact of drought and heat tolerance in climate change scenario, putative traits which could be beneficial over long time scale should include phenology, like osmotic adjustment, rooting characteristics. Molecular markers and Quantitative traits loci for osmotic adjustment and rooting characteristics could open the way for easy screening of genotypes for these traits. In India, most of water diverted to agriculture only about 10 per cent of water is used for horticultural crops. However, majority of the horticultural crops are perennial they invariably have deep and extensive root system, capable of extracting water from deeper layers. Hence, they have better productivity than field crops.

Farm Management Options

Higher water productivity requires selection of appropriate crops and cultivars and proper soil and water management technology. Cultural and agronomic practices that reduce the soil evaporation, run off, deep percolation, transpiration by weeds, application of mulches, micro-irrigation could improve water productivity. Pressure irrigation system along with fertilizer application (fertigation) resulted in remarkably high water use efficiency. Drip system of irrigation has helped in increasing yield and saving of water especially in high value horticultural crops like grapes, banana, strawberry, citrus, mango, cashew-nut and coconut.

(i) **Augmenting Poor Quality Waters:** In future, reclamation and proper use of brackish and sewage water could be an additional option for increasing water productivity and resource use efficiency both in field and fruit crops. Both water quantity and nutrients contained in urban and peri-urban wastewaters make them attractive alternative water source for agriculture and aquaculture. Treated wastewater from off-site treatment plants can be reused for irrigation of parks and gardens, agriculture and horticulture.

(ii) **Promoting Greenhouse and Plasticulture:** The green-house technology and use of plasticulture using drip system of irrigation along with fertigation is one of the most modern technologies at present to grow high value crops with remarkable saving in water use. Greenhouse technology has been successfully used in the hilly states of north and north eastern states as well as in states like Maharashtra and Karnataka. Utilization of plastic mulch along with dripline underneath has been very successful in controlling soil evaporation and water use by weeds. Studies have reported almost 30-40 per cent increase in yield of tomato by using straw and polythene mulch.

(iii) **Diversification and Intensification:** Options for improving productivity and economic efficiency of water further lies in the production of timbers, agro-horticulture system, and growing of low water requiring medicinal plants as intercrops or sole crops. In the State of Madhya Pradesh, different medicinal plants grown in agro-forestry/ agro-horticulture system gave very high cost-benefit ratio.

(iv) **Integrated Farming System:** Integrated farming systems are more productive, profitable and sustainable. Water conservation based models by integrating field and horticultural crops + livestock + biogas plants are quite prevalent in several parts of India. These practices do help in better resource utilization, generation, livelihood security and welfare of small land holders for holistic rural development. Also attention is needed to help the farmers in value addition, processing and marketing.

Strategy Paper 9 : The Indian Oilseed Scenario: Challenges and Opportunities

(Dr. R.S. Paroda; August, 2013)

Vegetable oils are critical for the nutritional security of people in India which occupies a prominent place in global oilseeds scenario with 12-15 per cent of area, 6-7 per cent of vegetable oil production, 9-10 per cent of the total edible oil consumption and 13.6 per cent of vegetable oil imports. India has rich diversity of annual oilseed crops. Despite having the largest area under oilseeds in the world (26.77 mha), India currently imports about 50 per cent of total oil requirement at a huge cost of Rs. 56,000 crore (2011-12).

Production Scenario

India attained an average productivity of 1,087 kg per hectare for the triennium ending 2012-13. The average yields of most of the oilseeds are invariably low The production scenario of vegetable oilseed sector in the country can be categorized into four periods, viz., i) Post Independence (1950-1966), ii) Coordinated Research Program (1967-1985), iii) Technology Mission (1986-1996) and iv) Post-Mission (1996- 97 till date).

- **Post-Independence Period:** This period witnessed mainly an area expansion The area increased by 32 per cent while the production increased by 34 per cent with negligible gain in productivity The growth rate of productivity was a meagre 0.07 per cent
- **Coordinated Research Program Period:** This period witnessed massive structural reforms in the national network in oilseeds. The area, production and productivity increased by 18, 41 and 19 per cent, respectively for the quinquennium 1981-82 to 1985-86 as against 1967-68 to 1971-72.
- **Technology Mission Period:** Technology Mission on Oilseeds was initiated by the Late Prime Minister Shri Rajiv Gandhi in May 1986, with very ambitious objectives of (a) self-reliance in edible oils by 1990 (b) reduction in imports to almost zero by 1990 and (c) raise oilseed production to 18.0 million tons by 1989-90 and 26.0 million tons of oilseeds and 8.0 million tons of vegetable oil by 2000 AD. The mission started functioning as a consortium of concerned Govt. departments, The implementation of "Technology Mission on Oilseeds" spearheaded by Dr. M.V. Rao, resulted in the country's oilseed production surpassing the target of 18 mt fixed for the Seventh Five-Year Plan. The import got reduced to almost negligible. Hence, India achieved near self-sufficiency in edible oils during early 1990s, which was popularly referred to as 'Yellow Revolution". This golden era witnessed the release of 200 varieties and hybrids. As a result, India achieved a status of being 'self sufficient and net exporter' during early nineties, rising from the 'net importer' state.
- **Post-Mission Period:** Government's economic policy allowed competition dominated by both

domestic and multinational players. At the same time, the increasing per capita income led to enhanced consumption of edible oils. The gap between the domestic production and the requirement became widened at an alarming rate. This completely eroded the gains. In addition, the increasing biotic and abiotic stresses, strong intervention of market and non-market forces led to a sticky domestic oilseeds production and profitability. Despite the above developments, performance of oilseeds on the domestic front during the last two decades has been commendable. The trend of vegetable oils production over the years did help to a considerable extent in reducing imports.

Demand, Import and Export Scenario

- **Demand Projections:** The domestic demand for vegetable oils has also been rising rapidly due to increase in per capita income and increase in standard of living. While our domestic output has been increasing at just about 2 per cent. Import bill thus began to increase at an alarming rate. On the export scenario of edible oilseeds and the products, the rate of growth was a meager four per cent. Need for a special oilseed mission to increase the domestic production of edible oilseeds, to combat the swelling import of edible oils, is being felt. The demand for vegetable oils is both income and price elastic. Demand for vegetable oil increases with increase in population, increase in standard of living and increased use for industrial, pharmaceutical, nutraceutical, cosmetic purpose. The total vegetable oil requirement is thus to be met through domestic production. The country is meeting now more than 50 per cent of its oil requirement through imports resulting in huge drain on our foreign exchange.
- **Export Trend:** India made excellent inroads through export of oil meals (especially soymeal) and castor oil to the tune of Rs. 23,000 crore thus plugging almost 50 per cent of the import bill. The advantage of exports can further be consolidated with proper policy back-up and value addition.

Future Road Map

- **Policy Issues Needing Perspective Changes:** We need forward looking policies on mitigation of various kinds of risks in oilseed production efficiency and profitability to ensure healthy oilseed economy. All options for risk mitigation like linking farmers to market, buffer stock options, and other commodity price need to be put in place for oilseeds sector as a matter of priority.
- **Trade-related Policy Initiatives:** Government of India, with a view to meet the demand of edible oils and to control the rise in prices, has been allowing import of edible oils. All imports of edible oils meals were totally channelized through governments for sale through the Public Distribution System. India has become a major exporter of oilseed meals, especially soymeal. Indian oil meals command a premium because of its non-GM nature. Soymeal export is currently of US$ 2 billion annually.
- **Support Price:** Under the harsh growing conditions faced by Indian agriculture, oilseeds have a clear edge over many minor millets and pulses in terms of higher productivity. Unfortunately, the support price declared each year by the Government of India is evidently in clear favor of rice and wheat compared to oilseeds. Similar consideration for oilseeds is therefore, warranted.
- **Need for Institutional Linkages:** Apart from the institutions as such, some institutional support programs (National Dairy Development Board, National Agricultural Marketing Federation and the flagship program of the government in oilseed sector; Integrated Scheme on Oilseeds, Pulses, Oilpalm and Maize have been tried in the past. These programs need to be studied for understanding their significance and impact so that efficient and functional institutional support is provided in future for the required growth of oilseeds sector.
- **Eco-regional Approach for Productivity Enhancement:** The concept of eco-regional approach refers to the practice of delineating efficient zones for specific crops for realizing potential yields with high input-use efficiency. Concerted efforts on two categories of crop-wise eco-regions, viz., high area – low productivity and low area – high productivity zones will enhance efficiency in our efforts to increase production and productivity of oilseed crops.
- **Natural Resource Management:** Correcting the present limitation and imbalance in soil nutrients can provide rich dividends. Declining per capita arable land and extending oilseeds cultivation to poor and marginal soils result in low productivity. Precision crop management with conservation agricultural practices and customized fertilizer application schedules would usher higher efficiency and profitability. Emphasis on integrated natural resource management in oilseeds should, therefore, be our high priority.
- **Crop Improvement Strategy:** The gains in productivity of oilseed crops have been achieved primarily through exploitation of available genetic variability. Conventional breeding coupled with modern tools such as biotechnology should now be the primary focus in crop improvement programs.
  - **Role of Biotechnology:** At present, biotechnological research on minor oilseed crops (safflower, castor, niger, sesame, linseed and sunflower) is in its infancy. Therefore, it is essential to initiate concerted efforts using tools of biotechnology in these crops.
  - **Transgenic Approach:** There has been considerable progress towards harnessing transgenic technology for oilseed improvement. The transgenic technology has removed the phylogenetic barriers for transfer of useful

genes across organisms. Modifying the fatty acid profile of the oil to suit industrial, pharmaceutical, nutritional, requirements using genetic engineering approaches has been a priority in application of biotechnology in oilseed crops. Transgenic technology, is facing stiff-resistance from a section of the society. It is the responsibility of scientists, policy makers, to allay the fears in public mind through scientific knowledge.

- **Exploring Frontier Sciences:** Significant innovations in frontier science and technologies such as nanotechnology, genetic engineering and biotechnology, hydroponics, vertical farming protected agriculture; precision agriculture provide unlimited opportunities for supporting higher production and product development. Oilseeds production will also benefit from innovations in industrial sector. These frontier sciences will have to be harnessed into ongoing research programs for productivity improvement.

- **Public-Private Partnership and Linkages:** The potential of public-private partnership through linkages in all aspects of oilseeds production and marketing needs to be harnessed for a win-win situation. The grey areas for PPP in oilseeds include incentives for seed production, forward/backward linkages for processing, value addition, contract research in niche areas, contract farming, joint ventures for higher order derivatives and speciality products, etc.
- **Diversification and Value Addition:** Designer oils with requisite blends can meet the expectation and to that extent of individual oilseed crop's potential. As for unique non-oil value aspects for specific aroma or non-oil uses (medicinal, ornamental or other uses), the individual oilseed crops would be grown for speciality purpose irrespective of productivity level. Major opportunities for oilseed crop diversification and value addition include introduction as catch crop in paddy fallows
- **Adaptation to Climate Change:** The low productivity and uncertain production of oilseeds is mainly due to their cultivation under rainfed conditions (about 70%). Oilseeds production is constrained by several biotic stresses like insect pests and diseases that are being further aggravated by changing climatic conditions. Global warming induced climate change is expected to trigger major changes in population dynamics of pests, and their biotypes. There is a need to generate information on the likely effects of climate change on pests so as to develop robust technologies that will be effective.
- **Transfer of Technology:** Concerted efforts are urgently needed for the dissemination of technologies on a participatory mode to be strengthened for effective delivery. The Farmer-Institution- Industry linkage mechanism should be strengthened. The potential information and communication technology should be harnessed on a dynamic and interactive mode. This can minimize the dissemination loss while sharing information and provide benefits to all the stakeholders involved in oilseeds. The learned author spelt out specific recommendations to achieve these objectives.

The success of 'Yellow Revolution', achieved through mission mode approach of TMOP during eighties, fully justifies revival of Oilseeds Mission approach with greater zeal and commitment of all to tide over the present crisis of large scale import of edible oils. Hence, we must have clear national policy of bridging the yield gaps and increased oilseeds production with specific aim to reduce our vegetable oil imports.

Strategy Paper 10 : Need for Linking Research with Extension for Accelerated Agricultural Growth in Asia

(Dr. R.S. Paroda; September, 2014)

The Asia region is agriculturally vibrant. With 38 per cent of total agricultural land, it houses 80 per cent smallholder farmers supporting 74 per cent of world's agricultural population. It accounts for about 58 per cent of the world's population and is the largest supplier of the world's food and agricultural products and has witnessed "Green Revolution" brought out by a science-led synergistic extension approach capitalizing genetic potential, irrigation, fertilizer, appropriate policies and farmers' hard work. The increased agricultural productivity resulted in quadrupling per caput GDP, thus almost halving the level of poverty in the region. However, continuing to secure such gains is becoming a major challenge especially in the context of declining factor productivity, deteriorating natural resources, impact of global climate change and above all a fatigue in the existing extension system.

Challenges

The problem has further been intensified with sharp rise in the cost of food and energy, depleting water resources, diversion of human capital from agriculture, shrinking farm size, soil degradation, imbalanced use of chemical inputs and overarching effects of changing climate. The region's agrarian landscape is predominantly smallholder farmers. It is estimated that by 2050, the food grain requirement in the Asia region would be around 70 per cent more than the current demand. Therefore, ensuring the availability of food, in both quantity and quality for the poorest of the poor remains a daunting challenge. In this context, the 'GCARD Road Map' which highlights the urgent changes required in Agricultural Research for Development (AR4D) is very important. The reduction in water availability and increase in animal and plant diseases will primarily affect poor countries.

Opportunities

Our rich genetic resources serve as a gold mine for specific/unique traits to be harnessed for germplasm improvement, through breeding and biotechnology to

develop varieties/breeds possessing high productivity. Accordingly, germplasm conservation will significantly help in achieving both sustainable agricultural growth and development in Asia. It is, therefore, necessary to build an effective national agricultural research system (NARS).

Innovations around good agricultural practices such as: conservation agriculture (CA), balanced use of fertilizers, small farm mechanization, micro-irrigation, integrated pest management, scientific land use for crop diversification, etc. would contribute considerably in arresting natural degradation.

This region also has huge potential to promote horticulture. There is need to diversify the food basket by producing more of vegetables and fruits, preventing post-harvest losses and adopting food processing technology. Mechanization and automation of dairy farms, measures to provide good quality feed and fodder, provision of improved seed varieties for fodder crops, value addition of milk and meat products are some of the measures to enhance livestock industry. Fishery is another potential sector which can help in achieving both food and nutritional security. The inland fish farms with adoption of modern technologies, managed by skilled human resource can make all the difference. Inclusive growth in agriculture through large scale adoption of new technologies, a major paradigm shift in our approach should be from R&D to AR4D, involving greater participation of all stakeholders. Regional partnerships are important to catalyze faster adoption of new technologies through sharing of success stories.

Linking Research with Extension

Our research should be sensitive to local needs and should meet the aspirations of both farmers and consumers. In India, the agricultural institutions (ICAR Institutes & SAUs) in collaboration with Department of Agriculture take part in technology generation and its transfer to stakeholders. Efforts are needed to capture farmer led innovations in agricultural practices and blend them with modern science through refinement. Agriculture is the only enterprise where prices are determined by others than the producer. To ensure competitive price of produce, role of middlemen has to be minimized and market forecasting systems have to be strengthened.

There is need to have a relook on domestic Agriculture Policy in order to make it more effective for infrastructure development, risk management and easy credit availability. Technologies relevant to women farmers need to be evolved and promoted to remove their drudgery. Asia can reap the demographic dividend if attention is paid to create more and better jobs to retain youth in agriculture who have lost their interest in this profession. In this context, new opportunities are emerging in IT linked agri-extension, seed technology, biotechnology, food processing, cold storage, packaging, supply chain management, insurance and farm credit. The success of Green Revolution was mainly due to holy alliance between researchers, extension specialists and the farmers.

A paradigm shift is needed from present national agricultural research institute (NARI) system to that of the national agricultural research and extension system (NARES) by having effective involvement of all stakeholders (researchers, extension personals, NGOs, Private Sector and the farmers).The future AR4D efforts by NARS must now be reoriented towards farming system approach involving farmers' participatory approach.

Strategy Paper 11 : Reorienting the Agriculture Research for Development Agenda for Sustainable Livelihood Security of Smallholder Farmers

Dr. R.S. Paroda: March 2017

Agriculture has remained an integral part of the socioeconomic fabric of rural India since time immemorial and also occupies centre stage in Indian economy as it sustains livelihood of over 70 per cent of the rural households and provides employment to over 60 per cent of the population. Despite wide variations in growth performance during last six decades after independence, which is primarily due to the subsistence nature of farming in India and the sector's heavy dependence on monsoon, the country has witnessed several innovations in agriculture. One of the most evident -"Green Revolution" was brought out by a science-led synergistic extension approach capitalizing genetic potential, irrigation, fertilizer, appropriate policies and farmers' hard work. This innovation accelerated the growth in agriculture sector and led to an unprecedented transformation in the development of our country. The increased agricultural productivity, rapid industrial growth and expansion of the non-formal rural economy resulted in higher per capita GDP, ensuring food security of the nation. However, continuing to secure such gains is becoming a major challenge especially in the context of growing population which is touching 1.3 billion, declining factor productivity, deteriorating natural resources, impact of global climate change and above all a fatigue in the existing research and extension system that largely operates in the public sector.

A. The Challenges Ahead

(i) Food Demand vs Small Farm Holdings

Both research and development and innovations by farmers had enabled India harvest record foodgrain production of 265 million tonnes in 2014, which later got declined to around 252 million tonnes in 2016 due to two consecutive droughts. By 2030, we would need to produce 70 per cent more food grains than what we are producing today, that too while facing multiple challenges like depleting water resources, diversion of human capital from agriculture, shrinking farm size, soil degradation, indiscriminate and imbalanced use of chemical inputs and overarching effects of changing climate. A consistently low investment over last two decades in agricultural research for development (0.3% of agricultural GDP) further complicates the

problem. Therefore, ensuring the availability of and economic access to food, in both quantity and quality (nutrition), for the poorest of the poor in the country remains a daunting challenge. In this direction, the 'GCARD Road Map' developed through interaction of diverse stakeholders from around the world in Global Conference on Agricultural Research for Development held in Montpellier, France in 2010 highlighted an urgent need for reorienting Agricultural Research for Development (AR4D) globally, especially to address the needs of resource-poor smallholder farmers and consumers. It also envisages a major paradigm shift towards farming system's research with greater thrust on "Innovations for greater impacts on small holder farmers" requiring partnerships among stakeholders and their capacity building.

(ii) Natural Resource Degradation and Climate Change

The ever increasing population growth is interlinked with fast declining and degrading land, water, biodiversity, environment and other natural resources which are around 3-5 times more stressed due to population, economic and political pressures in India compared to the rest of the world. The country has already reached the limits of land available for agriculture and hence very limited scope exists for horizontal expansion. Inefficient use and mismanagement of production resources, especially land, water, energy and agro-chemicals, has vastly reduced fertility and damaged our soil health. In Indo-Gangetic Plains, the food bowl of India, soil organic carbon is invariably less than 0.5 per cent which is just not sustainable. Today, soils are both hungry and thirsty. To a greater extent, lack of political will and appeasement policies to provide free or relatively cheap inputs like seeds, fertilizers, water, energy etc. have further exacerbated the problem.

B. Opportunities to Harness

(i) Innovations in Natural Resource Management

One of the main causes of slow growth in agriculture is relatively poor dissemination of emerging technologies relevant to the needs of smallholder farmers. Innovations in agriculture are needed to meet the major challenge of increasing resource scarcity and bring in structural transformation in the socioeconomic context, so as to reduce cost on inputs on one hand, and improve the livelihood of resource poor smallholder farmers on the other. Therefore, in order to liberate the nation from hunger and poverty, while sustaining existing natural resources, the policy makers will have to have a renewed thrust and commitment for additional funding (almost three fold -1.0% of agricultural GDP) for agricultural research for development (AR4D). Without this, the task of achieving inclusive growth and development will remain quite elusive.

(ii) Strengthening Collaboration and Partnerships

It is well known that Green Revolution was an outcome of partnership between National Agricultural Research System (NARS), International Research Centers like CIMMYT and IRRI, and extension system including progressive farmers. Regional and global networks and partnerships for knowledge sharing and enhanced capacity development of different stakeholders is a must for out scaling innovations in similar ecologies. It has been increasingly realized that under the changing scenario of production to consumption, the linear approach in technology development and deployment will not serve the purpose to address the new Sustainable Development Goals (SDGs). Therefore, for inclusive growth in agriculture through large scale uptake of new technologies, a major paradigm shift is needed from R&D to AR4D, involving greater participation of all stakeholders. The past experiences from the regional organizations/ programs like Asia-Pacific Association of Agricultural Research Institutions (APAARI), SAARC, ASEAN, Rice Wheat Consortium (RWC), Cereal Systems Initiative for South Asia (CSISA), etc. have revealed that regional partnerships are very important to catalyze faster adoption of new technologies mainly through sharing of success stories around good agronomic practices (GAP).

(iii) Linking Research with Extension

In the present context, the agriculture sector has to be more scientific oriented and technology driven. Our research should be sensitive to local needs and meet the aspirations of both farmers and consumers. There should be closer working relationship between research and extension organizations. The scientists involved in basic, strategic, applied and adaptive research, together with subject matter specialists, extension workers and farmers, should be seen as an integral component of knowledge dissemination and agricultural advisory system. The interface between research and technology transfer is indeed very critical for converting outputs into outcomes. In fact, we need to link "land-to-lab" and "villages to institutions". This would require a paradigm shift from "top down" to "bottom up" approach for technology generation, refinement and adoption. Furthermore, research agenda of the institutions should be better organized for technology development and its dissemination. For agricultural research to make an impact, there must be strong linkages among researchers, extension agencies, farmers and other stakeholders. In all the institutions, the technology transfer programs need to be an integral part of technology development in order to empower farmers with proper knowledge. Accordingly, the farmer participatory research has to be given major focus henceforth.

(iv) Empowering Women for Inclusive Growth

It is well recognized that women empowerment is quite important for both agricultural growth and household nutrition security. Globally, about 43 per cent women are engaged in agriculture. In India, 60 per cent of farming operations are performed by women. Therefore, agriculture can be a primary driver for the empowerment of women. Innovations improve their

work efficiency but would also ensure overall household development and nutrition security. However, women in agriculture are invariably deprived of access to agricultural knowledge, credit, technology to overcome their drudgery and market related services. Often, they are deprived of their rights to land and resources. All these adversely impact their performance. The State of Food and Agriculture Report of 2010-11 by FAO has already indicated that reducing the gender gap between male and female farmers could raise yields on farms by almost 20-30 per cent. As a consequence, it is expected that engendering agriculture would lead to reduction of undernourished people globally by 12-17 per cent. This in turn would translate into 100-150 million fewer hungry people. Hence, technology generation relevant to women farmers and its adoption should become an important agenda for future agricultural growth as was recommended by the first Global Conference for Women in Agriculture (GCWA) held in New Delhi from March 13-15, 2012.

(v) Retaining Youth in Agriculture

The ageing population of farmers and declining interest among rural youth to take up agriculture as a profession are challenges for agricultural sustainability not only in India but also in other countries of the world. A large section of youth invariably prefers to migrate to cities to seek employment, especially the Government jobs. Hence, a major challenge today is how to retain youth in agriculture, which certainly cannot be left unaddressed. The declining interest of rural youth in agriculture is directly related to existing poor physical amenities, socioeconomic conditions and lack of enabling environment. Economic factors such as low paid employment, inadequate credit facilities, low profit margins, and lack of insurance against crop failure are also discouraging youth to get engaged in agriculture. Social factors include public perception about farming, especially the parental desire that their children should opt out of agriculture are also the reasons for choosing occupation other than agriculture. Environmental issues include poor soil health, non-availability of water for irrigation and climate change. Concerted efforts are thus needed to stimulate their interest further by expanding their horizon and understanding of secondary and specialty agriculture for enhanced income and avoidance of risk factor in agriculture. Proper incentives for their involvement in agricultural education, research and extension and by linking them to the expanding markets will, therefore, have positive effects in attracting youth in agriculture.

Earlier, seed, pesticide, fertilizer and farm machinery were the only potential sectors to employ agricultural graduates/rural youth. Now new opportunities are emerging in IT linked agri - extension, seed technology, biotechnology, food processing, cold storage, packaging, supply chain management, insurance and farm credit. Private sector and NGOs are also engaging now the rural youth. In this context, greater thrust on vocational training of youth (including female) is urgently needed for relevant skill acquisition, greater confidence building and to serve as 'Technology Agents' to provide efficient knowledge/ service on custom hire basis. It is high time that all out efforts are made at all levels to engage youth in multifarious activities around 'Plough to Plate' so as to make farming both attractive as well as lucrative profession. Knowledge based agriculture around secondary and specialty agriculture can obviously enhance opportunities for additional income for the youth. Peri-urban agriculture, contract farming, protected cultivation, establishment of self-help groups or producer companies offer additional opportunities for youth to remain in agriculture.

Future Road Map: Need for a Paradigm Shift

The Success of Green Revolution was mainly due to holy alliance between researchers-extension specialists and farmers, backed by enabling policy environment. The technology dissemination approach adopted in the past was top-down and centered on individual farmers. Faster adoption of technology was also on account of miracle seeds of wheat and rice, promoted largely by the public extension system which over the years has become relatively weak as well as complacent. On the contrary, new innovations around natural resource management require bottom-up approach, involving farmers participation, while ensuring confidence building among farming communities to take risk and make agriculture more scientific and resilient. In the process, sharing of knowledge on good agronomic practices (GAP), without dissemination loss, and incentives for critical inputs becomes highly crucial to achieve future successes. Also partnership among key stakeholders becomes essential to promote growth in agriculture. In the process, care is also needed to overcome complacency that has crept in the public extension/ advisory services. Also, a paradigm shift is needed from present national agricultural research institute (NARI) system to that of the national agricultural research and extension system (NARES). This would require active involvement of stakeholders such as farmers, NGOs, private sector, scientists and policy makers. Another paradigm shift has to be in the extension approach towards translational research in order to ensure out scaling of innovations for greater impact on both higher productivity and income. In this context, extension approach has now to be around farming communities rather than individual farmers. Also, Natural Resource Management (NRM) related innovations would require more lead time to assess the impact on farmers' fields, unlike the impact of high yielding varieties on crop productivity. This obviously throws a new institutional challenge for needed reforms in our existing extension system, which is mostly dependent on public organizations. Role of private sector, especially through involvement of youth and gender in agriculture, becomes most relevant in the present situation. Hence, empowering youth (both men and women) through vocational training and building a cadre of 'Technology Agents' to provide technical backstopping as well as custom hire services to the smallholder farmers will go a long way in liking research

with extension for accelerating agricultural growth. In other words, we need to link now 'land with lab', the 'village with institute' and 'scientists with society' to ensure faster adoption of resource saving technologies that would benefit both producers and consumers. In the process, the Agriculture Technology Agents will become "job creators and not job seekers" and provide on farmers' door steps the best technologies as well as quality inputs. Another strategy could be to create 'Agri-clinics', where technology agents could join hands to ensure single window system of advisory services so that farmers need not run from pillar to post. In fact, a good farmer is more knowledge hungry and not so much dependent on government subsidy. Once convinced, the farmer is willing to take risk and invest in adopting new innovations.

The Way Forward

Agriculture in India must liberate the region from twin scourges of hunger and poverty and that of malnutrition of children and women. The nation must continue to feed the increasing population with adequate food supply. Accelerated science and innovation-led agricultural growth must be inclusive and should address the needs and aspirations of resource-poor smallholder farmers in the country. Under the growing challenges of resource degradation, escalating input crisis and costs with overarching effects of global climate change, the major gains in food production would largely depend in future on a paradigm shift from integrated germplasm improvement to that of integrated natural resource management. The future AR4D efforts by NARS must now be reoriented towards farming system's approach ensuring farmers' participation. Also, we need to employ more innovative ways for effective dissemination of knowledge and lay greater emphasis on out scaling innovations for needed impact on livelihood of small holder farmers. Henceforth, 'Farmer First' be our goal so as to bridge the income divide between farmers and non-farmers and benefit equally the producers and consumers. To ensure this, the developing countries like India must enhance their investments (almost triple) in AR4D in order to address effectively the emerging challenges and ensure food, nutrition and environmental security.

Strategy Paper 12 : Retrospect and Prospect of Doubling Maize Production and Farmers' Income

(Dr N.N. Singh; September 10, 2017)

Doubling of production is needed due to demand pull for meeting feed, food and industrial requirements and it can be achieved by comparative strong techno-economic competitiveness to export grains and seeds by developing climate resilient single cross maize hybrids suitable for *kharif* season and by bridging gap between realized yield and potential yield. Maize production would require more than 7-8 per cent compound annual growth rate in yield which would be possible due to 80 per cent area coverage under *kharif* maize with single- cross hybrids, which would increase average productivity from 2.56 t/ha to 5.0 t/ha.

Improving Productivity

Thrust on genetic enhancement

- Recognizing productivity advantage of single-cross maize hybrid including QPM, emphasis should be given for strengthening pre-breeding activities for diversification of germplasm for exploitation of higher magnitude of heterosis with improved adaptability, introgressing resistance for biotic and abiotic stresses for enhancing genetic resilience to climate change.
- Integrating use of new tools and breeding techniques is required to save on time and to reduce breeding cycle for genetic enhancement such as, DH, MAS, GWAS, round the year nurseries and needed infrastructural facilities to develop hybrids for wider resilience to climate change.
- Farmers need to be sensitized about newly developed QPM single-cross hybrids available without yield penalty and be encouraged to use QPM as food and feed by poultry sector than normal maize. Since maize is the main cereal for feed, the quantity of normal maize used as feed can be reduced to half due to doubled biological value of QPM for true protein digestibility.
- A mechanism should be developed for upscaling and outscaling cutting - edge technologies including GM maize after ensuring biosafety measures to increase productivity and profitability. Greater thrust needs to be given on seed production of single cross hybrids
- Since maize can be grown in almost all parts of the country, a suitable area and season for developing seed production hub should be identified in each state with all the necessary infrastructural facilities, like seed- processing plants, cold chains, safe storage facilities, uninterrupted power supply, etc. in PPPP mode and made available to all producing agencies on rent to cut- down on cost of transportation for availability of seed low cost at the door step of farmers.
- A mission- mode approach on seed production of single -cross maize hybrids is needed to bridge productivity gaps. A rolling plan for seed production for at least 5 years should be prepared for outscaling better single -cross hybrids suitable for a specific region, jointly decided by a committee under the leadership of eminent scientist, seed sector representatives and a group of progressive farmers.
- Enabling policies should be in place to encourage private sector to invest more in R&D to develop single cross hybrids and to produce enough seed for *kharif* maize; considering vast area and seed replacement rate (SRR) to cover 70-80 per cent *kharif* maize area and phasing out old cultivars. The benefit of the subsidy need to be extended to the best hybrids, irrespective of notified or truthfully labeled (TL) developed by public or private sector.

- Necessary cold -storage facilities to establish seed bank in each region should be developed as contingency measures to manage maize- crop in *kharif* during the unforeseen situations.
- Necessary coordination and convergence is required among seed companies to take up production on the basis of maturity to avoid contamination in seed production area. Progressive farmers should also be involved in hybrid seed production with proper training.
- A mechanism already in place should take advantage of PPV&FR Act; providing protection to produce seed of public sector bred hybrids by private sector by paying 3-5 per cent royalty negotiated on sale proceeds on exclusive/nonexclusive basis.
- Indian seed sector is very well established and has a potential to grow beyond boundaries of domestic market and enter global market such as Africa, SAARC countries, South East Asian countries. For this, needed statistics through Embassy are to be provided with enabling policies to help private sector to harness potential of global market.
- Quality testing laboratory should be established and equipped for testing transgenic seeds and QPM apart from normal seed.

Thrust on Production and Protection Technologies

- Realization of the drastic effects of climate change in the last 10-15 years warrant bringing in resilience to biotic and abiotic stresses and also revisiting of agronomic recommendations towards sustainable intensification by adopting Conservation Agriculture to reduce cost on inputs, improvement in soil health, water- use efficiency, human nutrition and by linking integrated Farming System and crop diversification for improving production and farmer's income and reducing environmental foot print.
- Priorities should be given to contain biotic stresses by developing host plant resistance, IPM approaches, biological control methods, and enhancing farmers' income by lesser expenditure on purchase of chemicals.

Development of Maize Value Chain

- Maize value chain development should focus mainly in efficiency improvement, considering consumer demand which becomes driver for innovation and value- creation, leading to continuous improvement in food supply and benefits to consumers.
- There is a need to reduce gender gap involving women to raise farm yield by 20-30 per cent and reduction in malnutrition by 12-17 per cent.

Outscaling Innovations

- There exists a huge gap between potential and realized yield of maize. An innovative mechanism with PPPP mode has to be developed to disseminate production technologies involving local agricultural graduates as paid technology agents.
- In the absence of local entrepreneurship at the village level such as input providers, input producers, implement providers etc., the opportunities are hijacked by outsiders leading to exploitation and deprivation of employment to local youth; forcing them to migrate to cities for jobs.
- More investment is needed in maize R&D for upscaling and outscaling innovations. Such investment would yield higher returns in terms of productivity and economic growth in longterm than input subsidies.

Linking Farmers To Market (LFM)

- It is important to improve market efficiencies by reducing price spread and raise producers share in consumers' rupee by stopping interference of middleman and encouragement of direct marketing for better profits to farmers. In this regard, e-Nam, ICT, print and electronic media offer new marketing opportunities.
- Farmers cannot hold on to maize- grains after harvest for long time due to their hygroscopic nature and are compelled to sell the produce as a result prices dip drastically. For better profit to farmers, the storage facilities at *Tehsil* level should be developed in PPPP mode for storage of produce; preferably graded and labeled signifying quality standards. This would help farmers to get credit against the receipt of the stored produce, and would avoid distress sales by them to realize better prices. This would also minimize storage losses and traders can lift produce from one place instead of door- to- door from farmers.
- A new mechanism should be developed in PPPP mode to make producer companies, self help groups, contract farming more farmer friendly under which buyers can provide farmers access to technology, quality inputs, more support in business skills, capital investment, credit facilitation, risk management and guaranteed better price. A comprehensive and progressive credit policy should be framed and implemented to free farmers from the clutches of money lenders.
- Engagement of rural - women and youth in village itself to sell specialty products such as frozen sweet corn, baby corn, roasted green ear, and packets of pop corn, ready-made QPM products, dry milling products, feed etc. at highway roadside or in nearby town/cities would ensure their livelihood security and income.
- There is considerable scope for the export of value -added dry- milling maize products and feed, certified organically produced specialty corn with good packaging, meeting quality of international standard. A strategy to LFM should be evolved for the participation of buyers across the country without restriction in movement of products and harmonization of tax laws/GST. Proximity to the national/international airports needs to be

exploited for export of value- added products, feed etc. for better income.

Capacity Building

- There is a need to organize periodically capacity-building programs for field officers, technology agents, other field functionaries involved in maize development programs and vocational training programs for farmers including women farmers.
- Deployment of local youth and women require knowledge empowerment and guidance in business skills and to manage risk. Also, investment to establish unit for maize value -chain in a PPPP mode can play a very important role by forming self help groups (SHGs) of various stakeholders. Success of such an endeavour would depend on the integrity and competence of leaders involved with good professional support.
- Awards and incentives should be instituted to ensure progressive farmers, maize scientists, development workers including NGOs and private sectors for their outstanding work and they should be involved in decision making bodies.

Institutional Reforms and Enabling Policies

Planning Maize Research for Development

- The maize research and development planning should be done involving all stakeholders, viz., farmers, scientists, development and private sector personals, policy makers, ensuring their support and commitment.
- Research agenda should emerge from farmers fields' problems and are to be addressed taking into consideration farmers- led innovation built on traditional knowledge. There is need to help farmers to diversify maize- farming system from supply driven to demand driven for overall growth- increasing productivity, profitability and environmental safety.
- Crop diversification, mechanization, value-addition and reduction in food wastage should be encouraged in PPPP mode with supportive policies by the Government to act as coordinator/facilitator ensuring reliable and efficient supply of productive resources, services and delivery system, enrolling local youth by providing aggressive training for skill upgradation and creation of non-farm rural employment.
- Farmer's should be sensitized by policy initiatives taken by Central Government for doubling farmer's income and for conserving natural resources such as PM Irrigation programme, PM Agricultural Insurance, NFSM, RKVY, NHM, National Mission on Sustainable Agriculture, eNAM etc.
- Also, QPM maize should be procured and provided though public distribution system (PDS) in the states predominated by tribals and poor masses where maize is directly consumed as food to ensure their nutritional security.

Promoting Sustainable Intensification Practices

- The integrated resource conserving maize based farming system needs to be scaled- up which has generated significant social, economic and environmental benefits to help farmers for increased production, productivity, improved livelihood, and income, while conserving natural resources, enhancing ecosystem services, adapting and mitigating effect of climate extremes under conditions of water scarcity and soil hunger.
- There is a need to review current support for adoption of resource conservation technology sustainable practices to maize with a view to eliminate 'perverse subsidies' that encourage harmful practices, such as over use of fertilizers, pesticides, water, leading to losses to genetic resources and natural resource.

Strategy Paper 13 : Indian Agriculture for Achieving Sustainable Development Goals

(Dr R.S. Paroda; October, 2017)

Globally, poverty and hunger are still twin challenges before human civilization despite specific temporal and spatial efforts. Though extreme poverty has been reduced by more than half since 1992, yet more than 800 million people live on less than $1 a day. And roughly, half of the world's population lives below $ 2.50 a day. Besides, 1 in 9 people are undernourished. Poor nutrition results in nearly half (45%) of the deaths among children under the age of five years i.e. nearly 3.0 million children per year. Unfortunately, every 3.5 seconds a child dies from poverty. Therefore, it is necessary to produce affordable, nutritive, safe and healthy food more efficiently and sustainably. On the contrary, agriculture is facing bigger threat now than ever before on account of degradation of natural resources, especially land and water, besides the adverse impact of global climate change. Hence, combating climate change, reducing emission and conserving natural resources, without compromising economic development especially on food front would require new set of policies, institutional reforms and additional investments in agriculture sector.

Modern agriculture has achieved much over the past century. While the global population has grown from less than three billion people in 1950 to more than seven billion people today, the levels of hunger have not followed this trend. Of the estimated 805 million people experiencing chronic hunger globally, around three quarters live in rural areas and are overwhelmingly dependent on agriculture for their food and livelihood. 526 million people in Asia and the Pacific (65% of total) are impacted by hunger, being the highest in the world. Most of them live in South Asia. Tackling hunger is not only about increasing food production; it's also about

increasing incomes and strengthening markets so that people have ready access to food. Fortunately, the Food and Agriculture Organisation of the United Nations has predicted that hunger levels are likely to decrease considerably by 2030.

Way Forward

The SDGs do present a unique opportunity for the entire agricultural sector to get aligned for achieving a better tomorrow for the world. Currently, India has the largest number of undernourished and poor people in the world. Hence, if India can accelerate the pace to achieve SDGs, then globally we could soon eliminate hunger, achieve food security and improve household nutritional security. At the same time, it is imperative that policy makers accord high priority to agricultural research for development (AR4D) and ensure enhanced allocations (a minimum of 1% of agricultural GDP) to NARS and strengthen the food systems for physical and economic access to resource poor people residing in rural and urban areas. In fact, agriculture sector be seen as an important sector to achieve faster the goals of eliminating both poverty and hunger as well as ensure nutrition and environmental security and protection of fast degrading natural resources. However, the success of achieving SDGs would require a Mission-Mode approach to implement and effectively monitor the progress on defined goals. Strategies to accomplish SDGs must, therefore, address the following recommendations on priority:

- Despite witnessing Green, White and Blue Revolutions, having attained impressive food production of 303 mt (estimated for 2020-21), milk production of 187.75 mt and both inland and marine fish production of 12.6 mt on GHI, India ranks 100 among 113 countries and prevalence of poverty is around 24 per cent. Despite physical access, our major aim should now be to provide economic access to available food through effective implementation of national food security act and other safety net initiatives, especially in the regions/states where maximum poverty and hunger still resides.
- Ensuring meaningful engagement of all stakeholders in the formulation of national strategies, implementation plans and monitoring of the progress towards achieving SDGs, using baseline data for defined goals to be a national priority.
- The functioning of National Agricultural Research System (NARS), involving ICAR Institutes and the State Agricultural Universities (SAUs), must involve other stakeholders such as NGOs, FPOs, private sector institutions, farmers and agribusiness entrepreneurs.
- Continuous prioritization as well as re-prioritization is needed for development research portfolio in tune with the fast-changing global, regional and national needs. The 'top-down' approach adopted in the past will have to be changed to make it a 'bottom-up' approach. A shift from project to program mode and also from commodity/crop to farming system's mode is urgently warranted. In this context, focus on crop diversification, hybrid seeds/high value crops, biotechnology, ICT, GIS and good agronomic practices (GAP) would help in doubling farmers' income and attain resilience in agriculture with efficient input (water, fertilizers, chemicals for pesticides) use.
- Adopting eco-friendly and climate resilient technologies, with emphasis on efficient farming systems in different eco-regions and strengthening of activities for improving soil health through organic matter recycling, conservation agriculture, efficient and need based use of nutrients, using decision support systems and soil test results, improved water use efficiency using micro-irrigation techniques etc. would help resilience in agriculture.
- Make best use of available knowledge and technologies through: i) defining recommendation domains (technology targeting); ii) increased investments (almost double) in managing efficiently land and water resources; and iii) strengthening input delivery as well as market linkage mechanisms.
- National Livestock Mission should focus particularly on quality feed and fodder, improved risk coverage including animal insurance, conservation and improvement of indigenous breeds; higher productivity and production; value addition; enhanced livelihood opportunities; increased awareness; and better availability of quality animal products to the consumers at affordable price.
- Need for developing new agri-food systems for pre- and post-production management through processing and value addition and by ensuring no wastage of food both during storage, transportation and consumption.
- Knowledge updation of farmers on new technologies, practices and recent advancements is a must as against providing subsidies. Building multilateral and multi-sectoral technology transfer mechanisms for linking science to society with greater emphasis on attracting and retaining youth in agriculture, especially through diversification, secondary and specialty agriculture are to be strengthened to empower farmers.
- Dissemination of available high- value technologies; market linkages through e-NAM, revision of APMC; provision of pledged storage; developing and providing need-based technologies for immediate use and also for anticipatory long-term needs of farmers/industries/consumers is now needed. We need to remain competitive in order to take full advantage of globalization of agriculture and have an advance preparedness for emerging new WTO regime.

- India must increase substantially its capital investments for creating much needed infra-structure, available by involving both public and private sectors, especially in the eastern and north-eastern regions so as to capitalize on rich natural resources that have great potential for faster agricultural growth and evergreen revolution.
- SDGs have several interconnected goals and, thus, require an effective coordination and convergence mechanism at all levels through an inter-disciplinary and inter-institutional/ departmental approach to draw collective strength for desired impact. Such coordination mechanism has to be top down for effective monitoring and evaluation.
- Widening the policy space with much needed faith in agricultural science and new technologies without fear and with human face, is very much needed for accelerating growth. Therefore, an aggressive approach on policy advocacy and reforms is urgently warranted for scaling innovations for achieving SDGs in the given time frame, i.e., 2030.

Strategy Paper 14 : Strategy for Doubling Farmers' Income

(Dr R.S. Paroda; February, 2018)

All the nations facing problems of poverty, hunger and malnutrition will need to accelerate their agricultural growth for achieving sustainable development goals (SDGs), especially while aiming at no poverty, zero hunger and safe environment for all. The Green Revolution not only led to food self-sufficiency but also helped to reduce the poverty and hunger. And yet, despite fivefold increase in foodgrains production, as against a fourfold increase in population, India still has around 250 million people who live in poverty and about 45 million children below five years of age who are malnourished. Moreover, after 50 years of Green Revolution, India is also facing the second generation challenges like decline in the factor productivity growth, poor soil health, loss of soil organic carbon, ground and surface water pollution, water related stress, increased incidence of pests and diseases, increased cost of inputs, decline in farm profits and the adverse impact of climate change. On the demographic front, India adds annually almost one Australia (about 15-16 million) to its population. Thus, any progress gets nullified by an overall increase in population. Also, around 48 per cent of the population is currently dependent on agriculture and allied fields and the agriculture sector contributes around 17 per cent to national gross domestic product (GDP). Moreover, the public sector capital investment in agriculture and rural development has declined from almost 20 per cent during Green Revolution period to currently less than 10 per cent. In the process, many States have remained deprived of growth and development. As a result, most farmers are not benefitted especially since majority of them are smallholders and find agriculture not profitable any more.

Why Double Farmers' Income?

Today, around 138 million Indian farmers' main concern is about declining farm income on the one hand and the increasing cost of inputs on the other. A recent study by the ICAR-National Institute of Agricultural Economics and Policy Research (ICAR-NIAP) has shown that around 70 per cent farmers in the country have annual per capita income less than INR15,000 (around USD 250). Dr PS Birthal and his team have further analyzed the situation and found that their geographical distribution is widespread, but mostly concentrated in Uttar Pradesh (27.4%), Bihar (11.4%), West Bengal (9.9%), Odisha (6.3%), Rajasthan (5.8%), Madhya Pradesh (5.3%), Maharashtra (4.9%), Assam (3.9%) and Jharkhand (3.2%). Most of these states lack the required infrastructure for agricultural income growth. Moreover, around 70 per cent farmers are marginal (owning less than one hectare), and 77 per cent of them earn even a meager income of INR 6,067 per capita a year. Further, about 40 million farmers have just around 500 sq m of land, which is just not sustainable. Accordingly, the distress of small and marginal farmers has drawn specific attention of policy makers lately. The Hon'ble Prime Minister, considering this as a national priority, rightly called for doubling the farmers' income by 2022. It is often argued that Green Revolution mainly helped the country to achieve national level food self-sufficiency, whereas it seemed to have bye-passed the majority (almost 86%) of smallholder farmers having less than 2 ha. Further, besides the second generation problems of Green Revolution, farmers are now faced with twin global challenges; i) global climate change, and ii) globalization of agriculture. The average land holding is around 1.1 ha, whereas many have much less than even 1.0 ha which is not sustainable for a farm family. To make farming profitable, these farmers do require both new technologies that can save cost on agricultural inputs, while increasing productivity, and the policy support for getting credit at low interest and also higher income by linking them directly to the markets.

Way Forward

To make agriculture both remunerative and attractive as a profession, and especially to double the farmers' income, an action plan for implementing the three pronged strategy proposed above is described here:

Policy Interventions

- A 'National Mission on FARMERS First', with an annual allocation of INR 10,000 crores to begin with and by merging/clubbing of various central schemes as well as through some new initiatives to empower farmers need to be initiated soon. This will help in catalyzing the activities/ programs specifically designed for scaling innovations that will increase farmers' income and have direct impact on smallholder farmers through adoption of three pronged strategy defined earlier.
- Needed regulatory reforms in the existing Acts especially pertaining to the land, water, seed,

fertilizer, energy and market, etc. must be brought about as a matter of national priority by the Central Government. Also, to have in place an effective coordination and convergence mechanism for various schemes, programs and activities by different Ministries would help achieving desired outcomes much faster. For this, a high level inter-ministerial committee to be chaired by the Prime Minister and co-chaired by the Vice-Chairman, NITI Aayog and Agriculture Minister will help ensure effective monitoring of the outcomes of various programs aiming at 'FARMERS First'. Also, this coordination committee be assisted by a standing Advisory Panel of Agricultural Experts.

- Remunerative minimum support price (MSP) for most of the commodities needs to be fixed and announced well in advance of planting season by the Ministry of Agriculture and Farmers' Welfare (MoA&FW) with assurance for either procurement or compensation directly to the producers for prevailing price difference in the market so that farmer is not a looser. Also, the reforms in methodology for fixing MSP by the Commission for Agricultural Costs and Prices (CACP), is essentially needed, for which a High Level External Review Committee of Experts be established immediately.
- For accelerating agricultural growth, needed incentives and rewards be put in place quickly to attract youth (including women) to diversified, secondary and specialty agriculture as individual producers, SHGs, Cooperatives, Farmers Producer Organizations/Companies or as knowledge/ service providers. In the process, farmer led innovations be scaled out through required validation, refinement and incentives in the form of credit at low interest rates (not >4%), bank support for required commercialization, insurance to avoid any initial risks, practically no or very low tax on rural based value additions and marketing of produce/ value added products. Incentives to innovators/ entrepreneurs could be in the form of state/national recognitions and awards.
- Right policy support for accelerated role of private sector will certainly change the game much faster. Hence, enabling environment to embrace private sector is the most critical need which be given due importance by the Government. In this context, support for hybrid seed production; fabrication of equipments/implements/ tool for scaling conservation agriculture and small farm mechanization; micro-irrigation (drip and sprinkler), protected cultivation, including fertigation; agroprocessing and value addition; fertilizers, including customized and biofertilizers; pesticides, including biopesticides, etc. would help accelerate agricultural growth.

Research and Development

- Besides the focus on productivity and production growth, we now need increased research and development emphasis on post-production, value addition, and market linkages (both domestic and foreign).
- There is an urgent need to improve the empowerment of targeted smallholder farmers and ensure delivery of last mile services. Hence, the technology dissemination related programs will have to be tailored and reoriented according to present day needs. In fact, a paradigm shift from public to private innovation extension system is the need of the hour to provide much needed knowledge, the quality inputs and much needed custom hire services at the farmer's doorstep.
- It needs to be ensured that smallholder farmers, especially the youth including female farmers, get their entitlements and are not sidelined.
- Identification of agencies/institutions responsible to take specific actions at the local, State and Central level and their effective coordination will be very helpful. Also, an independent monitoring and evaluation process for the much needed impact will be extremely useful.

Capacity Development

- Knowledge sharing and capacity development (especially women and youth) need to be considered a top priority to bridge the yield gaps, achieve diversification, scaling innovations that can save on production costs and help in rationale use of natural resources, ensure value addition and link the farmers to market.
- Greater emphasis must be given henceforth on skill (on farm as well as off farm activities) development at all levels. This will greatly help the farmers especially the smallholders to raise their income.

Financial Support

- There is an urgent need to triple annual budget allocation for the Indian Council of Agricultural Research (ICAR), an apex AR4D organization with proven track record, in order to continue meeting emerging challenges while providing national public goods for the betterment of farmers as well as Indian agriculture.
- Capital investment in agriculture for much required infrastructure in the States, that were left behind during Green Revolution period (especially the eastern region), must immediately be enhanced (at least to a minimum level of 15-20% from present < 10%) to create much needed infrastructure to help farmers increase their production as well as income. Such an effort will also help in achieving Sustainable Development Goals (SDGs) much faster.
- The State Governments (as they have major responsibility, agriculture being a State subject), must provide necessary financial support and the commitment for implementation of above three pronged strategy to double farmers' income. Role of NITI Aayog is thus very critical in this context.

In nutshell, In India, while farmers are the major producers, they also constitute the largest proportion of consumers. Hence, improving small farm production and productivity, as a major development strategy, can make significant contribution towards elimination of hunger and poverty, provided farming is made efficient and remunerative. Experience of countries that have succeeded in reducing hunger and malnutrition shows that growth originating in agriculture through smallholder farmers is at least twice as effective in benefiting the poorest as growth from non-agriculture sectors. The World Development Report of the World Bank (World Bank, 2008) has clearly emphasized that: 'Using agriculture as the basis for economic growth in agriculture-based countries requires a productivity revolution in smallholder farming'. As stated earlier, higher productivity requires higher investment in agriculture and agricultural research - a fact that needs to be heeded by the policy makers to make sure that 1.0 per cent of agricultural GDP is invested on AR4D, as against present level of just 0.4 per cent. Hence, three-fold increase in resource allocation for the national agricultural research system (NARS) be considered a prerequisite to double the farmers' income.

It is also a fact that India will remain predominantly an agricultural country during most of the 21st century. Therefore, we must have both vision and national strategy for shaping the destiny of agriculture by making it highly productive, efficient and economically attractive for the smallholder farming community. The target of doubling farmers' income by 2022, though apparently not easy yet a very laudable goal, augurs well of Government's intention to help farmers. It is also clear that if concerted efforts, as per suggested action plan, are made in a Mission Mode, the chances of making agriculture an engine of national economic growth and for smallholder farmers a respectable profession are indeed much brighter.

Strategy Paper 15 : Livestock Development in India

(Dr A.K. Srivastava; February, 2018)

India is blessed with huge livestock population reared under diverse production systems and agroclimatic conditions. The country has 15 per cent of world's cattle population, 58 per cent of buffalo population, 18 per cent of goat population, 7 per cent of sheep and 5 per cent of chicken population and ranks first in buffalo and goat population, second in cattle and sheep population and fifth in chicken population in the world. As such, livestock have an immense contribution for sustainable rural development and provides a stable, year round income, which is an important economic incentive for the small farmers. This sector plays a multi-faceted role in providing livelihood support to more than 60 per cent of the rural population. As per the report of the working group on Animal Husbandry and Dairying - 11th Five Year Plan: 2007-12, the livestock sector employs eight per cent of the country's labour force, including several small and marginal farmers, women and landless agricultural workers. Besides their monitory benefit and providing a steady stream of food and revenues for households, livestock provide employment to the family, act as insurance during crop failures, contribute to gender equality by generating opportunities for women, generate *in situ* fertilizers for enhancing the soil fertility, contributes to day-to-day expenses of the farm family, recycle waste products and residues from cropping or agro-industries, supplies energy source for cooking and at places, the number of livestock owned by a farmer determines the social status among the community.

Current Status of Livestock Production

Milk is the second largest agricultural commodity produced in India, next only to rice. India ranks first in milk production, accounting for 18.5 per cent of world milk production. The growth rate in milk production during 2013-14 was 6.3 per cent while the growth rate during 2014-15 was 9.6 per cent. The milk production in the country increased from 137.69 million tonnes (mt) in 2013-14 to 146.31 mt in 2014-15 and to 187.75 mt in 2019-20. The per capita milk availability during 2015-16 was around 337 g, which is well above the ICMR recommended level. Buffalo contributed to 49 per cent of the total milk produced in the country, while cattle contributed to 48 per cent. Indigenous buffaloes (13 recognized breeds of the buffalo) produced about 73 per cent of the milk produced by the buffaloes, while the remaining was from non-descript buffaloes. Among cattle, exotic and crossbred cattle contributed to 56.3 per cent of the total cow milk produced in the country. The contribution of indigenous breeds was to the extent of 25 per cent while non-descript cows contributed to 19 per cent of the total milk produced by the cattle.

India is the largest exporter of buffalo meat and third largest exporter of meat after Brazil and Australia. India started exporting meat since 1969 and exports both fresh and frozen meat to several countries, of which the major buyers of Indian bovine meat and other meat are Vietnam, Malaysia, Thailand, Australia, UAE, Saudi Arabia and Egypt. Among Indian states, Uttar Pradesh has emerged as the major exporter of buffalo meat, followed by Punjab and Maharashtra. The meat production showed a good growth rate during the last decade. According to the Department of Animal Husbandry, Dairying and Fisheries, the total meat production was only 2.1 million during 2003-04, which increased to 7 mt during 2015-16. Bovines are the second largest source of meat in India after poultry, and ahead of goat and sheep. Poultry contributed 3.26 mt, followed by beef (1.61 mt from buffalo and 0.33 mt from cattle), chevon (0.94 mt) and mutton (0.49 mt). Pork accounted for 0.39 mt.

SWOT Analysis of the Indian Livestock Sector

Strengths

- Vast livestock population, with adaptability to wide range of agroclimatic conditions, is a vital asset for

the country and offers scope for diversified animal agriculture.

- Good number of high quality buffalo germplasm offers a unique strength to produce high market value products like mozzarella cheese.
- Abundant crop residues and common property resources ensure adequate availability of roughages for animals.
- Low cost of production compared to the most other parts of the world, strengthens the possibility of reaping the benefits of comparative advantage.
- Animal protein, especially milk, consumption is regular part of the diet of the people and hence there is presence of large market.
- Rapidly increasing number of processing plants, especially in dairy sector is expected to boost value addition on the livestock sector.
- Considerable number of educated youths/non-livestock based companies and organizations venture into livestock, especially dairying, which is a strength to improve the quality of the produce.

Weaknesses

- Though cross breeding programs have improved animal productivity, at least in cattle, generally the country is still largely dominated by low yielding non-descript animals.
- Lack of cold-chain and poor support infrastructure, e.g. roads and erratic power supply remain a major challenge for procurement and supply of good quality raw animal products.
- Inadequate knowledge and low adoption of scientific livestock farming and clean milk/meat production practices.
- Non maintenance of records by the farmers constrains the availability of comprehensive and reliable production data for proper planning.
- Investment in livestock research is not commensurate with returns and potential.

Opportunities

- Purchasing power of the consumers is on the upswing with growing economy and continually increasing population of middle class.
- Expanding market will see creation of enormous job and self-employment opportunities.
- Demand for livestock products is income elastic. Continued rise in middle class population will see shift in the consumption pattern in favour of value added products.
- Untapped potential of improved technologies in certain areas leaves ample scope for improving productivity.

Threats

- Excessive grazing pressure on marginal and small community lands has resulted in degradation of land.
- Indiscriminate crossbreeding for raising productivity could lead to disappearance of valuable indigenous breeds and germplasm.
- Entry of multinationals could result in a large portion of milk being diverted towards value added products which, though it argues well for the producers, is likely to affect the availability of liquid milk supply for mass consumption especially for the poor urban class.
- Export of quality feed ingredients, viz., cakes, molasses, etc. is making the domestic producers rely on low energy fodders.
- With intensive industrialization of livestock sector in response to market forces, the small producers will find it increasingly difficult to compete with the industrial sub-sector and thus risk losing a significant means of livelihood.

Major Issues in the Livestock Sector

The Indian livestock sector is constantly looking ahead and promises to take greater strides in making livestock production more remunerative to the farmer. However, there are serious bottlenecks in our quest for making livestock sector a profitable venture. These issues are flagged here: i) low individual animal productivity; ii) dilution of indigenous germplasm; iii) shortage of feed and fodder; iv) inadequate breeding inputs; v) reduced reproductive efficiency; vi) reduced outreach of veterinary health services; and vii) inadequate human resource.

Indian Livestock Sector: Futuristic Needs

Unlike earlier days, wherein smallholder livestock production has been universal in the country, recent days witness a gradual transformation to semi-commercial or commercial mode. The requirements for age old traditional production system and the current as well as future production system are not similar and the country need to equip for effective technological backstopping and efficient input delivery system besides facilitating favourable market and marketing network. Availability of superior germplasm in required numbers, quality inputs including frozen semen, feed and fodder, vaccines and other health measures, machineries for organized and large scale livestock farms and ensuring the quality of the produce are some of the areas wherein we need to have concerted efforts in terms of research and development, viz.: i) animal identification and performance recording; ii) conservation and improvement of indigenous animals; iii) climate resilient livestock production; iv) improving feed and fodder availability; v) animal health improvement and control of diseases; vi) special animal product economic zones; and vii) policy measures

Recommendations

- Establishment of a strong and reliable national and regional data base on different aspects of livestock production needs to be taken up on priority to evolve suitable policy measures for improving livestock production and productivity.

- There is an urgent need for updating knowledge of stakeholders on the importance and recent developments in indigenous breed conservation and improvement for wider dissemination and application of frontier technologies to conserve the valuable germplasm in the modern era of intellectual property right (IPR) and climate change.
- Promising reproductive biotechnologies like multiple ovulation and embryo transfer (MOET), ovum pick-up and *in vitro* fertilization, and cloning need to be utilized to the maximum extent at least for breeding bull production. Further MOET and sexed semen can be used for faster multiplication of superior germplasm of elite female animals.
- Presently, data on the levels of aflatoxins, pesticide residues, heavy metals in feeds and fodders is inadequate. It is, therefore, imperative to generate objective information on this vital aspect so that we are able to produce livestock feed of internationally acceptable quality.
- Veterinarians may be slowly weaned away from routine artificial insemination activities, which can very well be taken up by trained inseminators, to utilize their expertise in specialized needs like precision livestock production and health cover management advisory service in view of increasing demand of veterinary consultant for large herds and increasing problems that needs special attention and expertise (for instance increasing infertility and emerging and re-emerging diseases).
- A well-planned and operational livestock disease control program involving public-private-participation (PPP) mode could be an option to ward-off huge economic losses due to changing climatic conditions.
- A comprehensive package about disease awareness, management and control measures needs to be developed for education at farmers' level to control the disease incidence.
- For effective transfer of technologies and implementation at end user level, it is important that adequate number of trained manpower and training facilities are ensured. Networking of institutions with KVKs and other local bodies may be an option in this direction.

Strategy Paper 16 : Women Empowerment for Agricultural Development

(Dr R.S. Paroda; May, 2018)

Agriculture is the backbone of Indian economy. Women do play a crucial role in building this economy (FAO, 2010-11). Over the years, there is gradual realization of the key role of women in agricultural development and their important contributions in the field of agriculture, food and nutritional security, horticulture, livestock, fisheries, processing, sericulture and other allied sectors. Rural women are thus the most productive work-force in the economy of developing nations, like India. Their activities typically include producing agricultural crops, tending animals, processing and preparing food, working for wages in agricultural and allied rural enterprises, collecting fuel and water, engaging in trade and marketing, caring for family members and maintaining their homes. Many of these activities are not defined as 'economically active employment' in the national context but they are critical for the well-being of the rural households. Statistical data are available regarding their participation in the agriculture sector and allied activities but their impact on the home environment has not been accounted for. Variations in women's participation in agricultural work depend on supply and demand factors linked to economic growth and agricultural modernization. Farm women do have an impact on their children's education, as they often encourage them to be educated to have a better life. Women have different roles to play:

- Multi-dimensional Role of Women
- Limited Role of Women in Decision-Making
- Women's Role in Innovation Systems

Empowering Women in Agriculture

India is at the forefront for acknowledging role of women in agriculture. India has established the World's First National Research Centre for Women in Agriculture (now ICAR-Central Institute for Women in Agriculture) in Bhubaneswar way back in 1996. The Institute has been engaged in developing methodologies for identification of gender implications in farming systems approach and developing women friendly technologies under different production systems. Empowerment process is strengthened through educational interventions, transfer of technologies, feasibility trials and knowledge-sharing. The Institute also emphasizes on undertaking vocational trainings to impart skills necessary to undertake different vocations and to relieve women from drudgery by providing time and labour saving tools and equipments. Empirical evidence suggests that women have moved from beneficiaries to active partners in shaping empowerment. Recognizing the role of women in agriculture, Dr M.S. Swaminathan had proposed to move the "Women Farmers' Entitlement Bill" 2011 in the Rajya Sabha that seeks, *interalia*, access to water, credit and inputs, land ownership for women-farmers as a policy reform to create enabling environment.

First Global Conference on Women in Agriculture

It was emphasized to develop an Action Plan to integrate and empower women for inclusive growth and development through an enduring global partnership program on gender in agriculture. Such Action Plan needs emphatic interventions by national and international agencies to ensure enhanced involvement and access of resources to women. It was felt that considering the urgency of addressing the gender- related issues in agriculture globally, a common knowledge sharing

platform on gender 'Gender in Agriculture Platform for Gender in Agriculture Partnership (GAP4GAP) is needed, which can help in collaborative working at the national, regional and global level. The platform should involve partnership from research and developmental organizations, national governments, regional and global fora, multilateral development agencies and donors and should act as knowledge repository and provide space for both policy research and advocacy on gender-related issues in farming systems and rural ecologies. The GAP4GAP can provide technical backstopping, guide for future investments, and facilitate effective networking and collaboration among partners and stakeholders. The gender-related initiatives would need generation and documentation of gender segregated data, linking women's role to health and nutritional security at the household level, enhanced visibility for role of women, generation of knowledge and evidence for support and contextualization of global issues to suit local needs. Such new programs on gender empowerment would require adequate resources for mobilizing women, forming groups, improving capacity and capability in technical, organizational and commercial (business micro-enterprises) sector and support systems (credit, inputs, markets). These should be prepared jointly in consultation with women, other relevant organizations (public, private and voluntary), which can potentially complement and supplement the efforts of other stakeholders.

Women and Household Nutritional Security

Empirically a strong linkage among agriculture, nutrition and empowerment of women is well established. Malnutrition is a big problem in the developing countries, and especially in girls in rural areas. Nutritional insecurity is a complex issue and involves a multi-sectoral solution. Control of women over household income is linked invariably with improved nutrition, health and education of children. For household nutritional security, efforts are needed to integrate scientific and socioeconomic aspects to empower women and form "nutrition umbrella base", which can help developing an integrated strategy. Enhanced government investment, awareness, capacity-building, and micro-enterprises should supplement these endeavours. Scientific institutions should produce effective technologies, database, knowledge on nutrition-rich food, and value-addition by involvement of women groups for nutritional security. Agricultural research for development (AR4D) system has to move towards innovations not only on nutritional aspects but also on increasing women farm-work efficiency and to reduce their drudgery in farm operations. This process would require reorientation towards more gender sensitive innovations with emphasis on empowerment of farm-women, including their financial empowerment. The new business models and agricultural marketing strategies should encourage women-members as part of producers and marketing associations. Such efforts should be backed by overall strategy to improve market access through development of market infrastructure and better access to information through information communication technology (ICT). For this, there is a need to revisit our agricultural education system, to encourage innovations in research-outscaling-marketing pathways and to augment role of women in policy planning and decision-making.

Ensuring Visibility of Gender

Despite growing evidence of substantial role of women in agriculture and household food and nutritional security, many policy-makers and agricultural scientists and development professionals are yet to recognize their important role in agriculture. As a result, agricultural policies and R&D programmes in many countries continue to be gender-blind, ignoring importance of women's work, and complexity and sensitivity of many of the barriers that constrain farm-women's abilities to perform and contribute efficiently and effectively to improve economic status of their families and also the society. Ironically, most of the rural-women are not so conscious of the economic and social importance of their work, and hence hesitant to demand any recognition, or rights for their contribution

Way Forward

It has been amply justified that women do play a vital role in wide range of agricultural activities, thus contributing to sustainable agricultural development. To achieve inclusive agricultural growth, empowering women for their greater participation, gender issues, drudgery and health and nutritional status is extremely necessary. Further, these issues are to be addressed through gender-friendly technology assessment, refinement and extension methodologies. If we look at women's role in food production, we can notice enormous discrimination– women in the sector receive less than 10 per cent of credit offered to small-scale farmers. The Food and Agriculture Organization of the United Nations (FAO) has estimated that if women farmers had the same access as men, agricultural output in 34 developing countries would have risen by an estimated average of up to 4 per cent. This would have reduced the number of undernourished people in those countries by as much as 17 per cent, translating to up to 150 million fewer hungry people. Thus, investments in women and overcoming their drudgery are perhaps the best actions for future development. There is clear evidence that when women farmers have the opportunity to earn and control home income, they are more likely to spend on their children's nutrition, education and health. Improving the knowledge and status of women would, therefore, deliver significant outcomes in terms of agricultural production, food security, child nutrition, health and education, thus would be contributing significantly towards Sustainable Development Goals (SDGs). In view of this, urgent action is required at the national, regional and international levels on the following:

- There is a need for collective advocacy to raise awareness of women's needs in agriculture and to ensure their visibility in terms of valuable contribution towards agricultural development.

- Women need to be educated and empowered to make their own choices for better farming options and for responding to new opportunities for diversified agriculture and better living.
- Women's ability needs to be increased in order to enable them to actively participate in the development processes by changing their perceptions and increasing awareness for greater social responsibilities.
- There is a need for encouraging collective action and leadership among women to develop programs that directly address women's needs and to make agricultural support systems gender-sensitive.
- Sincere efforts need to be made for removing drudgery of farm women by ensuring access to new tools and implements that increase efficiency and higher productivity. Also, reorient agricultural research for development (AR4D) agenda to be gender-sensitive and pro-women.
- An urgent attention is needed to address the discrimination through appropriate policies, legislation, enforcement mechanisms and establishing women's rights (e.g. access to markets, ownership of land).
- It must be ensured that the institutions and legal support mechanisms are in place to promote women's ownership and control of resources (e.g. land, bank accounts, farm implements).
- Social, educational and cultural institutions also must change to create an environment where women realize their full potential. Engendering farm-women thus is a high national priority. For this, investment in women's human capital through education and training for skill development is very critical for productive use of their abilities, time and energy.

Strategy Paper 17 : Motivating and Attracting Youth in Agriculture

(Dr R.S. Paroda; November, 2018)

The global population is expected to be 9 billion by 2050, and youth would represent around 20 per cent (FAO, 2014). Most young people (around 85%) live in the developing countries. India has a comparative advantage over other countries in terms of its young population. As per India's census, the total youth population increased from 168 million in 1971 to 422 million in 2011. In 2017, 356 million, against China's 269 million. India's population is expected to remain young longer than that of China and Indonesia, the two major countries, that along with India determine the demographic features of the Asian continent. India also enjoys a demographic dividend with more than 60 per cent of its population of working age. According to a World Bank report, the working age population will outnumber the dependent population for at least more than two decades (until 2040) in India. As per the estimates of National Higher Education Commission (NHEC), the average age of the Indian population in 2020 will be 29, as against 40 in the USA, 46 in Europe and 47 in Japan. Agriculture still remains the key sector, providing livelihood and employment opportunities to more than 60 per cent of India's population living in rural areas. Overall, in the developing world, youth and agriculture are the twin pillars of progress and prosperity, especially for achieving sustainable development goals.

Major Challenges

In the recent past, retaining youth in agriculture has been one of the major challenges in the developing world. The principal challenges in retaining youth in agriculture include: insufficient access to knowledge, information and education; limited access to land; inadequate access to financial services; lack of formal and informal on-the-job training; limited access to markets; and limited involvement in decision-making and policy dialogues. Over the years, the farming community has become gradually poorer due to small land holdings, which comprise over 80 per cent of total farm households. Multiple risks associated with agriculture intensify the challenges owing to over-exploitation of natural resources linked with rapidly increasing globalization, soaring fuel and food prices, volatile markets and growing climatic volatility. Youth is a great resource, to be used for agricultural development. In the past few decades, because of rapid industrialization and urbanization, youth and agriculture are experiencing unprecedented transformation. Another major dilemma in the developing world is the poor social image of agriculture due to which, rural youth are moving towards the urban sector, looking for alternative and better opportunities. It is evident through successful business models of leading public and private sector organizations, as well as multinational companies (e.g. IT sector), that youth are more innovative and productive as well as receptive to new technologies. On the contrary, in the agriculture sector there is a wide gap between energy (youth) and experience (older people), which is a cause of backward nature of farming and slow adoption of innovations and new technology. There are huge losses in the technology dissemination process, delinking science with society and making farming non-remunerative, non-resilient and unattractive to youth.

Role of Youth in Agriculture

Currently, the country has around 7,000 agricultural scientists in India's public sector, of which more than 35 per cent are below the age of 40. The two days of deliberations covered a wide range of disciplines and issues related to Indian agriculture, natural resource management, crop improvement and protection, horticulture, post-harvest technology, livestock and fisheries development, agricultural engineering and implements, information communication technology (ICT) and socioeconomics. The deliberations identified research needs across disciplines and regions where youth can play a prominent role. The key recommendations of the deliberations included: the urgent need to reorient agricultural research towards a farming systems mode by ensuring inter-institutional and interdisciplinary

collaboration; creating state-of-the-art research facilities; undertaking joint research with the private sector and international/ advanced research centres through the creation of excellent research infrastructure; provision of a seed grant (Rs 10-15 lakhs); encouraging scientists to initiate research; short to long-term training for young scientists at advanced research institutions; emphasizing greater involvement of women in decision-making bodies; and greater emphasis on human resource development through special allocation of funds for skill development.

Retaining Youth in Agriculture

A program on Attracting and Retaining Youth in Agriculture (ARYA) was initiated by the ICAR and is being implemented successfully by the *Krishi Vigyan Kendras* (KVKs) in different states of India. Overall, the deliberations led to the development of a Road Map to define and delineate pathways for developing and nurturing a new generation of young agricultural professionals and entrepreneurs, with greater emphasis on technical capacity development, institutional arrangements, innovative networking, appropriate investments and harnessing the full potential of youth, in order to realize a qualitative change in their lives. Most of the youth who remain in agriculture have limited knowledge and skills and are being forced to follow the same old traditional practices. In the Asia-Pacific region, the challenges and opportunities for youth in the agricultural profession do not differ much. Different countries are tackling the issue of involving agri-professionals in the farming sector. There are several youth-led successful models for transforming agriculture in different countries. However, these models lack an appropriate mechanism for regional and cross-border learning from different countries' experiences. Keeping these challenges and opportunities in view, a regional workshop on 'Youth and Agriculture: Challenges and Opportunities' was organized jointly by APAARI and the Pakistan Agricultural Research Council (PARC) in Islamabad on 23-24 October 2013, in collaboration with Global Forum on Agricultural Research (GFAR), International Maize and Wheat Improvement Center (CIMMYT), International Center for Agricultural Research in the Dry Areas (ICARDA), International Center for Research in the Semi-Arid Tropics (ICRISAT), International Food Policy Research Institute (IFPRI) and Bioversity International (now Alliance for BI & CIAT).

The deliberations highlighted the emerging phenomena of overurbanization and growing youth unemployment, which are leading to social disparity, on the one hand, and global food insecurity on the other. Prioritizing investment for attracting youth is, therefore, crucial for future agricultural development. Greater involvement of youth in farm advisory, empowering them with knowledge to serve the society through the creation of technology-led business models and providing value-added services and creating employment opportunities, is the way forward for enhancing agricultural productivity for a food-secure society. This needs a paradigm shift in our approach and policy focused on youth to transform them from 'job seekers to job creators'. Capacity development of youth through informal and vocational training and creating awareness of new opportunities in agriculture, including secondary and specialty agriculture, would attract youth in agriculture, help bridge the gap between rural and urban and boost rural economies in the region. The key points that emerged from the regional consultation were: (i) reorientation of agriculture to agricultural research for results (AR4R) by promoting agri-innovation; (ii) agri-business and entrepreneurship through involvement of youth at national, regional and international levels; (iii) urgently linking agriculture with health, environment, nutrition and other basic science disciplines to address challenges by young professionals; (iv) focusing attention on capacity development of youth through vocational training; (v) inclusion of agricultural education in the school curriculum and farmers' participatory approach to technology generation; and (vi) transfer and adoption to ensure faster growth in agriculture. Innovative approaches to developing and transferring technologies, efficient funding mechanisms, openness in knowledge-sharing, much-required marketing reforms and partnership at national and regional level are important areas to pursue; and to make agriculture intellectually rewarding for youth, special emphasis is needed on secondary agriculture, diversification, protected cultivation, crop intensification and use of ICT.

The Road Map

For attaining faster the sustainable developmental goals (SDGs), all nations in South Asia need to develop and promote a sound strategy around "Role of youth for accelerated growth in agriculture" for which the following 'Road Map' offering the youth a number of opportunities for economic, social and agricultural development was proposed at the conference:

- There is an urgency to have a 'National Mission on Youth in Agriculture' with an aim to impart better knowledge and skill to youth on: i) sustainable, secondary and specialty agriculture, ii) efficient knowledge dissemination, including information communication technology (ICT), iii) technical backstopping for innovative farming, iv) new agribusiness models, and v) entrepreneurship as well as linking farmers to markets through value chain. Under the Mission, concerted efforts are needed to build new skills of youth for innovative agriculture through both formal and informal education. The best option for this is to impart agricultural education right from school level. In addition, the central and state agricultural universities and ICAR institutes must initiate entrepreneurship training through vocational and formal diploma programs. Also, the university curriculum needs to be revisited to address the emerging needs and aspirations of present-day youth and markets.
- Priority attention needs to be given to develop a new research agenda for 'Youth-Agriculture Nexus' which (i) delineates different contexts for youth-oriented agricultural research, (ii) identifies

opportunities for young people's engagement in agricultural research and innovation for development (ARI4D), and (iii) determines youth's future pathway for attaining sustainable agricultural growth and income.

- Involvement of youth in 'Plough-to-Plate' initiative can help in doubling farmers' income. Hence, their greater involvement as entrepreneurs will be the key to future growth and development. For this, networking for knowledge sharing/dissemination, participation of youth in outscaling of innovations through their validation using technology parks/ innovation platforms, use of ICT, creation of agriclinics, much needed support for mentoring/ hand-holding, and awareness regarding intellectual property rights (IPRs) need to be the essential components of the proposed mission on youth.
- There is need for a paradigm shift from narrow focus on 'youth as a farmer' to 'youth for value chain development'. To provide better economic opportunities for rural youth in the changing agricultural scenario, there is an obvious need to move beyond the plot/field level agriculture i.e. from production to post-production level and to link with market for better income opportunities. The combination of agricultural value chains, technology and entrepreneurship will unlock vast economic opportunities.

Strategy Paper 18 : Urgency for Scaling Agricultural Innovations to Meet Sustainable Development Goals

(Dr R.S. Paroda; April, 2019)

Accelerating agricultural growth is an important goal for most of the nations for achieving Sustainable Development Goals (SDGs), especially to remove poverty, have zero hunger and ensure environmental security. Those developing nations that have reoriented their agricultural research for development agenda towards scaling of innovations have made much faster progress. Greater the emphasis on agricultural research for innovation, higher had been the growth for agricultural gross domestic product (GDP). In fact, Green Revolution was in itself an innovation led initiative around the use of high yielding dwarf wheat and rice varieties that responded favorably to higher inputs leading to quantum jump in productivity. The factors of success had been: i) political support, ii) good institutions and human resource, iii) availability of critical inputs (seeds, water, fertilizer, etc.), iv) enlightened extension workers and hard working farmers, and above all, v) strong partnership among the stakeholders. Considering emerging second generation challenges of Green Revolution like factor productivity decline, depleting natural resources, increasing cost of inputs, higher incidence of diseases and pests, higher cost of inputs, rising concern of nutritional quality and safety of food, reduced profit to farmers and above all the adverse impact of climate change. Obviously, increasing income, especially of 80 per cent farmers who are small and marginal, having holdings less than 2 ha, would require technologies and innovations by which they can save cost on inputs and have more income by higher productivity, quality and also by linking to value chain and markets. Thus, scaling of innovations like hybrid technology, conservation agriculture, microirrigation, integrated nutrient management (INM), integrated pest management (IPM), adoption of genetically modified (GM) food crops, protected cultivation, etc., becomes high priority. For this to happen, enabling policies, strong public-private partnership and innovative extension systems to transfer right knowledge especially around secondary and specialty agriculture would be needed. Moreover, innovation without incentives and rewards and congenial policy environment, including intellectual property rights (IPR) regime, would not be possible for which we shall need innovative institutional as well as policy related reforms to make a difference - as was experienced during the Green Revolution era.

Urgency to Meet SDGs: Some Initiatives

The Indian Council of Agricultural Research (ICAR), having the mandate for research, extension and education, hadbeen engaged in providing national public goods that help accelerate agricultural growth by disseminating appropriate technologies to the farmers. In the process, *Krishi Vigyan Kendras* (KVKs), now numbering around 680, have been instrumental in providing front line extension for scaling new technologies that had helped farmers increasing production as well as income. Besides front line demonstrations (FLDs), a large number of farmers in each district have been provided access to new seeds, planting materials, good agronomic practices (GAP) and training of farmers for skill development. These institutional systems have helped considerably in making faster growth in different sectors of agriculture. Provision of revolving fund for enhancing availability of seeds of improved varieties/hybrids, faster multiplication of planting material, fabrication of tools and implements, etc. all helped in accelerating the growth of Indian agriculture. For the benefit of both R&D investors and end-user farmers/ consumers, the concerned intellectual property (IP) related statutory bodies and the Ministries of Commerce & Industries and Agriculture and Farmers' Welfare, in consultation with public and private sector organizations/ stakeholders, must proactively visit the existing rules, laws and acts on the subject of innovation in agriculture. Where necessary, required amendments be brought about to create an enabling environment to encourage new innovations and their adoption, while ensuring proper access and benefit sharing. The Department of Biotechnology (DBT) has also taken up several initiatives for scaling innovations through Biotechnology Industry Research Assistance Council (BIRAC), a platform to nurture industry-academia connectivity. Other initiatives include biotechnology parks and bioincubators, science clusters, etc. Even though there are different schemes 5 for agricultural biotechnology such as Biotech-KISAN scheme, the performance is not on par with other sectors like health.

There are also schemes to encourage scientist/faculty to move to entrepreneurship. The key challenges for the entrepreneurs are lack of financing and market access. DBT had started several initiatives such as Students Innovations for Advancement of Research Explorations (SITARE), eYUVA (creating entrepreneurial culture in universities), BioNEST (nurturing entrepreneurship by establishing bioincubation centres) for supporting entrepreneurs. Also, there is a need for accelerating entrepreneurship fund and possibility of social immersion programs for incubators to assess the market needs. Similarly, various initiatives by the National Innovation Foundation (NIF) for promoting grassroot entrepreneurship included Micro Venture Innovation Fund, Grassroot Technological Innovation Acquisition Fund and establishment of NIF Incubation and Entrepreneurship Council. Innovations are also encouraged by organizing exhibitions and through awards and scholarships. Participatory research and decentralized fabrication and services are essential for improving technologies for outscaling in India.

Experiences Abroad

Since industrialization, agricultural innovations in the developing countries had predominantly been brought in by the public sector. But with commercialization of agriculture, private sector including multi-national companies (MNCs) having base in developed countries have been major providers of technology. In the United States, public sector universities became R&D labs for the private companies after the enactment of Bayh-Dole Act of 1980, which allowed universities and other non-profit institutions to have ownership rights on their discoveries that resulted from federally-funded research. This facilitated transfer of technologies to the private sector through establishment of Science Parks and Incubators. Europe also followed similar institutional framework to facilitate new innovations and their faster dissemination. Lately, greater emphasis on innovation in China, mainly public funded, has transformed its economy through greater participation of private sector and foreign companies for out scaling innovations.

Current Challenges

Earlier, agri-innovations had relatively simple process/cycle of their development and dissemination through public extension system for the benefit of end users, mainly the farmers. However, with the emerging complexities of modern time, new and rather more efficient players have entered in the process. The emphasis on commercialization of technologies and resource generation has also necessitated involvement of new actors, mainly private sector companies in commercialization of research products. These new initiatives are mainly being guided by profit motive and finding favour because of efficient and faster delivery mechanisms, though sometime more costly for smallholder farmers. On the other hand, some rural innovations by enterprising farmers are also recognized as potential options for solving the location specific problems, but they need validation, further refinement and outscaling for the benefit of larger farming communities,. Mainstreaming of such innovations is, therefore, a challenge which needs to be recognized and resolved by appropriate incentive and reward mechanisms and institutional/public-private partnerships. Thus, innovations have moved away from the conventional innovation systems (linear transfer of technology) to those of agricultural innovation systems (multi-stakeholder platforms) and also to farmers' innovation systems - grass root innovations. Problems such as nutritional security, climatic change and declining profitability are some of the major issues and challenges which need to be urgently redressed. In-depth analysis of commercialization mechanisms at the system and organization levels has also not been paid due attention which needs to be done on priority for upscaling and outscaling agricultural innovations. Also, the lack of enabling policies, slow dissemination of knowledge concerning new technologies, intellectual property right issues, inadequate infrastructure and environment for capacity development, and lack of financial resources do pose serious challenges for faster scaling of innovations. Hence, these need to be effectively addressed being now a national priority.

Opportunities

There are several technologies which need to be outscaled. In the dairy sector, such technologies include animal identification, precision animal feeding, advanced reproductive technologies, disease diagnosis innovations, technologies for detection of adulterants in milk and milk products, smallscale farm machineries (such as mobile machine milker). There are now four generations of technology for improving reproductive health and these must be scaled out. Artificial insemination and semen sexing can make a major impact on milk productivity. Kerala and Kolar Model of community milking, and technology for value added dairy foods are now standardized and need immediate interventions for its outscaling. In order to better understand technology and their spread, people's mind-set of "managing livestock under zero or low input" should be changed to "commercial enterprise". Scaling-out innovations in case of agro-processing and value addition also needs to be given due attention. Exploitation of value added products from agrobiomass like lignin and algae, food products of bioprocessing and chemical processing and composite fruit coating can generate immense benefits for farmers and rural entrepreneurs. Most of these processes are either restricted to labs or not taken up for required scaling at scale.

Policies for Innovations

For successful scaling of innovations, there is an obvious need to put in place enabling policies: i) institutional policies such as facilitation of farmers cooperatives like FPOs with proper legal framework, establishment of a cadre of trained agri-business professionals at the village level, credit at low interest to the farmers across value chain, machine rental services, etc., ii) research policies aiming at promotion of agro-

ecological based research, research for trade policy, agro-processing, value chain development, sustainable livelihood, new funding models for encouraging translational research, iii) price policies around fixing of minimum support price (MSP), inclusion of efficiency, compensation for risk and ecosystem services, and iv) right policies for more investment in resilient agriculture rather than subsidies, and promoting capital investments by the private sector. There is also an urgent need to attract private sector in development of whole sale markets, warehouses and cold storage, agroprocessing infrastructure, canal lining for irrigation and private agricultural extension. The National Agricultural Research System (NARS) seemed to have undergone various policy reforms in research, intellectual property rights (IPRs) and technology transfer mechanisms, yet more aggressive approach is needed to reap the benefits of new innovations around sustainable intensification of agriculture.

Intensifying Agri-Innovations

The evolution of Indian National Agricultural Research and Extension System (NARES) had primarily been based on social commitment and with a motive to provide national public goods and to serve the majority of resource poor and small farmers. Thus, innovations had been an integral part of Indian agricultural research for development (AR4D) system right from the beginning. In view of the need for evaluation of innovations for much needed socio-economical impact, India also felt the need for promoting innovations to generate agribusiness opportunities and to increase farmers' income. It is in this context, ICAR timely responded and prepared guidelines for Agri-IPRs Management and Commercialization in 2006 (Johl Committee Report, 1995; ICAR, 2006) and also initiated a National Agriculture Innovation Project (NAIP) with funding from the World Bank. Also, guidelines for incentives and rewards for outscaling innovations and resource generation were put in place. Somehow, the pace of promoting innovations and allowing the right incentives to researchers has remained slow due to lack of organization and management (O&M) reforms, which must now be accelerated. A countrywide network of Institute Technology Management Units (ITMUs) have been created for management of agri-innovations and agri-intellectual properties in all ICAR institutes duly supported by the Zonal Technology Management & Business Planning and Development (ZTM & BPD) units at selected ICAR institutes. This new initiative did help in kick-start innovation awareness and importance of their commercialization.

The Way Forward

The following are some important action points for scaling innovations for impact on smallholder farmers:

- Innovations have played and will continue to play a significant role in agricultural transformation. However, the innovation process involves both multiple stakeholders and the enabling policy environment which need to be paid due attention to ensure impact in the broader national agricultural perspective. Agricultural research must move from commodity centric to systems' approach, and all stakeholders (farmers, private sector, NGOs, etc.) be part of the research for innovation continuum. Hence, institutional/innovation platforms are essentially needed to encourage much needed scientist-farmer, and public private partnerships (PPP).
- In order to achieve an innovation driven agrarian economy, innovation capacity of research and development systems, civil society organizations (CSOs), and especially the farmers need to be developed. For this purpose, intensity of public investment will have to be enhanced considerably. Also, greater attention would be needed towards capacity development of people responsible for scaling innovations for successful commercialization.
- There is an urgent need to strengthen existing technology transfer system within NARS (frontline extension, Agri-Business Incubator, Agrinnovate India Ltd.) and establish technology parks as well as transfer systems for commercialization both in ICAR and SAUs. Also, it requires placement of adequate manpower, financial resources and freedom to operate. Convergence of technology and diversification of extension and other service systems are also critical for outscaling innovations.
- The available innovations, including those that are farmer-led, must be assessed for needed validation, refinement and prioritization based on their commercial potential. This should also entail identification of right partners for successful ventures. Financing, risk management and incentives for outscaling innovation are necessary to encourage potential entrepreneurs.
- An Innovation Platform would help accelerate scaling-out innovations and, therefore, an 'Agri-Innovation Board' be established urgently in the Ministry of Agriculture and Farmers Welfare. The Board should be headed by an eminent agricultural scientist and membership be drawn from different Ministries, including Finance, Commerce and Industry.
- To begin with, the Board must start financing activities to scale-out agricultural innovations. This could be under the funding support for innovation (Start-up India, Atal Innovation Scheme), or through a separate funding mechanism such as National Innovation Fund (NIF) initiated by the Council of Scientific and Industrial Research (CSIR).
- Concerned ICAR institutes and SAUs must ensure providing skill based certificate training for entrepreneurship, and in addition to provide much needed backstopping services so critical for successful scaling of innovations. The manpower, so trained, can work as para-innovators or technical service providers. Also to link with the industry, NARS should build effective partnership with organizations such as Federation of Indian

Chambers of Commerce and Industry (FICCI), the Associated Chambers of Commerce and Industry of India (ASSOCHAM), Confederation of Indian Industry (CII), etc.

- Farmers Producer Organizations (FPOs), self-help groups, cooperatives, producer companies, etc., could effectively be involved for outscaling innovations. These organizations should have easy access to technology, financial services, including credit, and hand-holding from public organizations for promoting demand-driven innovations in the broader national interest.
- Participation of private sector in R&D and upscaling and outscaling of innovations would need an enabling policy environment and access to public technology and funding resources. Role of private sector need to be expanded to non-conventional areas and the public-private partnership needs to be strengthened further. In order to facilitate this, the Government should move from "directive" to a "facilitation" role. This may require revisiting existing regulations in order to provide a "predictable and enabling" regulatory framework. Also, incentives and rewards to innovators need to be put in place to sustain their interest in outscaling as well as much needed technical backstopping.

Strategy Paper 19 : Horticulture for Food and Nutritional Security

(Dr K.L. Chadha and Dr V.B. Patel; October, 2019)

Horticulture has emerged as one of the potential agricultural enterprise in accelerating the growth of economy in India. It offers not only a wide range of options to the farmers for crop diversification, but also provides ample scope for sustaining large number of agro-industries, which generate huge employment opportunities. Diversification of horticulture has emerged as the best option for addressing nutritional adequacy, enhancing employment opportunities, farm income, use of natural resources and above all, emerging enterprises. The emerging trend worldwide and also in the country is indicative of a paradigm shift in dietary needs of the people, with rise in the income there is more demand of horticultural produce. In the current scenario, where more than 300 million people are malnourished, and millions of people are below poverty line, there is need for improving quality of life through ensuring food and nutritional security. Further, population of the country by 2050 is expected to be around 1,620 million of which 52 per cent will be living in urban areas falling under higher income brackets. It is estimated that per capita household demand of fruits (kg/ year) will be 115.50 by 2050. With the global share of 2.3 per cent land, 4.2 per cent water, the per capita availability of these resources in India is 4-6 times less than the world average; the pressure on limited resources will increase further. Rise in population and per capita income would impact the demand of high-value crop produce (fruits, vegetables, meat, eggs, milk, and fish) and value added fruit products. The report of committee on Doubling Farmers Income (DFI), 2018, estimated that by the year 2022-23, production level of 451 mt has to be achieved. The report states that it can be achieved through 2.8 per cent increase in area and 3.1 per cent in productivity (DFI, 2018). It is evident that from the year 2000 to 2016, horticulture has growth rate of 5.8 per cent owing to technological advancements, investment and enabling policy environment. Many new technologies pertaining to seeds and planting material, drip and fertigation, greenhouse, hydroponics, marketing models and quality assurance through branding have been adopted and the success stories are replicated. The past trend shows that target of production envisaged in 2000, for 2021 is achievable, as we have already reached the production level of 327.0 mt (estimated) in 2020-21. Thus, there are several opportunities and challenges, which will need attention. The issues which require to be addressed are innovation in technologies through institutional support as well as import of knowledge and technological backing for development through skills. Development strategies should be for cluster approach linked with post-harvest management and marketing, quality seeds and planting material, precision farming and smart horticulture, environmentally controlled horticulture, and enhanced ICT use to add efficiency to input management, knowledge transfer etc., and major emphasis needs to be given to value chain development and management for better profits.

Status of Horticulture

India has a wide variety of climates wherein a large number of horticultural crops comprising fruits, vegetables, ornamentals, mushroom, plantation crops, spices and medicinal & aromatic crops are grown. After attaining independence in 1947, major emphasis was laid by the GoI for attaining self-sufficiency in food grain production especially cereals resulting in Green Revolution during the mid-sixties. After the situation on food front improved over the initial Five Year Plan periods, horticulture started getting due attention during the VII Plan period onwards. The reasons which attracted the attention of GoI on diversification to horticulture were due to significant fatigue in rice-wheat based cropping system and also increase in small landholdings making farming economically non-viable. Therefore, there has been a shift from the production of staple commodities to high value horticultural crops and its products fetching more income to farming communities. Horticulture has been found to be the best option in view of several advantages, namely, production of more energy resulting in high returns per unit area compared to field crops and earning more foreign exchange. These crops also have high potential for efficient utilization of wastelands, and need comparatively less water consumption than food crops. These are also rich sources of vitamins, minerals and carbohydrates and have thus assumed a

great importance both in food and nutritional security. These crops have a high potential for value addition for sustaining large number of agri- and pharma-industries generating huge employment opportunities besides being environment friendly. The rapid change in demographic profile of the country is resulting in increased consumption of high value food items due to increased realization about their role in health and nutrition. In spite of global emphasis on cereal crops, there has been sustained interest in horticultural crops all over the world. In global trade, the share of horticulture produce and products has increased significantly. The fruit and vegetable production has been increasing throughout the world and particularly Asia contributes over 70 per cent share in the total world's production.

Drivers for Horticulture R&D

Starting with the VII Five Year Plan, the financial allocation for horticulture R&D rose tremendously from a meagre Rs 3.5 crores and Rs 25 crores in VII Plan to Rs 1050 and Rs 15,946 crores in the XII Plan, respectively. The increase in budget was 300 times for research and 638 times for development between these plans which resulted in establishment of a sound R&D infrastructure and launching of several flagship programs, viz: i) establishment of a Sound Research & Education Infrastructure; ii) development infrastructure; and iii) launching of flagship programs.

India - A Global Horticulture Stronghold

India occupies a place of pride in the world for production of different horticultural crops. From VIII Five Year Plan onwards, this sector has witnessed tremendous growth in area, production and productivity. As a result, India is now the second largest producer of fruits and vegetables in the world after China with a share of 12.2 and 10.7 per cent of total global production, though the fruit productivity is higher than China. Among fruits, India is the largest producer of banana (26.2%), mango and guava (41.9%), lemon and lime (16.4%), papaya (44.4%), pomegranate, sapota and aonla. India also produces 21.04 per cent of grape, 10.4 per cent of citrus fruits and 14.96 per cent of pineapple. Among vegetables, India is the largest producer of okra (73.6%) and pea in the world while second largest producer of potato (12%), dry onion (22.1%), brinjal (27.1%), tomato (11.1%), cauliflower (36.4%) and cabbage (11.9%). In plantation crops, India tops in coconut and arecanut production and is the second largest producer of cashew nut after Vietnam. In spice crops, India ranks first in the production of chilli (dry), coriander, fennel, aniseed, cumin, while in turmeric, garlic, ginger and small cardamom, India ranks second whereas in pepper, it occupies the third position.

Area, Production and Productivity of Horticultural Crops

The area under horticulture crops has increased from 12.8 mha in 1991-92 to 25.87 mha in 2020-21 resulting in cumulative increase of over 100 per cent during the last 30 years. During the same period, total production increased from 96.6 mt to 327.0 mt registering a cumulative increase of 338 per cent. The average productivity also witnessed a significant increase from 7.5 to 12.6 mt/ha in the same period with cumulative increase of 62 per cent. The total production and average productivity of horticulture crops would have been much more but for the large areas under tree fruits, which remain in non-bearing stage for 3-5 years after planting. It can be seen that the share of vegetables including tuber crops in total area and production of horticultural crops was the highest being 40.34 per cent and 59.15 per cent, respectively during 2017-18 followed by fruit crops with the share in area and production being 25.58 per cent and 31.23 per cent. Plantation crops and spices contributed 14.72 and 15.25 per cent of the area while the lowest area and production at present are under floriculture, medicinal and aromatic plants.

Horticulture Trade

The trade in horticultural crops has become increasingly globalized. This has been possible because of advanced technology, change in consumer preferences, and year round supply. As a result, large volumes of fruits and vegetables more from one continent to another, reducing seasonality of produce market. Also, multiple, regional and bilateral trade agreements and reduction of tariff barrier as a result of World Trade Organization (WTO) negotiations, have further boosted the trade and access to markets, thus providing consumers with an expanding array of fruits and vegetables.

Major Technologies Developed

Several new technologies have been developed by farmers and adopted to improve the production, productivity and post-harvest management of horticultural crops by different research and development organisations in the country.

Crop Improvement

Crop improvement in horticultural crops/plants is one of the most urgent tasks, as an enormous increase in demand for plant-derived products will rise in the near future due to the growing human population and the depletion of fossil resources. In addition, environmental and aerial pollution has a negative impact on soil, water, and climate, and thereby creates increasing stress for growing crops. Therefore, harnessing crops against stress factors is a second essential task for plant breeding. A third challenge is exploiting novel types of crops for producing raw materials, bio-chemicals, bio-fuels, or novel types of food and feed. The improvement of the yield and quality of horticultural crops has been receiving increasing research attention. Given the development and advantages of genome-editing technologies, research that uses genome editing to improve horticultural crops has substantially increased in recent years. To achieve the target, we need to : i) develop superior clones and varieties; ii) introduce and commercialise less exploited crops, and iii) work extensively to develop transgenic lines.

Alternate Horticulture Systems

A number of alternate horticulture crop production systems developed in various countries have been successfully introduced and successfully adopted in India. These include: i) protected cultivation, ii) peri-urban & urban horticulture, iii) organic farming, iv) post-harvest management, v) handling, and vi) value addition.

Food to Nutritional Security

This is consecutively seventh year when production of horticultural crops surpassed food grain production. Starting from 2012-13 with 269 mt production against 257 mt of food grains, it has touched 311.71 mt in 2017-18 against 284.83 mt of food grains and in 2019-20, it has increased to 320.0 mt as against 281.37 mt of food grains. This has been possible due to proactive government policies, increased infra-structural support, as well as farmers' zeal due to growing market and a quicker cash flow. Seeing the world scenario, the present availability of food grains, and fruits and vegetables is not adequate either to meet the food or nutritional requirements of the increasing population. The global production of food grains during 2017 was 2980.17 mt with a population of 7.6 billion. The world's population is expected to grow to almost 9 billion by 2050. The population is moving from rural areas to urban locations particularly in the developing countries and as a result rural population is estimated to increase 30 per cent by 2030 from 71 per cent in 1950.

About 815 million people of the 7.6 billion people in the world, are suffering from chronic undernourishment and around 12.9 per cent share belongs to developing countries, including two thirds in Asia and South Asia. About 2.1 billion people are overweight or obese. Consumption especially of fruits and vegetables has also increased at an annual growth rate of 18 to 21 per cent for fruits and 10 to 15 per cent for vegetables. Urbanization and industrialization is increasing pressure on land resource. About 17 per cent of world's population is living in India with only 2.6 per cent of the world's geographical area. Projected yields in cereal crops have started showing tendency towards plateauing, in spite of increasing investments and technological innovations to boost productivity. The inputs for agriculture production are diminishing. The decline in the share of agriculture in total production and employment poses serious challenges across regions. Therefore, there is need to diversify to high energy and nutrient-rich crops. Increased demand of food with prevalent farming practices is creating more intense competition for natural resources resulting in increased greenhouse gas (GHG) emissions, water scarcities, soil depletion, environmental degradation, deforestation, loss of biodiversity, and the spread of trans-boundary pests and diseases of plants etc. due to depletion of ozone layer altering the composition of incoming radiations. There is, therefore, need to develop future food production technologies which cause minimum stress on natural resources and least damage to eco-system. Food losses and waste claim a significant proportion of agricultural output, and reducing them would lessen the need for production increases. Agriculture production is required to increase by 70 per cent to meet global food needs. With time, the concept is changing from food security to nutritional security addressing both food energy deficiency and micro-nutrient malnutrition. A minimum of 400 g fruits and vegetables per person are recommended. While consumption of fruits and vegetable in the diet is increasing, there is insufficient availability and intake resulting in 14 per cent of gastro-intestinal cancer deaths, 11 per cent of ischemic heart disease deaths, 9 per cent of stroke deaths globally. 1.7 million (2.8%) deaths worldwide are attributed to low fruit and vegetable consumption. Substantial growth in income of developing countries has resulted in dietary transition towards higher consumption of fruits and vegetables and other food sources relative to that of cereals and thus need commensurate shifts in output.

Impact of R&D in Horticulture

Initiatives taken by the public, and private sector organizations and progressive farmers besides proactive policies of the government have brought about a sea change in the horticulture sector which is detailed below:

Production and Productivity

Average productivity of horticultural crops as a whole increased from 7.5 to 12.6 t/ha with cumulative increase of 62 per cent. It is the world leader in production of mango, banana, papaya, pomegranate, sapota, acid lime and aonla. In vegetables, India ranks first in production of okra in the world (73% of world production) and second in brinjal (27.55%), followed by cabbage (13%), cauliflower and broccoli (36%), onion (19.90%) and tomato (11%). India also leads in productivity of grape in fruits and cauliflower in vegetables in the world. Potato R&D has resulted in total replacement of imported varieties by improved indigenous potato varieties which have been instrumental in rapid growth in area, production and productivity during the last six decades or so. As a consequence area, production and productivity have increased 8, 25 and 3 times respectively resulting in a virtual potato revolution. Similarly research initiatives on tuber crops have impacted growth of these crops substantially by contributing to about 0.75 per cent agricultural GDP. As a result of R&D activities, a virtual revolution is taking place in mushroom production in our country and its production has spread to almost all parts of the country. As a result, there has been sudden spurt in mushroom production in the states of Haryana, Himachal Pradesh, Uttar Pradesh, Uttarakhand and Punjab. Oyster mushroom and paddy straw mushroom cultivation have specially picked up in Tamil Nadu and Odisha respectively. Production of mushroom has registered manifold increase from a meagre 500 tonnes in 1961 to 487,000 tonnes in 2017-18. Over the last decade itself, there has been 157 per cent growth in production of flowers, ornamental plants, cut greens and dry flowers. Rosa demascena is now extensively cultivated for extraction of essential oils, rose water, attar, gulkand in some pockets of Rajasthan and Uttar Pradesh. There has been a significant increase in the production of floricultural crops including both loose and cut flowers. Oil palm considered not suitable

for cultivation in India has successfully adapted as an irrigated crop in 13 states of India. Starting virtually from scratch, it now covers an area of 2,82,566 ha with crude palm oil production of 2,17,258 tonnes (2016-17). About 58 organisations and entrepreneurs are now associated with oil palm development in India. Sixteen companies are operating Oil Palm Development Program in the states of Andhra Pradesh, Karnataka, Odisha, Tamil Nadu, Gujarat, Chhattisgarh, Mizoram, Maharashtra and Goa and 26 oil palm mills with a total capacity of 286 tonnes/hour have been established.

Planting Materials

Significant developments in production of planting material and registration of nurseries have resulted in availability of a large quantity of quality, disease free, planting material of high yielding varieties. Commercial use of micro-propagated banana plants has resulted in significant yield increase. Raising of vegetable seedlings in polyhouse has emerged as a good option for producing quality planting material particularly plug plant production. In potato, the development of seed plot technique, TPS, micro-propagation techniques and aeroponics for mini-tuber production have helped in production of healthy disease free seed and planting material.

Production Technology

Hi-tech horticulture particularly high density planting, canopy management, rejuvenation, promotion of beehives for pollination have resulted in enhanced productivity in a number of crops. High density planting has become a success story in several crops but not limited to apple, banana, cashew, guava, litchi, mango, papaya, and pineapple. Development of technologies have resulted in massive area expansion, and replanting of old senile and uneconomic cashew gardens with high yielding varieties in all major cashew growing states. Micro-irrigation is now virtually a rule in new horticultural plantations

Horticulture: A Growth Driver

Horticulture has emerged as the growth driver of agriculture in India. Future of sustainable agriculture in the country lies in promoting technology-led horticultural development. The highest annual growth of 9.5 per cent has been recorded in fruit production as well as 7 per cent in vegetable production during the period 1991-92 to 2018-19. Currently, a shift from production of bulk/staple commodities to high value horticultural produce and products is in offing. Horticulture has emerged as a means for sustainable intensification and diversification globally to enable remunerative, viable, sustainable, alternate production systems in agriculture and an economically viable option for small holders. Production environment and market opportunity today is much different than in the past. With the horticultural crop production at 320.0 mt, the sector has emerged as a key driver of GDP contributed by Indian agriculture by contributing a share of to more than 34.45 per cent horticulture output in agriculture.

Post-harvest technology

Storage capacity of horticultural produce has increased with the establishment of a large number of cold stores. CA storage facilities are now available in several towns. The Government's focus on cold chain is manifested in the addition of over 34 mt of cold storage capacity, by MIDH, APEDA, MoFPI and Department of Animal Husbandry, Dairying and Fisheries. Cold chain is emerging as a promising sector for private investments. Improved post-harvest handling, ripening, packing and packaging technology are evident from quality and the range available in super markets and long distance markets. Value added products like dry flowers, pot pouries, potted plants and essential oils have penetrated in both the retail and super market chains.

Trade

There has been significant increase in export of various horticulture commodities. Indian horticulture has gradually penetrated in the international market with significant increase in exports of fruits (mango, banana, pomegranate, etc.), vegetables (okra, gherkins, etc.), flowers and cashew. Contract farming has become popular amongst the cash strapped farmers. Comparative advantages offered by horticulture crops through higher labour requirement have provided additional employment opportunities. The impact of these initiatives has become quite visible and their role in development of this sector has been recognised in our country.

Future Strategies

Keeping in view the increasing requirements of horticultural produce for food and nutritional security, exports, food processing and pharma industry, future strategies need to be focused on achieving self-sufficiency in production of quality planting material and seed, expanding existing area under cultivation, improving productivity, quality, saving post-harvest losses, adoption of alternate horticulture systems, production of healthy pest free produce and products and improving the transfer of technology. The following initiatives are suggested to achieve the objectives, such as:

- Exploitation of Genetic Materials
- Achieving self-sufficiency in healthy planting materials
- Improving Availability of Horticultural Produce
- Increasing Productivity
- Reducing Cost of Production
- Risk Management
- Improving Quality and Food Supply
- Promoting Alternate Horticulture Systems
- Promoting Urban and Peri-Urban horticulture
- Pre and Post Harvest Management & Value Addition
- Horticulture for Health and Nutrition /Emphasis on settling-up of Farmers' Producers Organization
- Improving Transfer of Technology and Skill Development in Horticulture

Way Forward

While a virtual revolution in horticulture has been observed in the horticulture sector in the country as evidenced by record production surpassing food grain production continuously for the past seven years, improved productivity and increased exports, the demand of 34 horticultural produce is increasing at a very fast rate due to demographic change, change in food habits from predominantly cereals to a richer mix of vegetables and fruits resulting in increased consumption due to realization of nutritional and health properties. Diversification to horticulture has been a fruitful proposition to farmers as it has brought substantial changes in the income particularly for small and marginal farmers. The requirement of horticultural crops particularly fruits and vegetables by 2030 would reach to 550 mt while significant development has taken place in food availability, a lot needs to be done to achieve high production levels in years to come. Though the conventional horticulture will continue to grow with small and marginal farmers, a shift to 'Hi-tech horticulture' has become extremely important. Besides, it is necessary that future efforts of research and development are directed on the issues: i) exploitation of genetic diversity; ii) achieving self-sufficiency in quality planting material; iii) improving productivity and availability of horticultural produce; and iv) reducing cost of production.

Conclusion

The strategy paper gives an account of the present status, the challenges and the way forward in horticulture R&D. What finally emerges is that India has a large production base, a wide variety of horticulture produce and linking to the export markets. India also has good natural resource base, an adequate horticultural infrastructure and excellence in certain areas. The challenges are the fast growing population, shrinking land and other natural resources, the fast eroding gene pool, some production constraints, especially of planting material, rootstocks, abiotic and biotic stresses, lack of skilled human resource in newly emerging technologies and huge post-harvest losses due to absence of dedicated cold chain. Given the challenges, the country confronts the R&D workers, who have worked tirelessly to transform Indian horticulture in keeping with the demands of resurgent India. Nature has placed India in a position of advantage and it is important for horticulturists, farmers and entrepreneurs to sustain the already achieved Golden Revolution in horticulture in years to come.

Strategy Paper 20 : Crop Biotechnology for Ensuring Food and Nutritional Security

(Dr J.L. Karihaloo and Dr R.S. Paroda; December, 2019)

Food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Achieving food security would require multi-dimensional interventions that address availability and economic and physical access to food and its proper utilization. The country's past achievements in agriculture, including significant increase in the foodgrain production from mid-sixties onwards, made possible primarily through breeding of high yielding semi-dwarf wheat and rice varieties and adoption of improved cultivation practices, adequately demonstrate the potential of scientific interventions for food and nutritional security. Despite these achievements, agricultural R&D is facing challenges on account of increasing demand for food, fast depleting natural resources (land, water, agrobiodiversity), rapid fragmentation of land holdings, adverse impacts of climate change, rising cost of cultivation, widening production disparities between agro-ecological regions, inefficient use of inputs, wastage of produce due to inadequate post-harvest processing and storage, and weak market linkages. These challenges have to be addressed through appropriate policy interventions and faster adoption of innovative crop production technologies that save cost on inputs, increase productivity and reduce wastage. A recent GoI report for "Agricultural Policies and Action-Plan for a Secure and Sustainable Agriculture" comprehensively deals with the diverse issues confronting Indian agriculture and recommends several measures and an action plan to accelerate agricultural growth and sustainability of farming. The strategy paper specifically examines the role of biotechnology, highlighting a few good examples of biotechnology application that have contributed directly or indirectly to food security with proven impact. It also enumerates various challenges for harnessing the potential of biotechnology, and suggests measures to effectively address these for greater benefits to the society.

Biotechnology encompasses a vast array of conventional and modern tools and techniques that have the potential to: i) increase food production, ii) improve its quality and safety, and iii) improve economic and social conditions of farmers and thereby their access to food. Such potential has been realised in several crops where biotechnological interventions have led to production of high-quality planting material; and genetically improved varieties incorporating genes for yield, resistance to biotic and abiotic stresses and improved nutritional quality.

Some Specific Developments and Their Impact

Among conventional biotechnologies, tissue culture technology has led to the establishment of thriving commercial micropropagation industry across the globe. In India, about 200 commercial tissue culture companies have been established with gross installed production capacity of about 500 million plantlets and actual production of 350 million per annum. Economic analysis has revealed significant benefits accruing to the farmers adopting micropropagation based planting material. For example, in banana, there has been more than 40 per cent increase in net income per hectare primarily due to higher yield and quality of produce.

Mutation breeding is a long established method of creating genetic variations to breed improved crop varieties. Till date, more than 3,200 induced mutation derived crop varieties have been developed globally, of which 335 have been registered in India (http://mvgs.iaea.org/AboutMutantVarities.aspx). Among modern biotechnologies, molecular breeding techniques have been widely used to introduce useful genes in crop plants including blast and blight resistance in rice, rust resistance in wheat and mustard, downy mildew resistance in pearl millet, and tolerance to salinity and submergence in rice. Bacterial blight resistant variety *Pusa Basmati* 1718 developed from a very popular Basmati variety PB1121 and having an average yield of 4.64 t/ha, has been notified for growing in the states of Punjab, Haryana and Delhi. There are plans to further improve this variety for resistance to different biotic and abiotic stresses. Quality protein maize (QPM) is a good example of marker assisted selection (MAS) for enhancing nutritional quality of staple crops. MAS developed QPM hybrids Pusa HM-4 Improved, Pusa HM-8 Improved and *Pusa HM*-9 Improved with enhanced endospermic lysine (48–74%) and tryptophan (55–100%), while having similar yield potential of the respective original hybrids HM-4, HM-8 and HM-9, were released for commercial cultivation in 2017.

Genetic modification (GM) is a powerful technology enabling transfer of desired genes across phylogenetically distant organisms. The technology has contributed to crop improvement primarily through development of varieties/ hybrids with traits for pest resistance, weedicide resistance (for effective weed management), and pollination control (for hybrid production). Resistance to bollworm in cotton, fruit borer in brinjal, stem borer and sheath blight in rice that otherwise cause heavy damage to these crops has been transferred from diverse biological sources through genetic modification. In India, Bt cotton is the only GM crop under commercial cultivation. The production of cotton has more than doubled from 15.8 million bales in 2001-02 to 36.1 million bales in 2018-19 and the productivity has increased from 302 kg/ha to 506 kg/ha during the same period, with the highest figure of 566 kg/ha having been achieved in 2013-14 (https://cotcorp.org.in/statistics.aspx). The substantial increase in cotton production since adoption of Bt technology has turned India from a net importer to one of the largest exporters of raw cotton.

Harnessing New Opportunities

High-throughput sequencing combined with bioinformatics has enabled rapid discovery of genes and regulatory sequences, and generated vast information regarding marker trait associations. Genome-wide association and genome-wide expression studies are uncovering molecular bases of complex traits. Genomic selection, selection based on genetic markers covering the whole genome, is emerging as an important breeding approach. Mass DNA screening of induced and natural mutants has become possible through TILLING and eco-TILLING. Advanced genome engineering and editing tools enable precise genome manipulation to yield desired phenotypes and obviate the need to insert foreign genes and selectable markers that have been the main safety concerns about GM technology. Cisgenesis, intragenesis, meganucleases, zinc-finger nucleases, TALEN, and CRISPR are some of the technologies being used for inserting genes from near related taxa or to modify native gene expression by silencing, overexpression and knockout mechanism for desired results. In 2016, US Department of Agriculture (USDA) decided not to regulate a mushroom and a corn modified with CRISPR/Cas9. Subsequently, in March 2018, USDA decided not to regulate any crop that has been genetically edited, as a consequence of which CRISPR edited plants are being commercially released in a short time.

Concerns and Challenges

Rapid population growth: Burgeoning population and diversifying food consumption patterns continue to put severe demands on our food production systems. India's population has reached 1.37 billion which constitutes 17.79 per cent of the world population of 7.7 billion. Though, foodgrain production in the country has increased from 227.32 million tonnes (mt) in 2007-08 to 285.01 mt in 2017-18 (https://eands.dacnet.nic.in/), per person foodgrain availability has been varying between 442.8 g/ person/day to 518.1 g/person/day during the same period, with no consistent trend. By 2030, India would need 345 mt of foodgrains which with the present production trends will be difficult to achieve.

Low R&D investments: Public investment in agricultural R&D has been growing at more than six per cent since 1980s and during 2012- 14 it averaged US$3.53 billion/year (2011 purchase power parity - PPP).

Need to improve R&D and regulatory management: NITI Aayog in its report on raising farmers' income pointed out that the Indian agricultural R&D system is under significant stress with lack of clarity on focus and inefficient use of financial resources (NITI Ayog, 2015). Collaboration among sister institutions and between laboratory and field have weakened over time and accountability declined. Consequently, there are shortfalls and delays in R&D project outputs and outcomes. Interinstitutional and public-private partnerships are hindered by similar management issues including lack of harmony between private and public R&D objectives, long gestation period and intellectual property ownership disputes.

Intellectual property protection: Free transfer of technology from public R&D institutions to farm sector was the norm till recently, which undeniably yielded rich dividends by way of wide spread adoption of improved seeds and production technologies by farmers and the consequent boost in agricultural production. However, with the increasing participation of private sector in agricultural innovation and enterprise the need to protect proprietary material and new technologies was realised and appropriate intellectual

property legislations introduced. Protection to some biological inventions like GM technology is granted under Patents Act 2005 while plant varieties are protected under Protection of Plant Varieties and Farmers' Rights Act (PPV&FRA) 2001. It is now recognized that protection of intellectual property (IP) rights is essential to encourage innovation and entrepreneurship, the benefits of which are shared by the entire society.

Need to improve public perception: While the use of GM technology for crop improvement has received strong support from global scientific community, there has been stiff opposition from some other groups due to which adoption of GM crops has suffered setback in a number of countries, including India. Scientifically untenable claims of adverse impacts of GM plants and food on human and animal health and environment have created fear and suspicion in public mind. Also, many of the negative attributes of the technology expressed in public debates in fact concern general issues of modern agriculture like, consequences of intensive agriculture on environment, corporatization and foreign domination of agriculture and their impact on farmers' livelihoods and traditional practices. Due to persistent negative publicity over the years, such perceptions have gained ground despite voluminous scientific literature proving the health and environmental safety of GM crops.

Capacity development: Commendable support has been provided by ICAR, DBT, MoEF&CC and other organizations in building physical and organizational infrastructure and human resources, notwithstanding the paucity of funding detailed earlier in this paper. However, considering the rapid technological advancements being made globally, and scientific, legal and social issues needed to be addressed during the course of biotechnology product development and delivery, there is need for regular augmentation and modernization of physical and technical capacities.

The Way Forward

The need to enhance agricultural productivity, nutritional quality of food, its accessibility to all sections of the society along with economic and social security of farmers cannot be overemphasized. While conventional crop improvement methods continue to be relevant, the food and nutrition needs of the growing population combined with depleting and deteriorating natural resources and emerging challenges of climate change necessitate adoption of new science for sustainably enhancing crop productivity and nutritional quality. Hence, to fully harness the potential of biotechnology, there is an urgent need for appropriate policy support, enabling environment and a clear Road Map to move forward. In this context, urgent action on the following recommendations is warranted:

Prioritizing biotechnology for food and nutritional security

A national policy on agricultural biotechnology is required to be formulated highlighting its expected role in achieving food and nutritional security. A list of priority crops along with needed genetic improvements for each of them needs to be compiled and a strategic plan developed for urgent action at the national level.

- Public sector investment in agricultural biotechnology needs be doubled. To ensure delivery of expected outputs at the farm level, the funding commitments need to be long-term. Indian private sector also needs to increase substantially its investment in R&D in order to become globally competitive and come out with new innovations. For this, a conducive policy environment needs to be created by the government.
- Greater attention needs to be given to strengthening public-private partnerships to ensure timely delivery of biotechnology products from development through validation, field testing and commercialization. Publicprivate partnerships should also be harnessed to build agribiotechnology business enterprises, agribusiness platforms and technology parks.
- Strong coordination between different R&D funding institutions like ICAR, DBT, Department of Science and Technology (DST) and other agencies is needed to work synergistically and avoid redundancies.

Biotechnology R&D priorities

- Development of nutritionally enhanced and biotic and abiotic stress resistant crop varieties that are well adapted to changing climate should be given high priority. Improvement of underutilized crops of high nutritional value and wide adaptation should also be taken up on priority. In states with intensive crop cultivation, adoption of herbicide tolerant genotypes needs to be considered especially in case of pulses, oilseeds, *kharif* cereals and vegetable crops.
- Given the relatively long time and expense involved in commercialization of GM crops, alternative biotechnological options should also be explored to achieve the desired improvement goals. Also, considering the huge diversity in plant genetic resources available *in situ* and in genebanks, the use of wild and weedy crop related species as sources of new genes needs to be enhanced substantially.
- The R&D programs should be executed by multidisciplinary teams with proper coordination, monitoring, evaluation and impact assessment.

Biosafety regulatory and IP management

- There is a strong need for reforming the regulatory system to make the decision making process fully science based, predictable and time bound. Taking into account the experiences since the enactment of Environment (Protection) Act, 1986, DBT had developed an elaborate blue print for reorganizing and modernizing the biotechnology regulatory

system. The Biotechnology Regulatory Authority of India (BRAI) Bill which was first placed in the parliament in 2008 should be revived, further reviewed and updated, and reintroduced in the parliament on priority.

- In view of the fact that genetic modification related technologies are evolving rapidly, regular review of biosafety regulations should be carried out to harmonise these with the new developments and knowledge.
- In order to fully evaluate the prerelease performance of newly developed GM crop varieties/hybrids, confined field trials should be undertaken in collaboration with ICAR institutes and SAUs following the well-established system of multilocation testing for the release of conventionally developed new varieties along with appropriate safety protocols.
- To encourage researchers to think more creatively and develop innovative technologies and products, IP in development of new varieties/hybrids and introduction of desirable traits through GM and related technologies should continue to receive protection under PPV&FRA and Patents Act. Appropriate clarifications may be made in the two Acts, if needed.
- Several important biotechnological processes, like those related to CRISPR, are protected by patents. Government agencies should facilitate their availability to the country's scientists through a centralized system of license negotiations. Capacity development
- Infrastructure for large scale phenotyping under controlled and open environments should be developed on priority, preferably in different agroclimatic zones of the country. This would also include efficient systems for storage, analysis, protection and sharing of the data.
- Greater thrust needs to be given on training and skill development programs especially in advanced molecular breeding, gene editing, genomics, phenomics and related information acquisition and handling tools. Since biotechnology R&D capacity differs widely across laboratories and institutions, it is desirable to conduct project based capacity development needs assessments taking into account individual and institutional capacities, objectives and expected outputs of the projects. Equal attention also needs to be given to capacity development in biosafety research and regulation, intellectual property management, partnership building and public communication.

Public awareness

Public awareness efforts need to be considerably enhanced to effectively communicate among various sections of the society factual information on the benefits and concerns about biotechnology and its regulation. Proactive strategies involving science-based messages suited to different audiences need to be developed to promote constructive dialogue with stakeholders ranging from policy makers to producers, traders and consumers.

Existing public extension system like ICAR *Krishi Vigyan Kendras* also need to be involved and suitably equipped to take up the responsibility of information dissemination and advice to farmers, particularly about field management of GM crops.

7 Foundation Day Lectures/Special Lectures

Preamble

TAAS has been organizing the Foundation Day Lectures and also the Special Lectures of eminent experts/research leaders on topics of current interest mainly at Dr. B.P. Pal Auditorium, IARI, New Delhi. Full house participation of more than 300 senior research scientists, policy makers, ICAR officials and especially the Post-Graduate students of IARI has been ensured in order to disseminate the best benefits and up-dates on various subjects/ topics of considerable national/ global interest. In this context, TAAS has so far organized 15 such lectures (11 TAAS Foundation Day, and 4 Special Lectures; see Annexure VIII), which have also been printed and distributed widely. The title and a brief description of all lectures organized are given here, whereas detailed lectures are available on TAAS website (www.taas.in)

A. TAAS Foundation Day Lectures

Foundation Day Lecture 1 : Regulatory Measures for Utilizing Biotechnological Developments in Different Countries

(Dr. Manju Sharma; 17 October, 2003)

The first TAAS Foundation Day Lecture was delivered on October 17, 2003 by Dr. Manju Sharma, the then Secretary, Department of Biotechnology, Ministry of Science and Technology (MoS&T), President, National Academy of Sciences India (NASI) Prayagraj (earlier Allahabad), and the former General President of the Indian Science Congress Association (ISCA). She, has been associated with promotion, development, identification and monitoring of research and product development. The learned speaker discussed different facets of biotechnology and biosafety and enumerated various mechanisms of risk assessment.

She emphasized that genetically modified organisms (GMOs) fall into two categories i.e. contained use and field release. Their use in agriculture involves exposure of the ecosystem. This continues to raise questions of adverse impact on non-target species and stability of the inserted gene.

To address these concerns, biosafety regulations have been developed by many countries. The most ambitious attempt to produce a globally harmonized regime for the biosafety has been under the Convention on Biological Diversity (CBD). The protocol seeks to protect biological diversity from the potential risks posed by living modified organisms. India is a party to the CBD and signatory to Cartagena Protocol on biosafety. All countries are not party to this agreement. Different counties follow different norms.

There are Latin American, African and South East Asian countries where the biosafety measures are not yet adequate. These disparities in overall policy and capacities amongst countries have profound cross border influence in terms of trade and commerce.

Keeping in view the accelerated growth of biotechnology and its potential applications, Government of India has evolved a regulatory mechanism for development, evaluation and release of biotechnology products. These rules and regulations cover all the areas of research as well as large-scale applications and release of GMOs and products thereof throughout India. To facilitate adherence of Rules, the Department of Biotechnology has evolved Recombinant DNA Safety Guidelines (1990). Apart from these guidelines, the Government of India has also amended relevant acts and rules to facilitate the development and release of GMOs and products thereof

1st Foundation Day Lecture delivered by Dr. Manju Sharma

Dr. H.K. Jain offering his comments

into the environment. Most of the regulatory systems are relatively open and transparent with precautionary approach, and are in general, compliance friendly. It is important to update mechanisms to meet the current challenges of the society based on the scientific knowledge which is growing phenomenally world over.

There are concerns in the society about both the advantages and risks of this emerging field of biotechnology. With proper scientific explanations, these have been adequately addressed.

In agriculture, biotechnology research is crucial for enhancing productivity and quality including value addition and nutritional enhancement of the crop. Recombinant DNA technology has enabled scientists to genetically modify plants, animals, and microorganisms. Modern genetic engineering techniques can facilitate introduction of a greater diversity of genes into organisms – including those from unrelated species – than traditional methods of breeding. Thus, plant biotechnology is an extension of traditional plant breeding. However, there are also concerns regarding possible risks and hazards arising from the use of GMOs and products there from. The two main areas of concern are the impact on environment and ecosystem and the effects on human health. Immediately after the advent of rDNA technology, discussions began about the risks emanating from recombinant DNA experiments. In 1975, at an international gathering of scientists in Asilomar, California, the first set of recommendations to manage the safety of recombinant DNA experiments were formulated which formed the basis of subsequent biosafety regulations. In view of the fact that these organisms and products would be released into the market and would be widely used, the scope of evaluation of possible risks widened. These risks are classified as follows:

- *For animal and human health*: toxicity and allergenicity
- *For environment*: generation of new live viruses by recombination (trans-capsidation, complementation, etc.)
- *For agriculture*: resistance/tolerance of target organisms; alteration of nutritional value; susceptibility of non target organisms; evolution of super-weeds; instability of transgene; higher cost of agriculture etc.

Foundation Day Lecture 2 : Public-Private Partnership in Agricultural Biotechnology

(Dr. G.S. Khush; 17 October, 2005)

The second TAAS Foundation Day Lecture was delivered on October 17, 2005 by Dr. G.S. Khush, Former, Head of the Division of Plant Breeding, Genetics and Biochemistry, International Rice Research Institute (IRRI), Manila. Dr. Khush, along with his team has developed more than 300 new rice varieties, some of which triggered Green Revolution in Asia in the 1960s.

Scientific advances in plant breeding led to "Green Revolution" regarded as the most important agricultural achievement of humankind. Food grain production in India doubled in a short span of 25 years between 1970 and 1995. While we should be proud of these achievements, we should not become complacent. Our population is increasing at the rate of 1.9 per cent per year. We are adding 19-20 million new mouths to feed every year. To meet this increase in demand, we will have to increase food grain production by 50 per cent in 2030 when our population is likely to stabilize.

Time tested methods of classical breeding such as hybridization and selection, ideotype breeding and hybrid variety development will continue to be used but tools of biotechnology will play increasingly important role in crop improvement.

Both the public and private organizations have important roles to play in harnessing the benefits of biotechnology and emerging field of genomics. Collaboration between the two sectors is even more crucial for addressing the problems of food security and poverty alleviation in developing countries. Several

Dr. G.S. Khush delivering the 2nd Foundation Day Lecture

examples of public-private collaboration and partnership have been put forth in this lecture which showed that large life science companies such as Monsanto, Syngenta, Pioneer are willing to donate their proprietary technologies (genes, promoter, process and sequence) for humanitarian causes.

In addition, the formation of global public-private alliances and international agreements will be critical to' ensure that the current explosion in genomics knowledge is tapped to solve the problems of poor producers and consumers. The public sector has critical assets in the form of germplasm and associated biological knowledge important in new science of genomics. However, to fully exploit these assets, public sector must develop a capacity in IP management, strengthen biosafety protocols and upgrade business skills. Most public-private alliances to-date are been based on free access to proprietary technologies for non-competing markets. Market segmentation is likely to be a key element in public-private negotiations in the future. To ensure that public sector organizations in poor developing countries have access to proprietary technologies, multinational life science companies should have enlightened patent policy.

Foundation Day Lecture 3 : Global Efforts for Improving Quality Protein Maize (QPM)

(Dr. S. K. Vasal; 3 May 2008)

The third TAAS Foundation Day Lecture was delivered on 3 May 2008 by Dr. S.K. Vasal. Dr S.K. Vasal, Distinguished Scientist, Centre for Improvement of Maize & Wheat (CIMMYT), Mexico mentioned that improving nutritional quality of crops was a noble goal. He emphasized that QPM was a great scientific breakthrough and a real success story for which maize scientists should feel proud of. Maize program in India had been involved in QPM research ever since the discovery of high lysine maize mutants. Initial emphasis was on soft opaques that led to the release of *Shakti*, *Ratna* and Protina in 1971. He further highlighted that marker assisted selection had also been deployed to convert some normal lines to QPM and a QPM version of Vivek 9 had also been developed.

Dr. S.K. Vasal delivering the 3rd Foundation Day Lecture

Dr. Vasal suggested following research areas for future consideration:

- There is need for more diverse QPM germplasm at inbred level.
- Specific QPM donors for various diseases and abiotic stresses are to be documented.
- Better understanding of modifying gene complex and regions where modifying alleles are present, need to be developed
- There is need to generate information to establish as to how the modification is affected at the biochemical and molecular level. There is already an indication that modified o2 kernels contain increased amounts of gamma-zein protein.
- Research on genetic isolation mechanisms to prevent contamination of QPM by normal pollen should be pursued.
- A strong resource inbred base germplasm should be built by deploying more than one strategy, including inbreeding in basic QPM populations, F2 pedigree populations and in some instances backcross populations and in limited cases converting normal to QPM.
- Well equipped biochemical laboratories should be established to provide rapid and reliable analyses.
- Practical strategies should be developed to speed up conversion process along with good recovery of kernel modification.
- Breeding procedures and strategies need to be deployed to form hybrid oriented populations for inbred extraction in homozygous genetic backgrounds.
- More research on storage grain pests is needed as it is related to kernel hardiness and ability to withstand insect pressure.
- Use of biotechnological tools to facilitate hybrid development should be taken up more aggressively.
- Conscious efforts are needed to identify more testers as part of on-going QPM research activities.
- More training programs are needed to attract talented researchers to carry out QPM research.
- Properly designed nutritional and feeding trials should be conducted for both human development and poultry production.
- Research on value addition in processed food and traditional preparations would help in achieving nutritional security.

Foundation Day Lecture 4 : Overcoming the World Food and Agriculture Crisis through Policy Change and Science

(Joachim von Braunon; 6 March, 2009)

The fourth TAAS Foundation Day Lecture was delivered on 6 March, 2009) by Dr Joachim von Braun, Director General, International Food Policy Research Institute (IFPRI) who has been the President of the International Association of Agricultural Economics.

Dr. Joachim Von Braun delivering the 4th Foundation Day Lecture

The speaker discussed critically the importance of policy decisions and their impact with relevant examples.

Today's world food situation is shaped by volatility of food prices, low growth in agricultural productivity, and severe constraints to access of investment capital for agriculture in many countries. The sharp rise in global food prices in 2007-08 severely undermined the nutrition security of the poor, provoked social and political instability, and increased competition for limited natural resources. The crisis, however, also renewed the focus on food and agriculture on national and global agendas, after decades of policy neglect and underinvestment in agricultural science, rural infrastructure, and institutions. India has responded strongly to the challenges in the world food system with policy actions.

Throughout the world, policymakers and the public long for simple solutions of these complex problems, but unfortunately, there are none. At the same time, some misguided policy actions have deepened the crises by threatening the open exchange of ideas, information, services, and goods.

Policy proposals to overcome the world food and agricultural crisis are composed of three sets of needed complementary actions:

- Promotion of agricultural growth
- Reduction of market volatility, and
- Expansion of social protection and child nutrition action.

Foundation Day Lecture 5 : Climate Change and Food Security: From Science to Sustainable Agriculture

(Dr. Mahendra M. Shah: May 7, 2010)

The fifth TAAS Foundation Day Lecture was delivered on 7 May, 2010 by Dr. Mahendra M. Shah, Director, Qatar National Food Security Program. Dr. Shah has done excellent work towards sustainable agricultural development, food security, climate change, integrated agro ecological and socio-economic modeling, policy analysis, international agricultural investments and trade policy. The speaker dealt with various national and international issues at length in his lecture.

Climate change results in irreparable damage to arable land, water and biodiversity resources, with serious consequences on food production and food security. The challenge in the 2050s will be doubling food production to meet the food needs of an additional 2.5 billion people, land expansion is not an option in all but a handful of countries. Over 75 per cent of additional food production will need to come from productivity increases.

In order to meet the challenges of climate changes, scientific and technological experiences of the last half century, including the remarkable progress in science based conventional breeding, will need to be combined with safe and ethical biological sciences-molecular genetics, informatics and genomic research

Dr. Mahendra M. Shah delivering the 5th Foundation Day Lecture

and improved land, water and agrobiodiversity management systems, and environmentally sound livestock production and fish farming.

The scientific community, civil society, national governments, and the international development community bear the fundamental responsibility to achieve nutritionally healthy, productive and sustainable food systems.

Foundation Day Lecture 6 : Harnessing Research for Development: India's Agricultural Development

(Dr. Uma Lele; 12 August, 2011)

The sixth Foundation Day Lecture was delivered by Dr. Uma Lele on 12 August, 2011. Dr Lele, Former

Dr. Uma Lele delivering the 6th Foundation Day Lecture

Senior Advisor in the Operations Evaluation Department of the Food and Agricultural Organization has served on the High Level Advisory Panels of the independent evaluations of the Global Environmental Facility in 2006, UNICEF in 2008, and is on the UNDP Panel in 2010-11.

The sharp rise in world food and fuel prices since 2007 has focused global attention on the role of agriculture in economic development. Following the Green Revolution in the 1970s, a consistent decline in the real prices of food for nearly 30 years led to a global complacency regarding food supply. In exploring how to respond to the combined food and fuel crisis, the role of knowledge, both global and local, in modernizing agriculture seems to be particularly appropriate. India now is not only the country with the second highest rate of economic growth next to China, but it has also been a global leader in outsourcing, improving knowledge management systems of large private enterprises throughout the world. The lecture highlighted as to how India can bring its economic growth and information revolution to address the issues of modernizing its agriculture.

To achieve broad based agricultural development involving a large number of small dispersed farmers however requires not just technology capital but knowledge in a whole range of area. This knowledge is imbedded in the efficiency with which seed, fertilizer and pesticides are produced, delivered and applied by farmers.

Multiplicity of actors and a range of institutions supply information and knowledge in these various areas including agricultural research, extension and education systems, universities and think tanks, private sector traders and processors, non-governmental organizations, international development agencies and environmental organizations, the media and the formal and informal rule making system.

Whether the pace of growth or indeed even the process itself is sustained, or is prematurely aborted, is critically determined by the way information and knowledge are processed by key stakeholders in societies.

The way a country's institutions adjust to changing circumstances and challenges determines whether countries progress. Seen from such a knowledge perspective how does India's performance look over time and space and relative to other countries? India not only has the distinction of enjoying the second highest rate of economic growth next only to China's since the turn of the new millennium. There, nevertheless continue to be huge differences among states in per capita incomes

Given that the poorest states depend the most on agriculture, Knowledge Management would seem to be a high priority for India's Agricultural Development. India's agricultural growth has slowed with considerable differences in growth across crops and states. Growth of wheat has been the highest and close to 2 per cent, rice is far behind and maize has been as low as 0.67 per cent. India experts are also calling for a total transformation of India's higher agricultural education to accelerate innovation.

Foundation Day Lecture 7 : Ensuring Food and Nutrition Security in Asia: The Role of Agricultural Innovation

(Dr. Shenggen Fan;11 January, 2013).

The seventh TAAS Foundation Day Lecture was delivered by Dr. Shenggen Fan on 11 January, 2013. Dr. Shenggen Fan, Director General, International Food Policy Research Institute (IFPRI) has conducted extensive research on pro-poor development strategies in. developing countries in Africa, Asia, and the Middle East. Dr. Fan highlighted that nearly 870 million people suffer from hunger today. Over 50 countries have levels of hunger that are "extremely alarming," many of which are in South Asia and Africa-South of the Sahara. According to the World Health Organization (WHO) of the United

Dr. Shenggen Fan delivering the 7th Foundation Day Lecture

Nations, more than two billion suffer from micronutrient deficiencies with a significant share residing in Asia.

Asia's food and nutrition security is under stress due to many interconnected factors that include population growth, urbanization, demographic changes, increased labour cost, high and volatile food prices, natural resource constraints, and climate change. In order to achieve food and nutritional security in Asia an integrated and more innovative development agenda must be adopted in terms of strategies, investments, technologies, institutions, and partnerships.

In this lecture, Dr. Fan emphasized the important role that higher investments in agricultural research and development (R&D) and the resulting advances in agricultural science and technology play in reducing poverty and food insecurity in Asia.

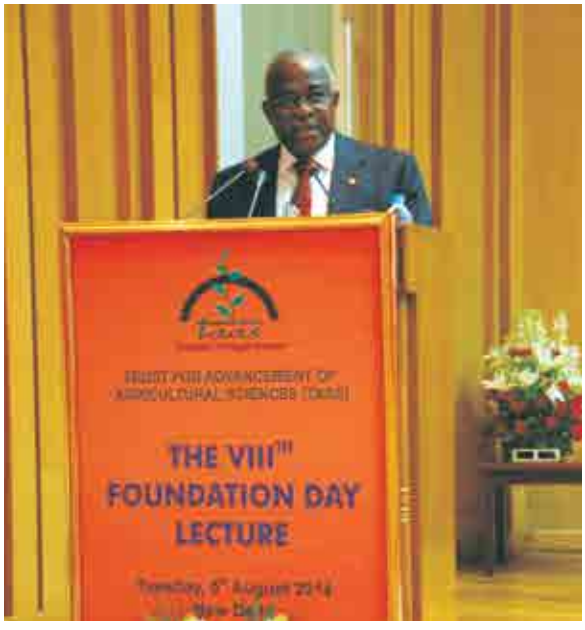
Foundation Day Lecture 8 : Sustainable Agricultural Development – IFAD's Experiences

(Dr. Kanayo F. Nwanze on; 5 August, 2014.)

The eighth TAAS Foundation Day Lecture on "Sustainable Agricultural Development – IFAD's Experiences" was delivered by Dr. Kanayo F. Nwanze on 5 August, 2014. A Nigerian national, Dr Nwanze, President of IFAD has a strong record as an advocate and leader with a keen understanding of complex development related issues.

Dr. Nwanze started off by defining sustainable development and stressed that development is sustainable if it leads to inclusive economic growth so that changes take root and persist long after the aid workers and development agencies leave. He described some of the experiences of IFAD and said that as a result of his interaction at ground level with people he had learnt 5 lessons, which are as follows:

- People must be at the center of all research and development



Dr. Kanayo F. Nwanze delivering the 8th Foundation Day Lecture

- There is no need to think small and be afraid of it The starting point for sustainable agriculture must be smallholder farmers
- Agricultural research is an essential element of sustainable development, and
- Poor rural people are not looking for charity

He concluded by asserting that only by following above tenets, efforts in agricultural development will be sustainable.

Foundation Day Lecture 9 : 21st Century Challenges and Research Opportunity for Sustainable Maize and Wheat Production

(Dr. Thomas A. Lumpkin; 28 September, 2015.)

The nineth TAAS Foundation Day Lecture on "21st Century Challenges and Research Opportunity for Sustainable Maize and Wheat Production" was delivered by Dr. Thomas A. Lumpkin on 28 September 28, 2015. Dr. Lumpkin, Former Director General, International Maize and Wheat Improvement Centre (CIMMYT), Mexico has been at the forefront of guiding wheat and maize research of development in the developing world particularly in India and across South Asia.

Shaping maize and wheat for the future

Maize

Globally, maize is a staple food for 900 million people earning less than US$ 2 a day (maize CRP), and is consumed indirectly by even more in the form of dairy and animal products. The demand for maize is expected to double by 2050 as populations increase and people include higher amounts of animal products in their diets. This challenge will be further exacerbated as abiotic and biotic stresses resulting from climate change, urban sprawl, groundwater depletion and soil degradation result in increasing loss of yields. This scenario will reduce national and regional agricultural systems' ability to adapt and react. As maize consumption increases, production shortages and erratic yields will result in price fluctuations and increasing stress on impoverished farming communities that are dependent on maize for their livelihoods. Maize is the third most important cereal crop in India after rice and wheat, accounting for ~9 per cent of total food grain production in the country. In the last 10 years, there has been a significant increase in both the production of maize, from 14 MnMT in 2004-05 to 23 MnMT in 2013-14 and the area, from 7.5 m ha in 2004-05 to 9.4 m ha in 2013-14. Current yield levels across the majority of India are fairly low with less than 3 t/ha, although there are a few high yielding locations achieving more than 5 t/ha (indicated in green). The increase in acreage is a result of profitability, varietal adaptability to diverse agro-climatic conditions, and the lowering of water tables in the rice belt of India. The increase in yield is attributed to the introduction of single cross hybrids and improved agronomy.

Dr Thomas A. Lumpkin delivering 9th Foundation Day Lecture

Wheat

The history of wheat dates to the beginning of agriculture and Middle Eastern civilization. Today wheat is grown on 215 m ha, making it the most widely grown staple food crop. More importantly for the poor, wheat is eaten where it is grown and provides 20-50 per cent of daily calories and up to 20 per cent of daily protein to 2.5 billion people. From South Asia through to Central Asia across the Middle East and on to North Africa, wheat is a staple food. Demand for wheat is not isolated to these traditional wheat-eating regions. Today African countries spend about US$ 12 billion annually to import some 40 mt of wheat. What was once considered a minor crop for consumers in Sub-Saharan Africa, wheat demand is growing faster than for any other commodity and is now considered a strategic crop for food security by African leaders. This has largely been driven by urbanization, globalization of diets, rising incomes and an increase of women in the workplace. Perhaps what is most concerning are the predictions for the near future. Demand for wheat in the developing world is projected to increase 60 per cent by 2050. India, the world's second largest wheat-consuming and producing country after China, has 17.5 per cent of total world population and 20.6 per cent of the world's poor. Wheat is predicted to be the staple crop most significantly affected by climate change, because of its sensitivity to heat and the fact that it is grown all over the world. Current projections predict that with every degree Celsius increase in temperature, wheat yields in semi-tropical areas could drop by 10 per cent. Increasing intensity and variability of weather events driven by climate change will lead to an increased threat to the South Asian agriculture as seen with the 2014-15 wheat crop which suffered a 5.5 per cent yield loss compared to 2013-14 due to late season rain damage.

The future of both maize and wheat productivity will have a huge impact on future global food security because maize is the number one crop for total production and wheat is the number one crop for production area and because they are widely grown at a broad range of latitudes and temperatures, water regimes and nutritional levels. For food prices to remain constant, yield must increase 1.2-1.7 percent for maize and 1.1-1.7 per cent for wheat annually. The approach to increase yields at this pace must combine emerging environmental, socioeconomic and scientific research innovations.

Getting the most out of the crop

Advancing yield gains in wheat

Global wheat yields must increase at a rate of 1.7 per cent per annum to keep up with the demands of 9 billion people by 2050 and must increase at an even more rapid pace in India. Current productivity is only increasing at a rate of 1.1 per cent and even stagnating in some areas. This challenge requires boosting yield on the current or even reduced cultivated land area. At the fundamental level this will be achieved by improving wheat's ability to capture and process the sun's energy, through photosynthesis, and making sure that the captured carbon ends up in the wheat grain. For example, only about 1 per cent of light energy hitting a wheat field ends up in the parts that are eaten, compared to maize's 3-4 per cent potential efficiency and sugarcane's 8 per cent or more efficiency. Even increasing wheat's photosynthetic efficiency from 1 per cent to 1.5 per cent would allow farmers to dramatically increase their yields on the same amount of land, using no more water, fertilizer or other inputs.

A consortium of world scientists has speculated that the radiation use efficiency (RUE) of wheat, could be increased 50 per cent through collection of strategies such as modifying the specificity, catalytic rate and regulation of Rubisco and up-regulate Calvin cycle enzymes, and agronomic strategies including optimizing light interception and N distribution of canopies while minimizing photo inhibition.

Taking advantage of Biological Nitrogen Fixation and Biological Nitrification Inhibition in maize and wheat

In the last 40 years the quantity of synthetic nitrogen fertilizer applied to crops has increased rapidly. Use of nitrogen fertilizer has resulted in significant yield increases but with considerable environmental impacts. Critics of the Green Revolution have raised valid concerns about the sustainability of imbalanced, intensive cultivation and its socioeconomic impacts. However, so far, no realistic alternative scenario has been proposed that would allow the world to meet the production demand posed by its expanding population, while lowering the environmental impact. What should be made clear to all is that the tremendous yield benefits of nitrogen fertilizer have not been widespread. Smallholder farmers in sub-Saharan Africa use a fraction of nitrogen fertilizer compared to those in the developed world, mostly due to cost and limited access to fertilizer. On average, only 9 kg of fertilizer per hectare of maize is applied by such farmers.

If cereals could be transformed to host nitrogen fixing organisms, global agriculture would have less need for fossil fuels and would cause less pollution from runoff. However this transformation would require the transfer of the nitrogen-fixing ability of legumes into the monocot cereal crops (especially maize, rice and wheat). Re-engineering the biology of a cereal crops to include the nitrogen fixing symbiosis, is seen as a way to reduce dependence on nitrogen fertilizer including its financial and environmental costs. The aspiration to develop nitrogen-fixing crops is long-standing, but recent discoveries suggest that this dream may be within reach. Engineering this trait requires the interplay between comparative and quantitative phylogenetic approaches. Recent discoveries suggest that quantitative phylogenetics associated with comparative phylogenomics and phylogenetics would generate traits and genomic features associated with nitrogen-fixing symbioses. Transforming cereals to fix atmospheric nitrogen should go hand in hand with improvements in their photosynthetic efficiency in order to avoid a yield penalty from the energy demand of BNF.

Nitrification, a microbiological process that generates nitrate (NO_3) may enhance losses of nitrogen fertilizer. This is the only known biological process that generates nitrous oxide (N_2O), a greenhouse gas contributing to climate change. Certain plants can suppress soilnitrification by releasing inhibitors from roots, a phenomenon known as biological nitrification inhibition (BNI). There is no detectable BNI in root exudate of maize or wheat, however some tropical grasses like Brachiaria spp., food crops like sorghum and wheat-wild relatives like Leymus spp. can suppress soil nitrification by releasing BNI compounds from roots, thereby reducing N_2O emissions. Reduced nitrification is essential to reduce N_2O emissions and to improve nitrogen use efficiency in agricultural systems. As part of a comprehensive approach incorporating genetic and agronomic management solutions, BNI-technology will reduce nitrogen losses, facilitate nitrogen retention and improve soil-health in next-generation climate-smart production systems.

To increase production and reduce pollution, alternative fertilization approaches that are both affordable and environmentally benign are necessary for the future of sustainable agriculture. Any increase in plant available nitrogen would have an important impact on the ability of smallholder farmers to increase productivity on their farms.

Novel strategies to develop better crops

There are a number of rapidly developing game-changing technologies that are poised to revolutionize basic research and plant breeding. Advances in genome editing tools are enabling crop researchers to precisely and easily manipulate a plant's DNA. The new and most powerful tool is known as CRISPR/Cas9. The simplest way to think of CRISPR is as a pair of molecular scissors that can be targeted to a specific genomic sequence using an easily engineered guide sequence, a short piece of RNA, that binds to its DNA target. This technology holds promise for precision transformation with desirable traits, such as disease resistance or drought tolerance. Other genome editing tools have been around longer, though CRISPR/Cas9 may be easier and cheaper to use and have a lower rate of failure. This system was originally a medical discovery but has successfully been applied in model plants, including maize, wheat, rice, tomato, and sorghum and promises to increase the efficiency of making genetic improvements. However one of the discoverers of this technology has recently proposed a suspension on its use until new safety concerns can be addressed. Also new legislation covering genome editing in light of the new CRISPR/Cas9 discoveries, especially within the European Union could potentially put restrictions on genome-editing technologies.

Managing future environments

Impending food production challenges will not be tackled by genetic gains alone. Global agriculture needs a strategy that will conserve and sustain natural resources such as land, water and biodiversity while significantly contributing to the rising demand for maize and wheat. This problem is further exacerbated by the inefficient use and mismanagement of production resources, especially water and fertilizer. Adaptation alone is not sufficient to sustainably overcome the challenges of climate change and variability. Business as usual production practices such as conventional tillage and farmers' nutrient and irrigation management systems will not reduce the above-mentioned challenges. However, new innovations are being developed to mitigate climate change challenges by adopting precision, agronomic and land management practices in cereal production systems.

Conservation agriculture (CA) has the potential to improve crop productivity, enhance resource use efficiency, and ameliorate weather extremes. CA may provide both adaptation and mitigation benefits and sustain agricultural production under the inevitable effects of climate change and variability. CA has been promoted by CIMMYT in recent years to address the developing world's production challenges and includes practices such as nutrient management, minimal soil disturbance and permanent soil cover combined with crop rotation practices. The benefits of CA are increased crop growth and productivity especially under environmental stress, reduced production costs and enhanced resource-use efficiency.

Precision conservation agriculture and remote sensing technologies are other areas offering exciting potential. Agronomy driven by sensor technology can address these challenges by monitoring soil moisture, fertility, weather, crop growth and yield and thereby making better use of existing natural resources, improving nutrient and irrigation management and supporting genetic enhancement, and can provide farmers with a wealth of information to improve crop management practices. With the rapid advancement and availability of technologies and data processing, sensor technology is increasingly becoming an important

tool for the fine tuning of management practices. The quantity and quality of data is increasing, while prices are decreasing. In fact, in many instances data is freely available to the public.

Water-wise technologies

Water is the most crucial input for agricultural production and expansion of the irrigated area has led to an impressive increase in crop production since the 1970s, but, its unrestrained use has resulted in depletion of surface and ground water resources and as a result serious water deficits are threatening agricultural sustainability. In India, during the period of 2008-2012, the total fresh water withdrawal was about 761 billion m3 of which ~90 per cent was associated with irrigation and livestock production. In order to satisfy growing demand for food, India needs to produce 37 per cent more rice and wheat by 2025 with nearly 10 per cent less water (Source: HS Sidhu and ML Jat, BISA-CIMMYT, India).

Though there are a range of interventions available for improving water use efficiency in agriculture, their applications, accessibility, affordability and investment priorities are very situation-specific. However, precision irrigation management has demonstrated potential for saving water and improving water use efficiency. Recently, BISA-CIMMYT Ludhiana has initiated new research on precision-conservation agriculture in rice-wheat and maize-wheat systems. The initial results on layering sub-surface drip with conservation agriculture based rice-wheat and maize-wheat rotations have shown tremendous potential to dramatically cut irrigation water use while producing higher yield and doubled water use efficiency. As evident in table 1, by switching from conventional (CTTPR-CTW) to conservation agriculture (ZTDSR-ZTW), the rice-wheat (RW) system productivity was increased by 4 per cent using ~15 per cent less irrigation water. However, with layering sub-surface drip irrigation with CA, the productivity of the RW system increased by 8.6 per cent with 50 per cent less irrigation water use and 116 per cent higher water productivity compared to the conventional farmer practice. In the maize-wheat system, the gains in productivity under CA+ sub-surface drip are larger than RW system. The biggest bottle neck in adoption of drip irrigation in cereal based systems is labor use in frequent shifting of drip lines for different operations and the life span of the tubing. Layering sub-surface drip in CA based systems is one of the best ways to resolve these problems and could facilitate faster adoption of drip irrigation system.

The impact of plant variety protection on germplasm exchange

The International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) is a legal tool to guide conservation of genetic resources and to ensure the fair and equitable sharing of the benefits arising out of their use. Under the treaty, all in trust CGIAR ex situ genebank collections were placed in the multilateral system, making them available on request for research, development and training. It is estimated that approximately 600 accessions are requested from CGIAR centers each day. To date, 132 countries have signed up to the treaty, to allow the open access flow of genetic resources.

In October 2014, the Nagoya Protocol (a supplementary agreement to the Convention on Biological Diversity) was brought into force to provide greater legal certainty over the benefits arising from the use of genetic resources. Signature countries are now establishing specific laws and regulations relating to it. The potential for the new Protocol to clash with the ITPGRFA is a cause for concern. Under the Treaty, all agreements are made on a multilateral basis, ensuring a global and coordinated approach. Food must flow across the borders and no single country should have the right to own genetic resources. This could change under the Nagoya Protocol and the introduction of bilateral agreements could lead to new and specific legislation in each country.

This could have a vast impact on CGIAR germplasm exchange. Unless the specific case and value of the germplasm held by CGIAR centers is considered in each country, the modifications in national legislation could inadvertently lead to greatly reduced exchange of CGIAR germplasm and hamper international cooperation built on the norms of public science (Jinnah & Jungcurt, 2009). Signatories to the protocol must use consistent language that recognizes the international nature of germplasm, especially collections held in trust by CGIAR centers. The bilateral nature of the Nagoya Protocol could also pose a risk that germplasm may be de-facto nationalized, preventing international organizations from exporting germplasm from countries that claim ownership and fail to provide consent.

Conclusion: Taking Borlaug's legacy forward

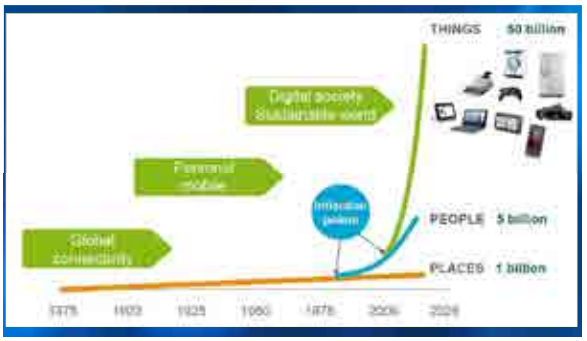
South Asia is home to 1.6 billion people and 40 per cent of the world's poor and faces a range of multifaceted challenges including climate change, rapid population growth, persistent poverty, chronic malnutrition, and declining crop yields. By 2050, 25-30 per cent of South Asia's wheat crop and 6-23 per cent of the maize crop are likely to be lost due to higher temperatures. To address these challenges, CIMMYT and the Indian Council of Agricultural Research (ICAR) established the Borlaug Institute for South Asia (BISA) in 2011 to address food, nutrition, livelihood and environmental security in South Asia.

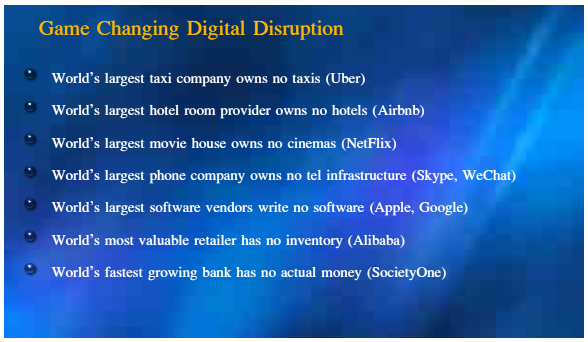
BISA is building on the Borlaug legacy by providing an international platform for agricultural research and development in South Asia. Key areas of research like those expressed in this paper have included genomic selection for heat stress tolerance in maize and wheat, conservation agriculture in wheat based cropping systems, water saving technologies, and the development of farm machinery. This has been achieved by offering an international platform for researchers to undertake cutting edge research to address 21st century challenges and research opportunities for sustainable maize and wheat production.

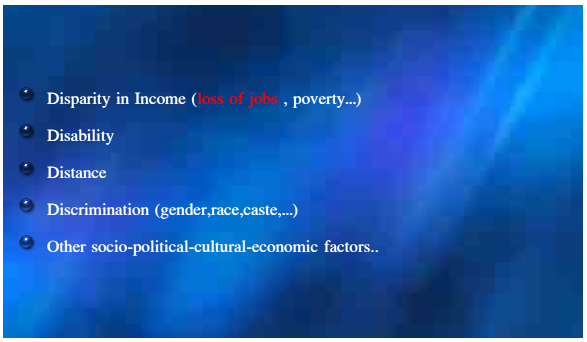
Foundation Day Lecture 10: Dynamics of Technology led Exclusion and Inclusion

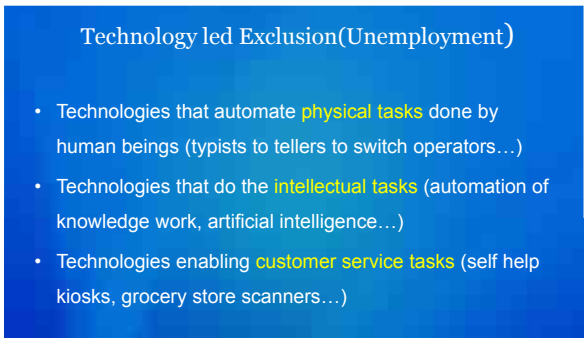
(Dr RA Mashelkar; 6 June 2016)

The tenth TAAS Foundation Day Lecture was delivered on 6 June 2016 by Dr Raghunath A Mashelkar, Former Secretary, Department of Scientific and Industrial Research and DG, CSIR. Dr Mashelkar has described that the notions of inclusion and exclusion have a long tradition in sociology, but have gained significant currency more recently in public policy analysis. However, a certain conceptual inflexibility arises when the distinction is applied to complex social situations. He examines the main approaches to inclusion/exclusion in the sociological tradition, systems theory and the theory of new inequalities. Several situations of inclusion and exclusion viz., self-inclusion/ self-exclusion, inclusion by risk/ exclusion by danger, compensatory inclusion, inclusion in exclusion and sub-inclusion. Actually the technology has changed the way of life. The whole lecture has been given in the form of slide share made by him giving relevant examples.



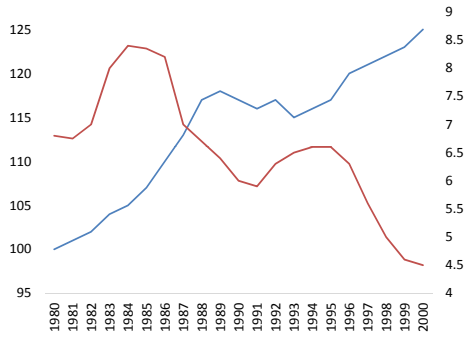






Technology led Employment

- Technology led productivity gain led economic growth
- Access to products and services at lower costs leading to more consumer saving as well as spending
- More employment in consumer goods markets



AlphaGo bot bullies human world Go champion, takes the series 3-0

AFP, Seoul | Updated: Mar 12, 2016 15:14 IST

AlphaGo takes a third consecutive win over Lee Se-Dol -- one of the ancient game's greatest modern players. Deemed as a major breakthrough for artificial intelligence. (YouTube)

Technology Growth Leads to Tech Job Growth

- More people needed to create new technology
- More People needed to maintain new emerging technology (3D Printing, Advanced Robotics, IOT…)
- More people required to assist other people in using new technology
- New technology requires new labour forms, to design, test, implement, refine new technology such as smart automated information systems

Emerging Trends on Replacing Human

- Jobs that require emotional and relational work, creativity, synthesizing, problem solving,& intelligent interpretation will still continue to require human intervention, but that itself is reducing. Why?
- Exponential growth of computing power leading to superlative increase in artificial intelligence
- Google translate displacing translators, investment advice algorithms displacing investment advisors…

Jobs that require head and heart- writing, music, acting, movie making?

- New technology of morphing. Allows movie producers to isolate, digitize and store every visual expression, movement and sound of an actor. Then reprogram them in virtually any recombination.
- In future replacement of sound stages, sets & even actors by 'synthespians', which are 'created from libraries of gestures and expressions housed in a computer bank of live actors' appear to be on cards!

The Risk of Jobs being Replaced by Automation

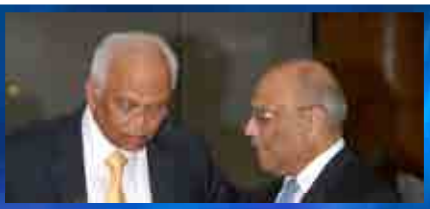
Ethiopia	85%
China	77%
Thailand	72%
India	69%
S.Africa	67%
OECD	57%
USA	47%

Source: Technology at work v2.0, Martin school, 2016

Can some of these Challenges be overcome by Technology led Inclusion?

New Dictionary of Innovation Emerging!

- More from less for more (MLM)
- Gandhian innovation
- Affordable excellence
- Frugal innovation
- Reverse innovation
- Inclusive innovation



Innovation's Holy Grail – MLM

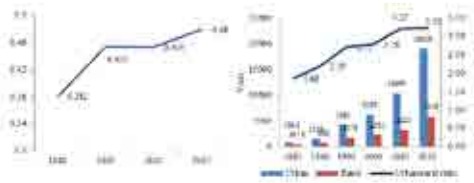
C.K. Prahalad
R.A. Mashelkar

Harvard Business Review– July, August 2010

Drivers for Exclusion

- Disparity in Income (loss of jobs , poverty...)
- Disability
- Distance
- Discrimination (gender,race,caste,...)
- Other socio-political-economic factors..

Income Disparity in China



Gini index of income inequality in China

Rural-urban disparities in annual per capita disposable income

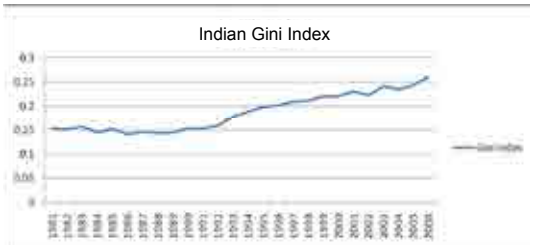
World Economic Forum

Committed to improving the state of the world; More from Less for More

Indian Challenge:

Both Incomes & Income Inequality Rising!

Indian Gini Index



Vietnam
MLM Led Inclusive Innovation
A True Win Win

Deputy PM Nhan

Vietnam Inclusive Innovation Project (GRA as a Knowledge Partner)

- World Bank funded (USD 55 million)
- Developing inclusive technologies
- Scaling up, and commercialization
- Capacity building

Asian Development Bank – MLM Address - Eminent Speaker's Forum

- Invited as Eminent Speaker by Asian Development Bank in its Eminent Speaker's Forum in Manila on 5th December 2014
- Presented 'Inclusive Innovation: More from Less for More'
- ADB now setting up MLM Innovation agenda.

- **Cambridge** (21 June, 2010) – Judge Business School Inaugural BP Lecture
- **Belgrade** (18 December 2012) – Public Lecture
- **Brussels** (3 April 2013) – I4G Group (EC)
- **Clermont-Ferrand** (5 April 2013) – Michelin Corporate Innovation Board
- **Brussels** (11 March 2014) – EU Innovation Forum 2014
- **Paris** (19 March 2014) – OECD
- **Paris** (3 July 2014) – OECD

'If inclusive innovation delivers access equality despite income inequality, then EU needs it here and now, just look at the income inequality among the 28 member states of EU, and then the need to create access equality across EU!'

Comment by participant during Q&A after RAM lecture

The Big Question

Why should EU or OECD be interested in Inclusive Innovation?

EU's MLM Opportunity

RAM Letter to Commissioner Maire Goeghegan-Quinn

(2 June 2014)

'This can be done by moving the emphasis from `quality and sustainability' to `quality, sustainability and affordability', considering the economic diversity of the 28 member states of EU'.

Tender Document by EC (26 June 2015) says ` *in addition to the requirements of `quality and sustainability' ask also for quality, sustainability and affordability', considering the economic diversity and situation in the 28 EU Member States and beyond'.*

MLM Innovation - OECD Drivers

1. ***Increasing income disparity***
2. *Constrained investment capital resulting from the crisis*
3. *Potential for companies to benefit from increasing the size of the pie (emerging 1b market)*
4. *New opportunities in bottom up innovation – co-creation*
5. *New sources of job creation*
6. *Drive towards circular & sharing economy*
7. *Source of new value creation through new business models and value chains it spans*

MLM is not about ...

Stripping products and services to make them cheap, somehow

Inclusive Innovation is about .....

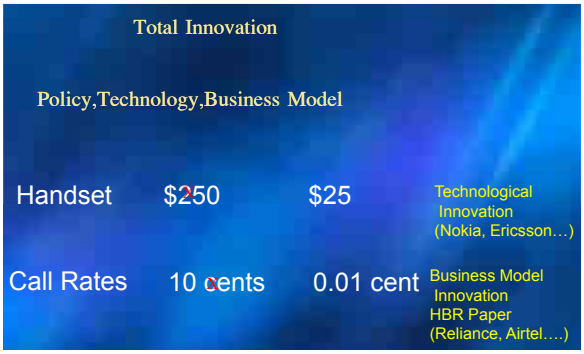
Giving high quality at affordable prices!

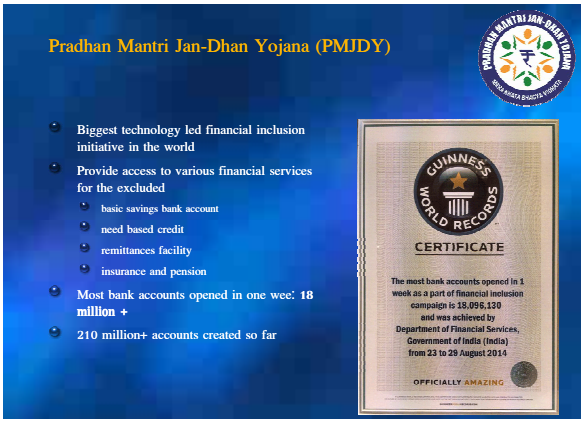
Technology Led Inclusion

The Big Question! Can we achieve Access Equality despite Income Inequality?

Income Inequality 1000 : 1 ?

Access Equality 1:1!





Drivers for Exclusion

- Disparity in Income (loss of jobs, property..)
- Disability
- Distance
- Discrimination
- Other socio-political-cultural-economic factors...

Three essential of Technology led Inclusion...

Availability, Accessibility, and Affordability

But 'total inclusion' will require 'extreme' affordability

Extreme Affordability Dreams!

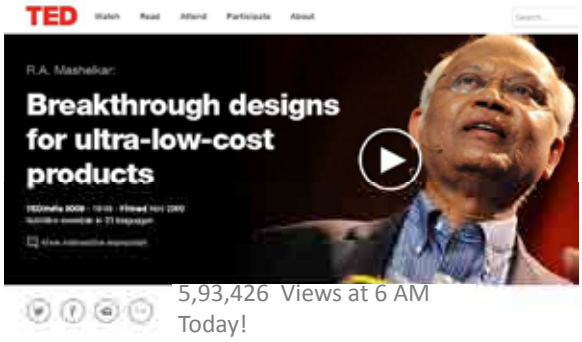
- High Quality Hepatitis B vaccine – 40X cheaper...
- High Quality Cataract Eye Surgery – 100X cheaper...
- High Quality Open Heart Surgery - 20X cheaper...
- High Quality Artificial Foot – 300X cheaper...

No dreams, - India has done it!

MLM is not about.....

Stripping products & services to make them cheap, somehow

It is about... Giving high quality at affordable prices



Affordable Excellence
No Dream – A Reality!

Case - Hemoglobin Detection

Affordable

25 fold Reduction in Price!

High cost (~ $ 25 per test) to ultra low cost ($ 0.5 per test)

Excellence

From 'invasive' with needles to 'non-invasive' with no needles

Breakthrough High-tech Innovation needed

MLM through Cutting Edge Technology

High Technology :

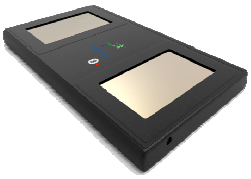
Photoplethysmography +
Spectrophotometry +
Sophisticated photon scattering software

SANKET

An IOT Based Revolution in personal Cardiac care

Personal 6 Lead ECG event monitor

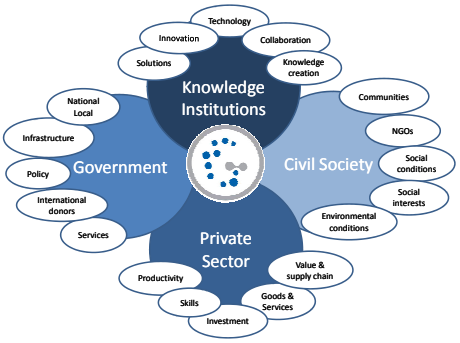
Anjani Mashelkar
Inclusive Innovation
Award Winner (2015)



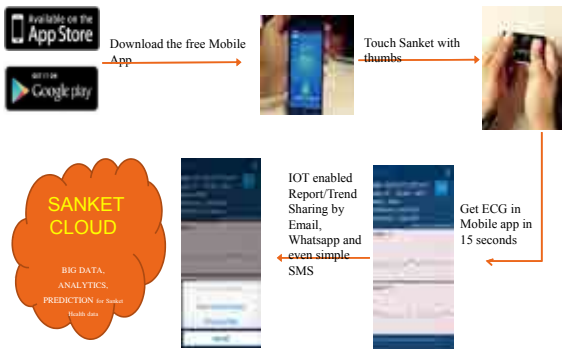
Listen to your heart...

#thumbsupforsanket

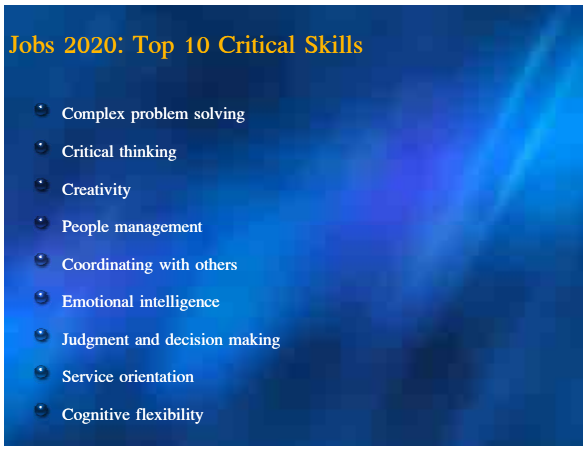
True Inclusion Needs Robust Inclusive Innovation Ecosystem



How simple is it ?



Dynamics of Technology led Exclusion and Inclusion



A FINAL THOUGHT

The proportion of the population that needs to engage in traditional full time employment, in order to keep the humanity fed, supplied, healthy and safe, will decrease. This will hopefully lead to a **human restructuring** of the general social contract around the number and type of jobs and employment in the world, and again, **hopefully a better world.**

Foundation Day Lecture 11 : Can India Achieve SDG 2 – Eliminate Hunger and Malnutrition by 2030

(Dr Prabhu Pingali; 24 January, 2019)

The eleventh Foundation Day Lecture on "Can India Achieve SDG 2 – Eliminate Hunger and Malnutrition by 2030" was delivered by Dr Prabhu Pingali on 24 January, 2019. Dr Pingali is a Professor in the Charles H. Dyson School of Applied Economics and Management at Cornell University, Ithaca, NY (USA).In 2015, member states of the United Nations approved the 2030 Agenda for Sustainable Development that were to be achieved through 17 Sustainable Development Goals (SDGs). These goals aim "to build on the work of the Millennium Development Goals (MDGs) and complete what they did not achieve" . The 17 goals of the SDG have 169 targets, which has been designed to take a holistic approach to address the social, economic and environmental aspects of sustainable development. Goal 2 of the SDGs aims to end hunger, end all forms of malnutrition, double agricultural productivity and incomes of small-scale farmers and ensure an environmentally sustainable food production system and main genetic diversity of seeds and cultivated plants. It is explicit in its aim of tackling malnutrition, which was absent in the framing of the MDGs. It also gives an added emphasis on sustainable food systems focusing on environmental issues and genetic diversity.

Dr. Prabhu Pingali delivering 11th TAAS Foundation Day Lecture

Although there have been great strides towards hunger reduction in the past 25 years due to production increases of the green revolution, malnutrition remains, micro nutrient deficiencies are stubbornly high and inter and intra-regional inequalities in reducing hunger and poverty persist. Therefore, the challenges in the way of achieving the SDGs remain high. What is acknowledged in the SDG approach is that promoting growth and development in the agricultural sector is crucial to improving food security and nutritional status in developing countries. Agricultural policy with

a smallholder focus to promote agricultural growth becomes central to achieving the SDG hunger goals.

The SDG 2 also explicitly recognizes that addressing hunger and malnutrition require more than achieving calorie sufficiency and thereby places an emphasis not just on the quantity of food consumed but also its quality and diversity. Hence a food systems approach that promotes the supply and affordability of a nutritious diet is central to successfully meeting SDG 2. Also, important are the multi-sectoral factors that influence progress in achieving SDG 2, these are access to clean drinking water and sanitation, women's empowerment and behavior change and overall investments in public health.

Where does India stand with respect to hunger and malnutrition?

Despite significant economic growth, India has not made comparable progress on reducing hunger. By 2011, India had been able to achieve the MDGs poverty reduction target, but it had fallen far short of the hunger reduction target. While the prevalence of undernourishment has decreased nationally, it is still around 15 per cent, which is amongst the highest in the global south. Even more startling, the absolute number of people undernourished in India has remained almost the same between 1990 and 2015. The prevalence of undernourishment is measured as percentage of population that has access to sufficient amount of food, measured in calories per capita, per day (ibid). By definition, this measure of hunger gives a high weight to calorie dense food, such as staple grains. In order to meet the SDG target 2.1 by 2030, India would need to reduce the number of hungry people by at least 200 million.

Doubling agricultural productivity and incomes of small scale producers?

SDG target 2.3 calls for doubling productivity and income of smallscale producers by 2030. In the case of crop agriculture, productivity growth could come from increasing yields, intensification of cultivation – growing two or three crops per year on the same piece of land, or increasing the efficiency of input use, thereby raising total factor productivity. Presumably all of the above strategies would lead to commiserate increase in farm incomes. In addition, explicitly income growth-oriented strategies would include the promotion of production system diversification, for crops and livestock, and enhancing rural non-farm employment opportunities.

Dignitaries sitting on Dais during 11th Foundation Day

Why the focus on smallholders?

A majority of the world's agricultural production takes place on small and marginal farms and presently, there are over 500 million small farms (less than 2 ha in size) cultivated by two billion of the world's poor. In India, 85 per cent of all farm holdings are under 2 hectares, according to the latest round of the latest agricultural census. Despite recurring predictions that small farms will soon disappear, they have persisted and in the case of India, have increased in number. Small farms face numerous challenges in production, especially in terms of access to essential factors of production such as credit, inputs (seeds, fertilizers, pesticides), information and production technologies in addition to poor access to output markets. Addressing these challenges is crucial for agricultural development, and for successfully achieving SDG 2.

What are the opportunities for doubling crop productivity?

The green revolution is a testimony of how a combination of high rate of investment in crop research, policy support, market development and infrastructure has led to extraordinary growth in food crop productivity. There has been an overall increase in yields for all major crops in India over the last half-century. However, the magnitude of these increases has varied by crop and region. Overall, cereals have experienced by far the most dramatic increase in yields. From 1950 to 2014, average yield of rice, wheat, and maize yields increased by 258, 315, and 381 per cent, respectively. Coarse cereals and pulses witnessed only a marginal improvement in yields during the same time period. So the gains have come for calorie dense staples relative to protein and micro-nutrient rich pulses and coarse grains.

Prospects for intensification of production systems

Intensification of cropping system is another avenue for increasing crop productivity and incomes. The high productivity states such as Punjab, Haryana and the Southern Delta regions have witnessed high levels of intensification following the Green Revolution. These areas have had two or three crops per year on the same piece of land for decades. While much of Central and Eastern India is characterized by low intensity (one rainfed crop per year) production systems. Irrigation investments have been the primary driver of intensification and the focus has been on promoting an additional crop of the primary staple, so we have seen the spread of rice-rice systems in the South and Rice-Wheat systems in the Indo-Gangetic

plains. So what are the prospects for sustaining the current level of intensification in the high productive areas and increasing intensification in the lagging regions?

Increasing efficiency of input use and TFP

Increasing input use efficiency enhances agricultural productivity by increasing the ratio of the value of output to total value of inputs used and thereby enhancing profitability and incomes but also enhancing the sustainability of the production system. The pathways to increasing production efficiency can be through crop improvement, as well as, through improved crop and input management practices. Yield improvements coupled with the effective management of resources (nutrient, water, natural resources) is essential to improve efficiency and achieve sustainable intensification.

Climate change adaptation and mitigation

Impact of rising temperatures on the major staples, such as rice and wheat is well studied. Declining productivity of these crops can be expected with rising temperatures. However, less well understood is the impact of climate change on crops that are important to the poor, such as millets and sorghum. Also, less studied is the impact of climate change on a more nutritious food system, such as its impacts on the productivity of fruit, vegetables, pulses and livestock products. Given the lack of technologies currently available to safeguard productivity and the lack of information about climate impacts on these foods, vulnerability of non-staple crop production becomes a major food security concern for the future. Safe guarding the production of these crops & livestock will be important to the goal of achieving nutrition security. Climate change can also have adverse impacts on production systems in the rainfed areas, particularly those in the semi-arid and the arid fringe areas. Higher temperatures could drive some of these areas out of crop and livestock production activities, especially where irrigation infrastructure is not well established.

Managing crop biodiversity

Agricultural intensification and the adoption of modern varieties of the major staple crops led to the ubiquitous monoculture systems in the favorable production environments across the developing world. The lower productive rainfed environments, on the other hand, continue to maintain diversity of crops grown, such as traditional millets and root crops. These environments have also sustained the cultivation of landraces of rice, wheat and maize. Narrowing of crop genetic diversity in the Green Revolution (GR) areas has been averted to some extent by the replacement of the first generation modern varieties with second and third generation varieties in more recent decades. The expansion in the numbers of varieties available through crop breeding programs has reduced the risk that intensive production systems would concentrate on a few dominant varieties. Modern plant breeding has also helped expand the genetic base of modern varieties by incorporating genes from landraces and wild relatives of staple grains into the breeding populations.

Conclusions – so what are the prospects for SDG 2?

The SDG commitments provide a great rallying opportunity for addressing the chronic developmental problems faced by India as it moves towards becoming an emerging economy. Eliminating chronic hunger and malnutrition is a particularly high priority given that the we have not seen significant progress in this area despite sustained economic growth and income improvement. SDG 2 also brings smallholder productivity and income growth to the center of the strategy to eliminate hunger, thereby directly contributing to rural poverty reduction goals. Achieving progress on SDG 2 requires us to channel public, private and civil society resources and expertise. It also requires multi-sectoral coordination across the various ministries, such as: agriculture, food, women and child development, health, water and sanitation, rural development, etc. Achieving progress on SDG 2 would also require us to identify synergies and trade-offs across all other SDGs. To achieve geographical spread across the sub-continent, the commitment to the SDGs would need to be made at all levels, from the center and the states to the local panchayats. Finally, the political economy factors that have impeded progress in hunger and malnutrition in the past need to be identified and redressed. So, what are the prospects for achieving the various targets of SDG 2?

Ending hunger: It is certainly possible that India will be able to achieve the end of hunger as defined in terms of caloric adequacy. However, it is not at all certain that we will be able to make adequate progress on "hidden hunger" micro-nutrient deficiency. This is because we don't have systems in place yet to enhance supplies and to promote wide spread access and affordability to food diversity, especially for fresh fruits, vegetables and livestock products.

Ending all forms of malnutrition: We should expect to see significant reductions in child stunting and wasting given the current political commitment to addressing the problem, however, complete elimination will require significantly more inter-ministerial collaboration than there is today. At the same time the emerging problem of obesity is expected to rise towards 2030 since this problem has not yet been recognized at the political level as an important public health crisis that needs immediate attention.

Doubling small farm productivity and incomes: Low productivity agricultural regions, especially those in Eastern India, will continue to lag behind in productivity and income terms unless concerted efforts are made to diversify their production systems and connect smallholders to urban food value chains. The more productive zones would also need to diversify away from their predominant focus on the primary staples – rice and wheat, and move towards greater levels of commercialization. Enhancing input use efficiency in the high productive zones, especially for water, fertilizer and fuel, would also lead to significant income gains.

Adapting to climate change: The major staple crops will be able to adapt to climate change because of the research and varietal development that is currently underway to buffer these crops from the effects of rising temperatures and improve their resilience to unanticipated extreme weather events. The non-staples, especially pulses and coarse cereals have not had similar efforts and will not be able to adapt to climate change as effectively as the major staples. Also, agricultural production in the arid zones and the arid fringe areas in the semi-arid tropics may not be able to adapt to higher temperatures and we could see agriculture moving out of these areas.

Sustainable production systems: We have the technology and management practices that can substantially enhance the sustainability of the agricultural systems in India and improve resource use efficiency. However, the current policy environment does not provide the incentives for farmers to change their behaviors and practices in order to make their farming practices more sustainable. That's the political economy challenge that has been difficult to overcome in the past and the prospects are poor that it will change in the next decade.

7B. Special Lectures

Special Lecture 1 : Challenges in Developing Nutritionally Enhanced Stress Tolerant Germplasm

(Dr. S.K. Vasal; 3 May, 2004)

This special Lecture was delivered by Dr. S.K. Vasal, Distinguished Scientist, International Center for Improvement of Maize and Wheat (CIMMYT) and the recipient of World Food Prize on 3 May, 2004. The highlights of the lecture are as follows:

Plant breeding research has resulted in a succession of landmark achievements during the twentieth century. We have witnessed a series of agricultural revolutions beginning with hybrid corn revolution in the US and later in Europe, China and now expanding into several developing countries of Latin America and Asia. The list of crops deploying hybrid technology continues to expand covering even vegetables, horticultural and even self-pollinated crops like rice not amenable to hybrid research. Hybrid corn revolution was followed by green revolution in wheat and rice some thirty years ago. A demand driven livestock revolution is also underway in Asia contemplating demand for meat and animal products to double by 2020. We are currently in the midst of an exciting and perhaps most dramatic revolution of our times. There have been considerable increase in the area planted to transgenic crops. The countries in the forefront are USA, Canada, Argentina, Brazil and China and the principal transgenic crops are soybean, cotton, maize and canola. The adoption rates vary in different crops but are significantly higher in soybean compared to other crops. Two noteworthy traits in transgenic crops are herbicide tolerance and Bt insect resistance.

During the seven-year period (1996-2002), the global area of transgenic crops increased from 1.7 million hectares to 58.7 million hectares in 2002. Accompanying gene revolution is also scientifically revealing and informative. Human genome is already mapped and some crop species like rice, maize and others will also soon be mapped. Hope with all this knowledge being generated at an accelerated pace, we may realize the dream of Dr. Norman Borlaug to be able to transfer useful genes from one crop species to another for genetic resistance to biotic and abiotic stresses and enhanced nutritional quality traits. Very often, he cited the examples of transferring rust resistance from rice to wheat and some specified proteins as gliadin and glutelin from wheat to other species as maize and others. Recently, Egyptian scientists have successfully transferred drought tolerance from barley to wheat. Examples of this kind will certainly help plant scientists to tackle complex and difficult problems in an effective, efficient, and cost effective manner with a greatly reduced time span.

Special Lecture 2 : Global Perspective of Wheat Improvement

(Dr. Sanjay Rajaram; 18 December, 2010)

A special lecture on "Global Perspective of Wheat Improvement" was delivered on 18 December, 2010 at NASC Complex, DPS Marg, New Delhi by Dr. Sanjay Rajaram, former Director, Wheat Program, CIMMYT. He is one of the most distinguished wheat breeders known for his valuable contributions globally. His wheat varieties are grown on an estimated 58 mha worldwide. For his contributions, he has been honored with a World Food Prize and a number of national and international awards.

Dr. Sanjay Rajaram, former Director, Wheat Program at CIMMYT, Mexico and the recipient of 5th Dr. M.S. Swaminathan Award for the year 2010 gave a global perspective of wheat program. He spoke about meeting the increasing demand of wheat due to increase in population and indicated that there will not be easy solutions as this demand has to be met from the available

Dr Sanjay Rajaram delivering special lecture during award function

area and lower genetic gains due to technological fatigue. Though solutions are not easy but he firmly believed that the target of 100 mt can be achieved. Speaking on the global scenario, he highlighted the fact that worldwide the area under wheat is 217 mha producing 621 mt with productivity of 2.9 t/ha, which is very low. The developing countries have a little more than half of the acreage with a little less productivity and production of 308 mt.

Wheat is very important is the daily consumption for countries like India and China as it provides 500 calories per capita per day which is nearly a quarter of the daily requirement. This component alone will have large implication in wheat market chain at global level where, on an average, 100 mt is traded annually in the international market. Fast adoption of improved varieties has occurred in India as compared to Latin America and China, while substantially lower in Middle East and Africa. He mentioned that during the first three decades starting from 1965, wheat production in India increased by 3 per cent per year while from 1995 to 2005, the productivity growth remained sluggish at 1 per cent per year.

Hence, to meet the target, a substantial rise in the productivity growth rate in the range of 1.6-1.8 per cent per year is required. Declining international price of wheat will also have an implication on how the targets will be met. It is expected that by 2020, the requirement for wheat will be somewhere between 750-800 mt against the current production of 620 mt. This will be mainly due to the additional demand of wheat for animal consumption and biofuel. It is expected that nearly 50 per cent of this requirement will be met from Asia alone.

The change in wheat area, adoption of modern varieties having high yield potential, pricing, government policies and international collaboration with CIMMYT facilitated the green revolution. He also outlined the drivers of future revolution Such as molecular marker assisted development of transgenics, development of climate resilient varieties, selection of varieties resistant to *Fusarium*, yellow rust, Hessian Fly and abiotic stress. He concluded by stating that both crop improvement and efficient natural resource management strategies have to be integrated.

Special Lecture 3 : Challenges and Opportunities for Food Legume Research and Development

(Dr. M.C. Saxena; 25 January, 2012)

A special lecture on "Challenges and Opportunities for Food Legume Research and Development"was delivered on 25 January, 2012 at BP Pal Auditorium, ICAR-IARI, Pusa Campus, New Delhi by Dr. M.C. Saxena, former Assistant Director General (ADG), ICARDA, Syria. He is an eminent agronomist and crop physiologist, whose work at the International Center for Agricultural Research in the Dry Areas (ICARDA) on food legumes has enormously benefitted the resource poor farmers in West Asia, North Africa, Central Asia (CWANA).

Dr. MC Saxena giving Special Lecture

Food legumes, such as chickpea, cowpea, dry beans, dry peas, faba bean, lentil, mungbean, pigeonpea, urdbean and other pulse crops are a good source of dietary protein, to complement the cereal-based diet, particularly for vegetarians, in the developing world. However, the global production of food legumes has not kept pace with increase in the global population. Therefore, there is general trend of decline in global per capita availability and consumption of pulses. This should obviously have nutritional consequences for the societies that primarily depend on pulses for enriching their daily food. In India, the production declined from 13.77 kg/yr in 1990 to 11.40 kg/yr in 2006; Fortunately, there is some resurgence in the last five years and the availability has improved to 12.44 kg in India and 9.1 kg/ha in the world as a whole. The major factor responsible for poor growth in production of the food legumes is their low productivity.

Recent developments offer unprecedented opportunities to legume researchers for meeting the challenge of enhancing the economic competitiveness of the pulse crops through genetic improvement, and development of appropriate management practices that reduce their cost of production and permit full realization of their genetic yield potential. A recent study indicated that the overall consumption of pulses would increase by 10 per cent by 2020 and 23 per cent by 2030. The increased demand for consumption would necessitate yield increase of 70 kg/ha by 2020 and by 120 kg/ha by 2030. Application of science and technology, along with effective technology transfer and policy and institutional support to farmers, should make this target reachable.

Special Lecture 4 : Enhancing Smallholder Farmer Participation in Markets: The IMOD Way

(Dr. William D Dar; 24 June, 2013)

A special lecture on "Enhancing Smallholder Farmer Participation in Markets: The IMOD Way" was delivered on 24 June, 2013 at ICAR-IARI, Pusa Campus, New Delhi by Dr. William D Dar, Director

General, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) who has made outstanding contributions towards food security and agricultural sustainability in Asia and Sub-Saharan Africa. His work has created great impact on the lives of resource poor farmers. Dr. Dar mentioned that in the early 1970s mass famines were considered to be inevitable in the developing world. Food production was falling well below the needs of the ever increasing populations. Therefore, increasing food production was CGIAR's top priority. With the Green Revolution in rice and wheat, production of food was so rapid that the conditions of famine were averted. But, the Green Revolution varieties were not suited for cultivation in dry areas as they were irrigation and fertilizer intensive. Therefore, the condition of farmers in these areas remained bad. To add to the woes further, in 1990s the policies of economic liberalization brought major economic upheaval to the developing world. Agriculture slipped to lower priority as marketing was deregulated. Poor farmers were left on their own. They suffered from hunger not only because they were not growing enough food but because they were unable to buy the food. In order to become food secure, they needed both increased food production and increased incomes.

Dr. William D Dar, DG, ICRISAT delivering the Special Lecture

In 2008, the World Bank produced a comprehensive report based on analysis of new trends in agriculture "Agriculture for Development" which stressed that production is mainly by small farmers. The state regulates the competition and supports greater inclusion of smallholder farmers. In this vision, agriculture assumes a prominent role in the development agenda. Implementing this vision, objective number one became "Improve access to markets and establish efficient value chains". In order to escape hunger and poverty in dryland area small holders needed to have better access to markets. ICRISAT decided to make it the centre piece of their strategy i.e. the Inclusive Market Oriented Development (IMOD) Way.

Dr. Dar further elaborated how incomes of these poor farmers increased by adopting innovative farm practices, developed by ICRISAT like, micro-fertilization, crop diversification and watershed management, etc. combined with risk management by government and non-govt. organizations and easy market accessibility.

8 Success Stories

Preamble

The TAAS has started a new feature to convey research results of successful entrepreneurs in the form of success stories/case studies which create visibility, credibility and clarity around the value and application of change management. It has fascinated humans since the beginning of time. We connect with stories, so it is important to know how to effectively share stories about your nonprofit. When you tell stories about your nonprofit, you show others a piece of your heart. A success story is a valuable learning tool to the rest of the team. It may also give insights into how customers used the given solution and how it impacts their business. Success stories are also the ones which encourage other people to keep walking their own chosen paths. TAAS has so far developed two (2) success stories and several are in pipeline which will be available shortly.

Success Story 1 :

Biofertilizers & Biopesticides

Biofertilizers & Biopesticides for Enhancing Agricultural Production

(Dr Basavaraj Girennavar; June, 2020)

Dr. Basavaraj Girennavar, Chairman, Criyagen Agri. and Biotech Pvt. Ltd. Bengaluru, strongly believes that patronizing farmers by giving subsidies alone will not solve the problems of the farming community in the long run. Farmers have to be empowered as entrepreneurs through right information, right market, right pricing and insurance. There are some winds of change, but they are happening at a slow pace. They have to gather into a breeze and a friendly storm through a systemic process taking into consideration the needs of all stakeholders - farmers, traders, consumers, governments and the whole spectrum of society as a strong agricultural system will be a true backbone of the society, especially in a country like India where more than 50 per cent of the population thrives on the agrarian economy. Criyagen as a responsible organization in the industry is evolving a process through integrated nutrient management and integrated pest management for crops in the first few years and then moving on to organic and eventually settling down to natural production systems. Farmers at the microeconomic level can't reduce their productivity or profitability and at the macroeconomic level the balance of the nation's food security needs to be maintained so that changes don't drastically affect the national food production goals.

Launching of Dynamic Nutrient Provider at UAS, Dharwad

World over the leaders such as George Washington and Mahatma Gandhi had hailed farming as the cornerstone of any civilization, but unfortunately today in India there is a huge imbalance in the farming community. There have been instances of farmers earning lakhs of rupees and at the same time there have also been examples of farmers losing lakhs of rupees. It is in this context that wedding agriculture with technology will result in the farming community donning roles of successful entrepreneurs. Unfortunately, today we do not have a concept or process for auditing in agriculture such resources, assets, liabilities and opportunities. Farmers have not adopted or adapted to changes over a period of time and have just followed traditional practices without batting an eyelid on whether such systems would benefit them or not. There needs to be an element of market integration, an element of rationality and awareness on what price points are profit points. If such a system is evolved then farmers can integrate seamlessly with the market to ensure sustainability and profitability. With agriculture being the primary source of income for more than 50 per cent of the population, we need to work hard with conviction and creativity to ensure farmers become the strong backbones of our agrarian society.

Failure is the stepping to success and Criyagen typically exemplifies how initial failures have been strong lessons learnt to build a strong foundation for future success. Lessons have been learnt both at the individual levels and Criyagen as an organization, especially when it came to convincing farmers to gradually switch over to organic products instead of chemical fertilizers, which initially provided good returns in terms of yields and disease management. However, problems faced initially helped evolve an approach and attitude for solving bigger problems with various possible value-added outcomes. Being a start-up with quality products as well as a good team with support from various State Agricultural Universities (SAUs), Criyagen began to educate farmers and the farming community about the importance of organic fertilizers and biocontrol agents on their role in retaining soil fertility and long-term benefits in retaining available natural resources.

An innovative entrepreneur sees big problems as big opportunities, especially in a strongly agricultural backed country like India that is beset with agrarian crisis. Converting problems into opportunities by resolving issues, ensuring sustainability and making it an engine of growth as well as making it a source of wealth generating employment opportunities will make agriculture a thriving business in the country. Globally, today, India is best suited to chart a strong and sustainable agricultural growth as its population depends on farming activities as their primary source of income. In developed countries, only 2-5 per cent of the entire population is involved in agricultural practices. Despite India having the biggest share of land holding for agriculture in the form of acreage, the productivity is very low. In USA, one farmer produces food for about 150 people, whereas in India one farmer produces food for only two people. Along with such low productivity, the safety standards in the use of pesticides or fertilizers are also very low in India. Bridging the enormous productivity gap by scientifically joining the dots of inadequacies to segment the food basket into safe, healthy, for domestic, organic or naturally-farmed healthy as well as nutritious food will go a long way in making India and the Indian agricultural sector top notch providers of nutritious food for the rest of the world.

Prof. MS Swaminathan at Criyogen facility at UAS Dharwad

Food is the only means of building a healthy next generation, which no technology can provide. So focusing on healthy food, healthy body, healthy mind, healthy life style and a healthy country eventually will ensure that agriculture gains a new momentum. In the 1950s, India was a calorie deficit country but in 2000 the country fulfilled the calorie requirement based on 2 major crops rice and wheat, which resulted in obesity and other lifestyle related diseases sometimes life threatening too. In view of this, there is need to shift the focus from restricting agriculture to just producing food to connecting it to employment, national health, people's health, economics and eventually the overall well-being of the people. The mission now should be to produce healthy food for the whole world utilizing the human resource capacity in agriculture and connecting it to the massive agricultural land holding as well as diversity in crops and diversity in outputs. Such an opportunity can have a positive impact on society to drastically cut down farmer suicides, recurring drought and poor productivity (sometimes as low as one-third of global standards) and soil erosion.The credit for the overwhelming success of any organization can be attributed to the strong efforts of all stakeholders including owners and promoters, dedicated staff, retailers/ traders and the end users. Criyagen was able to establish a strong market presence at the very outset of the launch of its products due to its innovative nature of tying technical capabilities with market needs resulting in the launch of a unique bouquet of products. It has inbuilt capability to build a potential market by developing promising products based on market needs. The satisfaction of end-users is ensured by the team working closely with the farmers to understand their general needs and specific requirements. The constant end-user interaction helps the organization to chalk out measures for improvising products on a regular basis to enhance relevance and efficiency based on the crop and conditions. Additionally, implementation of technology in routine tasks has helped in managing time, resources and funds through information and communication technology (ICT) and m-commerce platforms.

Farmer-friendly initiatives of developing products to ensure sustainability with productivity and profitability through well-developed R&D efforts, highly motivated team members as well as strong support from friends and family have resulted in scripting the success story of Criyagen. The organization is open to business and financial advice from experts and well wishers, which has also contributed towards the steady success. Timely help from financial institutions for funding and support have given a fillip to the establishment of infrastructure and state-of-the-art laboratories. Criyagen provides direct employment to 125 personnel, including marketing staff in Karnataka and other states of India such as Maharashtra, Andhra Pradesh, Haryana and Tamil Nadu. It also provides employment to 100 farm laborers through a contract system.

Dr Basavaraj explaining about Criyogen to Dr T. Mohapatra, DG, ICAR and Dr SA Patil, Former Director, ICAR-IARI

In order to keep the team connected with the vision, mission and goal of sustainable agriculture with focus on productivity and profitability, meetings are regularly held at macro and micro levels on a monthly, quarterly and annual basis. Of late, an advisor has also been engaged to help the team and get the staff motivated and work tirelessly towards achieving a common goal. The annual meetings are held outside in a resort with good ambience wherein staff members get an opportunity to open-up their thoughts to prioritize what should be the agenda for all as an organization, as a team and as individuals. After that the team gets motivated and charged-up and returns with zest to fulfill the vision and mission of the organization. It would be an ongoing and evolving, more robust and intense exercise so that all staff members would be on the same page as far as the organization as well as the vision and mission are concerned.

Criyagen now envisions evolving and focusing on three segments of crop nutrition, animal nutrition and human nutrition. The concept is to connect the nutritional aspects of all the three components to evolve a holistic approach that can sustain long-term growth for the benefit of the human beings. A farmer has to grow food and feed crops to foray into crop nutrition with rejuvenating soil fertility through micro-organisms. Farmers also venture into dairy activities and hence have to focus on cultivating or outsourcing crops required as animal feed. The farmer, his family and farming community members need nutritious food, which again the farmer has to grow. To evolve this holistic approach, the farmer need to work as an entrepreneur with focused commitment to ensure sustained and profitable crop production. Thus, a farmer can connect with the big problem, convert it into big opportunities to grow organic and naturally grown and nutritious crop varieties. This concept may take a long time of 5-10 years to evolve, but the organization wants to chart the course with a view to benefitting the farming community. As suggested by Dr. Trilochan Mohapatra, Secretary, DARE & Detector General, ICAR during his visit to Criyagen, there are good prospects of signing the MoU with ICAR because they have huge infrastructure and a massive budget outlay. The matter is currently under discussion with ICAR. The aim is to reach out to more farmers and farming community members through the 720 *Krishi Vigyan Kendras* (KVKs) of the ICAR, utilize the benefits of its research centers and getting closer to multilocations with agrarian situations or opportunities.

Dr. S.A. Patil, former Vice-Chancellor, University of Agricultural Sciences (UAS), Dharwad, former Director, Indian Agricultural Research Institute (IARI)) and former Chairman, Krishi Mission, Karnataka State Agriculture Department, is one of the key person, mentor, advisor and a regular visitor to Criyagen facilities. He has advised the Criyagen team to keep the farmer at the centre stage for evolving any products or solutions. Dr. Ashok Dalwai, Additional Secretary, Government of India on his visit to the Criyagen campus suggested that the soil testing services be scaled-up on the pattern of the human blood testing model. Ms. Neeraja Shastri, IAS also visited the facility representing the Secretary, Department of Agriculture and Cooperation (DoAC), Government of India. She was highly impressed by the work done at Criyagen and suggested that they should continue the good work and assured all support from the DoAC. Shri N.H. Shivashankar Reddy, Hon. Minister for Agriculture, Karnataka; Shri Jagadish K.G. Commissioner of Agriculture; Director of Agriculture, Government of Karnataka and other experts (Fig. 16); Shri Vijay Bhaskar, Chief Secretary, Government of Karnataka and Shri Basavaraj Patil Sedam, Former Member, Rajya Sabha have visited Criyagen and were highly impressed with the achievements made and encouraged the Criyagen team to continue intensive efforts for the welfare of farmers. The other visitors include Heads of Cooperatives from Maharashtra and around 1,000 dealers/ society retailers and all these visitors were greatly benefited.

Impact of the Work

Criyagen has developed a wide range of solutions to give farmers the needed confidence to grow more low cost and high quality ecofriendly products. The innovative products are the result of constant improvement and the investment in the R&D. The R&D Department at Criyagen seeks new solutions to existing problems keeping farmers' needs and sustainability in mind. The strong research orientation ensures that implementation of tomorrow's solutions is planned today. The avowed vision in establishing Criyagen as an Agri and Biotech Company has been to finding right solutions for making agriculture a sustainable business proposition with a farmer becoming an entrepreneur. Towards this end, the organization has been undertaking awareness programs to share the right information and provide inputs at the right time, which in turn have greatly benefited farmers in achieving better returns for their investment along with safe INM and IPM solutions leading to better outcomes while being ecologically and economically relevant. The organization is fully aware that it still has a long

way to go in terms of reaching each and every farmer with required products, information, knowledge and services at their finger tips with the intervention of technology in agriculture. In this context, AgriApp another start-up of Criyagen team is working closely to bridge the ICT, IoT, Big Data and m-commerce gap. The goal is to help farmers in achieving the best results for their investment by providing quality products at the right time. This will in turn help farmers to achieve ecologically and economically sustainable agricultural products with a fair margin of profitability akin to an entrepreneur running his business venture. The products and services of Criyagen are instrumental in vigorous crop growth and enhanced income and the farmers are indeed very happy about the contribution of the organization towards their wellbeing.

In recognition of his efforts and the efforts of his company, Dr. Basavaraj Girennavar received the *Udyog Ratna* Award for his achievements in the field of agriculture. Criyagen has been working for over 10 years in Karnataka to create awareness among the farming community about scientific agriculture practices and sustainable agriculture. Criyagen has strong technical collaboration with the State Agricultural Universities at Dharwad and Bengaluru to carry out research & development projects. Sincere efforts are being made to evolving a team of dedicated staff who are willing to work in rural environments to create an impact in the lives of farmers. Criyagen apart from its direct employment and hiring farm laborers has also created several jobs in rural areas through which current youth can stay connected with their rural agriculture practices instead of migrating to cities. Improving products is a constant endeavour at Criyagen, which is playing a pivotal role in improving soil fertility and increasing soil productivity.

Success Story 2 :

Fish Story

Fish Farming in North India

(Padma Shri Sultan Singh, December 2020)

Background

The aquaculture plays significant role in providing nutritional security and it is one of the important sectors of food industry. Three Indian major carps, namely, *Catla*, *Rohu* Labeo and *Mrigal* contribute over 90 per cent of the total Indian aquaculture production. In Haryana state, there was not even a single hatchery to produce fish seeds. Shri Sultan Singh of village Butana, district Karnal, Haryana is the first person of the State who started recirculation of aquaculture system which is used in home aquaria and fish production where water exchange is limited and the use of bio-filtration is required to reduce the ammonia toxicity by establishing Sultan Fish Seed Farm at Karnal in 1984. Being born in farmers' family, he got good experience of agricultural activities by observing his family members who were engaged in agriculture work for their livelihood. He had very little interest in farm operations like sowing,

Shri Sultan Singh explaining about fish species to Dr S Ayyappan, Former DG, ICAR

irrigation, weeding or harvesting of major crops such as rice and wheat being grown at his family farm of about 125 acres of cultivable land. Therefore, his parents used to give him the responsibility to take animals for grazing even when he was studying in the college. Since childhood he always wanted to do something innovative and different from what his family members were doing. The major challenge in the fish business faced by Shri Sultan Singh at the initial stage was the lack of availability of fish seeds as there was not even a single fish seed hatchery in northern India. All the seeds were coming from Kolkata and sometimes seed used to come through train or flight causing delay in transit resulting in sixty to seventy per cent seed damage. He learnt fish breeding from *Krishi Vigyan Kendra* (KVK), Karnal in 1983. Shri Sultan Singh was successful in constructing the first Breeding Hatchery in 5 acres of land in Karnal, Haryana in 1986.

Initial Establishment

The initial support he got for this enterprise was from his family as they finally trusted him and shared land for starting a new business on fish cultivation which nobody else was doing in Haryana state at that time. Moreover, with regard to gaining knowledge and resources, it was a very big leap at that time to adoptfish production as a profession. He proved the success of his work to the family and developed some confidence in them resulting in all kinds of support extended by them in his venture. Shri Singh had no knowledge of fishery technologies. Dr. Markandey supported him at all levels as teacher and guardian and trained him in fish breeding and provided consultations required from time to time even after his transfer from KVK, Karnal. The other important aspects of his success in this field are: i) suitability of environment for the fishery sector, ii) the state is not prone to flood, and drought, and iii) most importantly, the people who were once convinced with the efforts made by him provided full support at all levels. This encouraged him and developed greater

confidence in him to do something better and more beneficial for all farmers of the country.

Infrastructure and Further Strengthening

In the beginning, there was not much infrastructure available for fish farming and the work was only limited to village ponds taken on lease. But after gaining wide knowledge on aquaculture, the confidence level increased to move ahead and develop large infrastructure for fish farming. In 1986, the first breeding hatchery was established in North India with one breeding pool and four hatching pools. In addition to these,additional infrastructure consisting of breeding pools, conditioning pools, overhead water tank and tube wells, feed storage rooms and resting facilities for laborers were also created by him .In order to move further towards increasing fish production, he gained knowledge through training in government organizations including ICAR-Central Institute of Fisheries Education (ICAR-CIFE) Mumbai; ICAR-Central Institute of Fisheries Technology (ICAR-CIFT) Kochi, Kerala; ICAR-Central Inland Fisheries Research Institute (ICAR-CIFRI) Vadodra, Gujarat; *Krishi Vigyan Kendra* (KVK), Karnal; ICAR-Central Institute of Freshwater Aquaculture (ICAR- CIFA) Bhubaneswar, Odisha; ICAR-Central Institute of Brackishwater Aquaculture (ICAR-CIBA) Chennai and also undergone 3 months training on integrated fish farming system at Network of Aquaculture Centers in the Asia-Pacific (NACA) in Wuxi, China. Using the knowledge gained in these trainings, he adopted hi-tech farming system in ponds with aerators to enhance the fish production and water quality parameters to earn more profits. After gaining confidence in fishery, he entered in other sectors such as dairy farming to use wastes in ponds as fish manure, established small poultry with 1,000 birds and a stud with 7 horses and keeping dogs for farms protection.

Fresh water prawn was introduced in Haryana state with the help of fishery department and incurred heavy losses in the year 2002. In 2005, *Shinghada* (*Mystus aor*) an endangered species was introduced which is generally found in rivers but due to river pollution its population was decreasing. Its parent fish were collected from river and their nature was studied for three years which was followed by breeding in stagnant water at the farm successfully. A new breed known as *Pangaas*, a bone less fish, was introduced for the first time in north India from Kolkata in 2008 and grown in high density in ponds because it has higher number of erythrocytes (red blood cells) than any other fish.

In order to manufacture value added fish products, ready-to-cook and ready-to-eat, like kalimirch tikka, masala fish tikka, grilled fish, fish nuggets, fish burger and other 35 value added fish items without adding any preservatives, the first fish processing plant of India was established at Karnal in 2011. A quality control laboratory for testing of fish products and other food items for own use as well as public use was set- up in 2016. This project was initiated with the help of Ministry of Food Processing Industries (MoFPI) and Indian Council of Agricultural Research (ICAR) and the technical support was provided by the ICAR-CIFT which is a fish based microbiology laboratory for testing of samples for the export purpose. Aquaponics and hydroponics were also started with the use of fish tanks/ pond water so that plants utilize nutrients from fish waste available in water and grow well without any use of soil. The use of these technologies is very important since the produce is always pure and organic and has high market value. These technologies are being applied only after fish breeding season. Under 'in-pond raceway system (IPRS)', The following species were grown successfully using this system: i) all carps, sole fish, *Roopchand, Pangassius,* Shingi and Pabda species grown in fresh water system; ii) trout, mahasheer, snow trout, salmon and arctic charr species grown in cold water area in this system; and iii) prawns (*vannamei*), sea bass, milk fish and cobia species grown in brackish water in this system.

Shri Sultan Singh explaining about fish harmone to college students

Production Scenario and Significant Achievements

The current fish production in open pond farming system is the maximum 2-3 kg per cubic meter water area. The scientific recommendation is to stock the maximum seed between 4,000-5,000 per acre which results in production of 3 tons per acre in one year with average weight of 800 g per fish which is very less. In the same area at Sultan Singh Fish Farm, the stocking is 10,000 fishes with a production of 8-9 tons per acre in nine months time. The production is 9 kg per cubic meter with semi-high tech. farming method which is 3 times higher as compared to other farmers which produce 3 kg per cubic meter. Through 'Re-circulating aquaculture system (RAS)' technology, it is possible to produce 30-50 times more fish as compared to open pond farming system. Under this technology one can grow high marketable fishes like sea bass round the year which is not possible in open pond farming system. Advantage of this technology

Fish processing laboratory

is saving land and conserving water as the same water can be recycled up to 10-15 years in addition to increase in yield up to 30-50 times. Another advantage of RAS is that it has round the year growth period independent of winter and summer stress on growth and high individual fish weight gain leading to high production. Using RAS, Pangasius (*Pangasius hypophthalmus*), *Shingi* Fish (*Heteropneustes fossilis*), *Desi Magur* (*Clarias batrachus*) and Common Carp (*Cyprinus carpio*) are being successfully cultured at Sultan Fish Seed Farm with different production range.

Value Addition and Marketing

The fish processing plant was established in 2011 and started producing new fish products like *kalimrich* fish tikka, *masala* fish tikka, grilled fish and many more items. However, in order to attract people and get their feedback on quality of the products, initially these products were sold free of cost. The positive response from people encouraged in marketing these value added fish products. The marketing was another big challenge as in north India people do not prefer eating fish due to many reasons. Therefore, the company started participating in exhibitions relating to the food shows, food fairs organized by the government institutes like ICAR-IARI, NFDB and by other private organizations or companies in India and abroad to attract people to this venture. The fish processing plant is currently manufacturing value added ready- to- cook and ready-to- eat fish products such as *kalimirch tikka*, *masala fish tikka*, grilled fish, fish nuggets, fish burger, prawns, honey fish, fish fingers, fish cutlets, fish soups and 35 more value added fish items. The production of these processed fish products progressively increased from 3.6 tons (2016), 4.2 tons (2017), 14.8 tons (2018) to 22.1 tons (2019). Supply of fish feed and aquaculture systems was another important activity of fish business at Sultan Fish Seed Farm. Floating fish feed extruder is being used to make pellets in which the ingredients used are rice husk (rice polish), soybean, pearl millet, fish meat and oil, etc. Different formulations include use of medicines and growth promoters to protect fishes from diseases. Around 2 tons fish feed is produced every day which is sold in local market. The shelf- life of this feed is one year if kept in closed container away from moisture.

Economic Returns

In every livestock business, there is always risk but in the field of fisheries there is not much risk involved and the benefit is quite good. From economic point of view, one can double or triple income in one year time with simple fish farming. For that purpose, one has to be vigilant about water quality parameters, feed consumption and dissolved oxygen level in ponds. The total cost of production in one acre of pond is about Rs.4,00,000 per year which includes the following: i) cost of fish seed in one acre of land for 10,000 yearling fishes - Rs.50,000; ii) cost of manuring/ fertilization, etc., in the pond - Rs.25,000; iii) cost of feed and other feed related products - Rs.2,50,000; iv) miscellaneous expenses of labour, water, electricity etc. - Rs.25,000; and v) cost of lease rent of land - Rs.50,000.

While the production of fish in one acre pond is around 8 tons per year with an average weight of 800 g per fish. Sale of 8 tons of fish at farm gate is about Rs.9.60,000 at the rate of Rs.120 per kg of fish. Hence, annual profit from fish farming is Rs.5,60,000 from 1 acre of land. This profit margin is quite good and achievable, if farmers adopt improved fish farming technologies. If farmer adopts RAS farming system, then he can make a profit of Rs.50,00,000 from 1 acre of land in 18 months time. To make huge income like farmers of Andhra and Gujarat, they have to come together and form a society for processing and exporting purpose. Therefore, it is easy for farmers to increase their income minimum 2.5 times in a year. In addition, farmers are also benefited by recharging of the ground water by digging ponds. On an average, a kilogram of fish gives 35 per cent of fish meat and 65 per cent goes waste. This 65 per cent of waste material is being used in making by products like fish feed, fish meal using ingredients like rice bran, soybean, ground nut oil. Waste water out of production plant of catfish is also being used after collecting it in a rearing pond of catfish. In fact, an omnivorous fish consumes everything like gut, blood and flesh.

Constraints and Lessons Learnt

Shri Sultan Singh faced several problems in his venture and he struggled hard to find out their solutions which also paved way for his success in fishery sector. In the beginning, public acceptance of fisheries sector was the most crucial hurdle to tackle. All villagers, and his relatives and friends were vegetarian and hence were against this work. Not only that, the whole state of Haryana was largely vegetarian and religious sentiments were involved. However, all this did not stop him from moving forward in fish farming sector. Eighteen years of hard work and initial bold

step of providing fish free of cost convinced most of the population to gradually adopt fish eating for maintaining good health. Seed mortality was another big problem as seed was used to be brought from Kolkata and during transportation this seed was damaged many a times. In addition to seed mortality, receiving seed was another problem because sometimes trains were late and one has to wait whole night at railway station. However, these problems encouraged him to establish his own seed hatchery and produce seed at his own level which made him very popular not only in India but also abroad and hence subsequently generated huge profit.

Key Factors of Success

For success in fish farming sector, Shri Sultan Singh had always been trying new innovative approaches and was always prepared to take the risk. The following points are important for success as per his experience: i) hard work and perseverance, ii) patience for achieving success, iii) advance planning, iv) never give-up and face challenges, v) clear vision, vi) self-confidence and trust, vii) knowledge sharing, and viii) hard decision making. Shri Singh strongly believed that there are two keys to success in life, one doing something new and another taking risk. He had taken breeding work in some exotic endangered or near extinct species such as *Shinghada* which was never bred in India before. He took risk and was the first in the country to breed this species in stagnant water. Usually fish breeding farms stick to 3-4 fish species but he introduced new species such as Shingi, Sea Baas and Desi Mangur and achieved good success.

Impact of the Work

Being a farmer Shri Sultan Singh believes that every farmer of India has got some hidden talent in the field of agriculture. To bring out this talent, he shares his experience and expertise with other farmers to boost their morale and adopt fish farming as a profession. Since 1983 when fish farming was adopted as a profession and convinced with his achievements in this business, more than 20,000 farmers started fish farming throughout the country. They all are highly satisfied with this endeavor and earning their livelihood comfortably. Around 20,000 farmers from all over India have been trained from 2001-2020 free of cost in innovative fisheries technologies. They all are benefitted by seeing the infrastructure and also gaining knowledge on various aspects of fish farming. The organizations like National Institute of Agricultural Extension Management (MANAGE), Hyderabad, Extension Education Institute (EEI), Nilokheri, Haryana and Fishery Departments of various states get farmers and entrepreneurs trained utilizing all facilities available at Sultan Fish Seed Farm. The staff of Fishery Department of Haryana state and KVK, Karnal also collaborate and support these training programs. Mostly these training programs are of three days' duration which also include question and answer sessions and thorough discussions. Generally, the specific areas of training include fish breeding methodology of fresh water fishes; integrated fish farming practices; fish rearing methods and techniques; maintenance of nursery and farming ponds; fish diseases and their prevention and control both in RAS and ponds; working components; advantages and disadvantages of RAS technology; seed selection, stocking ratio, feeding technique, manuring and related information on RAS; ponds to grow more fish from lesser area; species selection for viability of RAS unit; fish processing and value addition; Government schemes on fisheries for subsidy to farmers and visit to RAS facility, field, processing factory and fish feed unit. In addition, every Saturday and Sunday, Shri Sultan Singh provides training to 7-8 trainees from different places at their own cost.

Specific Suggestions

For becoming a successful entrepreneur in fish business, Shri Singh being a farmer and having vast experience and knowledge about fishery sector suggested that the youth and entrepreneurs of our country should to adopt fishfarming after completing education because this sector has immense scope for growth through the use of new technologies, innovative approaches as well as upscaling and outscaling of production of fish and various fish products. The students from science discipline can develop new techniques of fish farming aimed at enhancing production and income which can benefit the smallholder farmers and the country as a whole. The students from disciplines other than science can adopt fish farming as profession because it is highly remunerative and is vital for sustainable livelihood. He also emphasized that one has to face some new challenges every day and struggle hard to overcome these problems/difficulties and find appropriate solutions. In the process, one develops interest and finally starts loving this sector. He suggested that the youth (men and women) should not be 'job seekers' rather they should be 'job providers'. If students come together and form a group/network to work using technical knowhow, the investment and work stress per person will be drastically reduced and the huge manpower will become available to take-up the fish farming enterprise at a bigger scale for harnessing benefits for all the partners. He also assured them to provide any help needed at any stage and time to make the business successful and highly remunerative.

9 Dr. M.S. Swaminathan Award for Leadership in Agriculture

The Trust for Advancement of Agricultural Sciences (TAAS) has instituted an award in honor of the renowned agricultural scientist Dr. M.S. Swaminathan, whose pioneering contributions to Indian agriculture had led to the Green Revolution in the late 1960s resulting in food self- sufficiency in India and neighboring countries. The award is given annually to an eminent scientist (either from India or abroad) for his/her outstanding leadership qualities in agriculture as demonstrated by significant contributions made towards overall agricultural growth in the developing world, especially in India. TAAS has conferred ten (10) such awards already and the eleventh and twelfth awards will be conferred during second half of 2021 (Also see Annexure IX).

First Award: Dr. Norman E. Borlaug

The first award was given to Nobel Laureate for Peace Dr. Norman E. Borlaug, the only agricultural scientist to have received this honor for his work on wheat improvement at the International Maize and Wheat Improvement Center (CIMMYT), Mexico. His high yielding dwarf wheat varieties resulted in Green

H.E. the President of India, Dr. A.P.J. Abdul Kalam presenting 1st award to Dr. Norman E. Borlaug

Citation : Dr. Norman E. Borlaug

Dr. Norman E. Borlaug, an epitome of agricultural research and development, dedicated to the alleviation of world hunger and poverty, was born in Cresco, lowa on March 25, 1914. He received B.S. Degree in forestry and the M.S. and Ph.D. in plant pathology from the University of Minnesota, USA.

In 1944, he was appointed geneticist and plant pathologist assigned to organize and direct a Cooperative Wheat Research and Production Programme in Mexico. Due to his dedicated efforts, the programme became an outstanding success. It eventually made Mexico self-sufficient in wheat production by 1956 and laid the foundation for wheat improvement and increased production in other parts of the world.

In 1963, Dr. Borlaug became the leader of the Wheat Programme of newly established International Maize and Wheat Improvement Centre (CIMMYT). In this position, he directed his efforts to wheat research and production problems in Asia. The high yielding, fertilizer-responsive, disease resistant and widely adapted dwarf wheat varieties developed by him laid the foundation for the 'Green Revolution' in various parts of the world, especially in India. He has been visiting India regularly since 1963 and has been a source of great inspiration to all Indian agricultural scientists and scholars.

Dr. Borlaug, Fellow of Science Academies of 15 countries, including the Indian National Science Academy and National Academy of Agricultural Sciences, India, has been conferred honorary doctorate

degree by 51 Universities from all over the world. He is a recipient of numerous academic, scientific and civic awards. He is the only agricultural scientist in the world who received Nobel Peace Prize in 1970.

Dr. Borlaug currently denotes his time as a Senior Consultant to CIMMYT, as a Distinguished Professor of International Agriculture, Department of Soil and Crop Science, at Texas A&M University and as President of Sasakawa Africa Association. He also serves as ex-officio consultant on wheat research and production problems to many governments in Latin America, Africa, and Asia. Since 1980, he has been working hard to bring about a Green Revolution in Africa.

In appreciation of his monumental contributions to Indian agriculture and for being a great motivating force to propel agricultural research for world food security, the Trust for Advancement of Agricultural Sciences, New Delhi, India has great pleasure in honouring Dr. Norman E. Borlaug with the 'First Dr. M.S. Swaminathan Award for Leadership in Agriculture' on this Fifteenth day of March, 2005.

Revolution in India and other developing countries in mid-sixties when there was acute food scarcity. This award was presented to Dr. Borlaug by the then Hon'ble President of India, Dr. A.P.J. Abdul Kalam on March 15, 2005 at Vigyan Bhawan, New Delhi.

Second Award: Dr. G.S. Khush

The second award was given to renowned rice breeder, Dr. G.S. Khush, the recipient of world Food Prize, by the Hon'ble Prime Minister of India, Dr. Manmohan Singh at Vigyan Bhavan, on October 9, 2006. Dr. Khush, while working at the International Rice Research Institute (IRRI), Manila was responsible for the development of more than 300 high yielding rice varieties which gave tremendous boost to productivity of rice in rice growing countries, resulting in increased rice production in Asia.

Hon'ble Prime Minister of India Dr. Manmohan Singh presenting 2nd award to Dr. G.S. Khush

Citation : Dr. Gurdev S. Khush

Dr. Gurdev Singh Khush, a world renowned plant breeder, has made enormous contributions to the development of more than 300 high yielding rice varieties that played significant role towards achieving 'Green Revolution'. A worthy son of a farmer, Dr. Khush graduated from the Punjab Agricultural University, Ludhiana in 1955. He joined the International Rice Research Institute (IRRI), Manila in 1967. In 1986, he was promoted as Principal Plant Breeder and Head, Division of Plant Breeding, Genetics and Biochemistry. He provided excellent leadership for the global rice improvement program benefiting millions of resource poor rice growers in the world. A semi-dwarf rice variety IR36, developed by him was one of the most widely grown rice varieties in the world during 1980s. IR64 developed during 1980s is the most widely planted rice variety in the world.

Dr. Khush is one of the most decorated agricultural scientists in the world. He received honorary Doctorate degrees from nine universities, including University of Cambridge, England. He is one of the five Indian scientists who have been elected to the membership of the Royal Society as well as US National Academy of Sciences. For his monumental contributions to rice improvement, he received Japan Prize (1987), the World Food Prize (1996), the Wolf Prize from Israel (2000) and the China International Scientific and Technological Cooperation Award (2001). He was honoured by the Government of India with the prestigious "Padma Shri" Award in 2000.

In India, Dr. Khush has been actively involved in the development of plant breeding and agricultural biotechnology. He has been a member of the Scientific Advisory Committee (Overseas), of the Department of Biotechnology, Government of India, for over a decade. He worked closely with the Indian Council of Agricultural Research (ICAR) for enhancing human resource development for improving rice productivity in India. He retired from IRRI in 2002 and joined the University of California, Davis, as Adjunct Professor.

The Trust for Advancement of Agricultural Sciences salutes this great son of India and take pride in honouring Dr. Khush with the prestigious Dr. M.S. Swaminathan Award for Leadership in Agriculture' on this Ninth day of October, 2006.

Prof. M.G.K. Menon, Former Member, Planning Commission presenting 3rd award to Dr. S.K. Vasal

Third Award: Dr. S.K. Vasal

The third award was presented to Dr. S.K. Vasal, an accomplished maize breeder, by Prof. M.G.K. Menon, Former Member, Planning Commission (now NITI Aayog) on May 3, 2008, at Shinde Auditorium, NASC Complex, New Delhi. Dr. Vasal's work at CIMMYT, on maize, led to the development of protein rich maize, known as Quality Protein Maize (QPM), which has resulted in nutritional improvement of several million people in the developing world. In recognition of outstanding work, Dr. Vasal received the World Food Prize in 1996.

Citation : Dr. Surinder K. Vasal

Dr. Surinder K. Vasal is an accomplished plant breeder and geneticist whose work on maize led to the development of high quality protein maize (QPM). He, along with his colleague, Dr. Evangelina Villegas shared the 2000 World Food Prize for their valuable contributions.

Dr. Vasal was born in 1938 in Amritsar, India. He did Ph.D. in Genetics and Plant Breeding from the Indian Agricultural Research Institute, New Delhi. Dr. Vasal began his career as a researcher in the Department of Agriculture, Himachal Pradesh and later worked as Maize Breeder at the Himachal Agriculture College.

In 1967, Dr. Vasal took up an assignment with the Rockefeller Foundation in Thailand to conduct research on maize in close collaboration with the National Corn and Sorghum Research Center of Kasetsart University. From there, he moved to the International Maize and Wheat Improvement Center (CIMMYT), Mexico in 1970 and supervised the high lysine maize program. He also held positions of Germplasm Coordinator, Head of Maize Research and Coordinator of Asian Regional Maize Programme. Dr. Vasal was honoured to be the first distinguished scientist at CIMMYT.

With the development of quality protein maize, the amino acid content in the diets of several millions has improved since 1990s. Quality protein maize germplasm, developed by Dr. Vasal is now being used worldwide for developing QPM cultivars. Dr. Vasal has developed important concepts and methodologies and released a large number of promising inbred lines for use by the maize researchers worldwide.

In 1997, Dr. Vasal took up a new role, leading CIMMYT's Asian Regional Maize Programme in Thailand. He strengthened regional hybrid research activities and coordinated the Tropical Asian Maize Network (TAMNET). He specifically played an important role in human resource development by training hundreds of young scientists from the developing countries.

Dr. Vasal is a member of the American Society of Agronomy, the Crop Science Society of America (whose Presidential Award he won in 2000), and India's National Academy of Agricultural Sciences. He has received the 1996 International Service in Crop Science Award and the 1999 International Agronomy Award, in addition to accolades from the Governments/Institutions in Honduras, Peru, Panama, India, Vietnam, Bangladesh and a few other countries. He is also the recipient of Chinese Friendship Award of 2001.

The Trust for Advancement of Agricultural Sciences takes pride in honouring Dr. Vasal with the Third Dr. M.S. Swaminathan Award for Leadership in Agriculture on this day, the 3rd May, 2008.

Hon'ble Dr. Montek Singh Ahluwalia, Dy. Chairman, Planning Commission presenting 4th award to Prof. Ratan Lal

Fourth Award: Prof. Rattan Lal

The fourth award in the series was given to Prof. Rattan Lal, an eminent soil scientist from Ohio State University (OSU), for his outstanding contributions in the field of sustainable management of natural resources. His contributions have made great impact on food production through better soil management by the resource-poor farmers of developing courtiers. This award was presented to Prof. Rattan Lal by Dr. Montek Singh Ahluwalia, Deputy Chairman, Planning Commission (now NITI Aayog) on August 11, 2009 at Dr. BP Pal Auditorium, New Delhi.

Citation : Prof. Rattan Lal

Professor Rattan Lal is an eminent soil scientist. His scientific contributions have made profound impact on sustainable management of natural resources and world food production among resource-poor farmers in the developing countries. He has conducted classical studies on watershed management and linked them to C-sequestration and climate change. He has liberally shared his research findings with other scientists, thus promoting effective soil management practices globally. His work has been recognized worldwide. Professor Rattan Lal has received numerous prestigious Awards including the 2007 Nobel Peace Prize Certificate and 2005 Norman Borlaug Award. He has held several important positions in a number of professional societies. He was elected President of the prestigious Soil Science Society of America in 2006-2007. Professor Rattan Lal has authored 1375 research papers, including 13 books, which have received great admiration of the scientific community and comprise principal reference materials in soil science.

Born on 5th September 1944 in Karyal, Punjab and educated at PAU and IARI. Professor Rattan Lal earned his Ph.D. from the Ohio State University in 1968. After working at IITA, Ibadan, Nigeria for 18 years, he joined OSU in 1987 as Professor of Soil Science. Since 2000, he holds the position of Director, Carbon Management and Sequestration Center, The Ohio State University, USA.

Professor Rattan Lal continues to do excellent work in Soil Science. His main areas of interest are: Soils and Climate Change, Carbon Sequestration in Soils, Sustainable Management of Soils in the Tropics, Global Food Security, Soil Degradation and Management, and making agriculture as a component of solutions to environmental issues.

The Trust for Advancement of Agricultural Sciences takes pride in honouring Professor Rattan Lal with the fourth Dr. M.S. Swaminathan Award for Leadership in Agriculture on this day, the 11th August, 2009.

Fifth Award: Dr. Sanjay Rajaram

The fifth award was presented to Dr. Sanjay Rajaram, a distinguished wheat breeder. His work at CIMMYT led to the development of improved wheat varieties which have been released in more than 50 countries, including around 25 in India. These varieties have helped in increasing wheat production in many developing countries. This award was presented by Dr. A.P.J. Abdul Kalam, former President of India on December 10, 2010 at Shinde Auditorium, NASC Complex, New Delhi.

Former H.E. President of India Dr. A.P.J. Abdul Kalam presenting 5th award to Dr. Sanjay Rajaram

Citation : Dr. Sanjay Rajaram

Dr. Sanjay Rajaram is one of the most distinguished wheat breeders known for his valuable contributions globally. He led CIMMYT's wheat breeding program for over two decades. Under his leadership, the CIMMYT program made tremendous impact on global wheat production.

As wheat breeder, Dr. Rajaram contributed towards the development of as many as 480 wheat varieties that have been released in 51 countries, and are grown on an estimated 58 million hectares worldwide. Twenty-five of his varieties have so far been released in India. For this contribution, he has been honoured with a number of national and international honours and awards.

Using a novel approach of exploiting winter and spring wheat gene pools, together with shuttle breeding and mega environment testing, Dr. Rajaram and his team developed outstanding cultivars with very high yield potential. Applying the concept of slow rusting, he developed wheat varieties with durable resistance to leaf rust, which invariably remained effective for more than 20 years. Dr Rajaram and his team also successfully incorporated blight resistance into modern wheat varieties.

Dr Rajaram graduated with a B.Sc. degree in Agriculture from the University of Gorakhpur. He obtained his Masters in Genetics and Plant Breeding from IARI, and proceeded to do his Ph.D. in Plant Breeding from the University of Sydney, Australia. Dr. Rajaram has authored/co-authored more than 400 research publications, including 110 papers in refereed journals, and mentored 700 young scientists from the developing world. He also guided 22 Masters and Ph.D. students. During his long career, he has served as Director of Wheat Research at CIMMYT, Director of ICARDA's Biodiversity and Integrated Gene Management Program, and consultant to a number of governments and international organizations. In 2009, he led a study in Egypt, the report of which is being used by the Egyptian Ministry of Agriculture to plan a major expansion of wheat production program.

The Trust for Advancement of Agricultural Sciences takes pride in honouring Dr. Sanjay Rajaram with the Fifth Dr. M.S. Swaminathan Award for Leadership in Agriculture on this day, Saturday, the 18th December, 2010.

Sixth Award: Dr. M.C. Saxena

The sixth award was presented to Dr. M.C. Saxena, an eminent agronomist and crop physiologist, whose work on food legumes at International Center for Agricultural Research in Dryland Areas (ICARDA) has enormously benefited the resource poor farmers in West Asia, North Africa, Central Asia (CWANA) and South Asia, particularly Bangladesh, India, Nepal and Pakistan. His seminal work has helped in increasing the pulse productivity in these countries. This award was presented by Dr. Balram Jakhar, former Union Minister of Agriculture and H.E. the Governor of Madhya Pradesh on January 25, 2012 at Dr. BP Pal Auditorium, IARI, New Delhi.

Former H.E. the Governor of Madhya Pradesh & Former Union Minister of Agriculture Dr. Balram Jakhar presenting 6th award to Dr. M.C. Saxena

Citation : Dr. M.C. Saxena

Dr. Mohan C. Saxena is an eminent agronomist and crop physiologist, whose work at the International Center for Agricultural Research in the Dry Areas (ICARDA) on food legumes has enormously benefitted the resource poor farmers in West Asia, North Africa, Central Asia (CWANA) and South Asia, particularly Bangladesh, India, Nepal and Pakistan.

His work on managing drought, common in this region, resulted in the "Winter Sowing" technology for chickpea and lentils in the lowland Mediterranean areas of the West Asia and North Africa region, resulting in 50-60 per cent increase in crop productivity and water-use efficiency. This research was

recognized through King Baudoin Award of the CGIAR for ICARDA and ICRISAT. He had served as leader of Legume Program, then as Director of Germplasm Improvement Program and also as Assistant Director General (ADG) at ICARDA for almost two decades. His support to Indian legume program, especially kabuli chickpea and lentil led to much greater benefits to resource poor farmers of India.

Dr Saxena did Ph.D. in Agronomy at the Indian Agricultural Research Institute (IARI), New Delhi (1962), and Doctor of Science in Plant Nutrition from the University of Hohenheim, Germany (1965). After serving briefly at IARI and the Bhaba Atomic Research Center, he joined the G. B. Pant University of Agriculture and Technology, Pantnagar and undertook research on agronomy of warm and cool season pulses, particularly soybean. His work on soybean greatly helped in popularizing Soybean Production Technology in India.

Dr Saxena's research contributions and leadership have been widely recognized. A major Laboratory at ICARDA is named after him for his accomplishments. He has been awarded Gold Medals by Indian Society of Agronomy and the Indian Society of Pulses Research and Development and Honorary Doctorates from three Universities. After his retirement from ICARDA, he has been appointed as a Visiting Professor at the Arid Land Research Center of the Tottori University, Japan. The Crop Science Society of America has recently given him a Lifetime Achievement Award by conferring an Honorary Membership of the Society.

In recognition of his important contributions, TAAS has great pleasure in awarding Dr. M.C. Saxena the Dr. M.S. Swaminathan Award for Leadership in Agriculture on this day, Wednesday, the 25th January, 2012.

Seventh Award: Dr. William D. Dar

The seventh award was presented to Dr. William D. Dar by Dr. K. Kasturirangan, Member, Planning Commission (now NITI Aayog) on June 24, 2013, at Dr. BP Pal Auditorium, IARI, New Delhi for his outstanding contributions towards food security and agricultural sustainability in Asia and Sub-Saharan Africa. The work done by him has created considerable impact on resource poor farmers. Dr. Dar is well known for his efforts to promote public-private partnership and for inclusive market oriented development (IMOD).

Hon'ble Dr. K. Kasturirangan, Member, Planning Commission (now NITI Aayog) presenting 7th award to Dr. William Dar

Citation : Dr. William D. Dar

Dr. William D. Dar, Director General, International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, Hyderabad, Andhra Pradesh, has made outstanding contributions towards food security and agricultural sustainability in Asia and Sub-Saharan Africa. His work has created great impact on the lives of resource poor farmers. Dr. Dar has also actively promoted Public-Private-Farmer partnership linking strongly the end users with the National Agricultural Research System (NARS) as well as International Agricultural Research Centers (IARCs). Under his leadership, effective research collaboration has been established in areas like germplasm exchange, biotechnology, crop improvement, water conservation, capacity building, and policy reorientation.

Dr. Dar has had a distinguished career as an educator, agricultural scientist and able research administrator. Being a great promoter of regional cooperation, Dr. Dar also served as Chairman of the Asia-Pacific Association of Agricultural Research Institutions (APAARI).

Prior to joining ICRISAT, Dr. Dar had served as Advisor to the President of the Philippines; Secretary, Department of Agriculture of the Philippines; Executive Director of the Philippine Council of Agriculture, Forestry and Natural Resources Research and Development (PCARRD); Director, Bureau of Agricultural Research (BAR), Department of Agriculture; and the Vice President (R&D) of Benguet State University, Philippines.

In recognition of his significant contributions, Dr. Dar has been honoured with a number of awards and degrees of Doctorate of Science. He also received the Life-time Achievement Award for his outstanding contributions in the field of pulses research from the Indian Society of Pulses Research and Development (ISPRD).

Dr. Dar is a champion of the poor. He successfully led ICRISAT into renaissance and excellence with a motto of "Science with a Human Face". His transformational leadership has turned ICRISAT into a forward looking institute, financially strong and producing scientific breakthroughs as public goods for greater developmental impact. His passion is to help alleviate the socioeconomic conditions of the poor living in the semi-arid tropics of Asia and Sub-Saharan Africa.

In view of his outstanding contributions, the Trust for Advancement of Agricultural Sciences (TAAS) has great pleasure in awarding him the prestigious Dr. M.S. Swaminathan Award for Leadership in Agriculture on this day, Monday, the 24th June, 2013.

Prof. MS Swaminathan presenting 8th Award to Dr Thomas A Lumpkin

Eighth Award: Dr Thomas Lumpkin

The eighth 'Dr MS Swaminathan Award for Leadership in Agriculture' was given to Dr Thomas Lumpkin, Former Director General of CIMMYT, Mexico on 28th September, 2015. Dr MS Swaminathan was the Chief Guest for the function. This award was conferred on him for his outstanding significant contributions in the field of agricultural research, education, development and administration, with particular focus on technology development, refinement and adoption of conservation agriculture in cereal and vegetable production systems of South Asia, ethnobotany and marketing systems.

Citation : Dr Thomas Lumpkin

Dr. Thomas A Lumpkin has been at the forefront of guiding wheat and maize research for development (R4D) in the developing world, particularly in India and across South Asia. His passion is for improving the livelihoods of smallholders in developing countries through science-driven technologies, enabling them to produce more food while using fewer resources and in a sustainable way to ensure a new Green Revolution. He has written numerous books and research articles on azolla, azuki bean, edamame, wasabi, global horticulture and approaches to alleviate malnutrition and poverty in the developing world. He is widely known among the CGIAR, international agricultural donor agencies and national agriculture systems in the developed and developing world for his leadership in agriculture, and for the reinvigoration of the International Maize and Wheat Improvement Center (CIMMYT) and the World Vegetable Center (AVRDC).

As a leader in the oversight of the WHEAT and MAIZE CGIAR Research Programs (CRPs) since 2011 and 2012, respectively, Dr Lumpkin has made intensive contributions in deploying improved wheat and maize varieties in India through innovative public private partnerships. He has made an impact in the region through his strong emphasis and focus on input-use efficiency, precision agriculture for smallholders, adaptation to the changing climates in South Asia through effective integration of climate-resilient varieties, resource-conserving technologies and institutional innovations for sustainable intensification of wheat- and maize-based systems. His vision for a new Green Revolution and research combined with an in-depth knowledge of constraints faced by the smallholder farmers of South Asia prompted him to launch the Borlaug Institute for South Asia (BISA) in India, in close partnership with the Indian Council of Agricultural Research (ICAR). He had also been the founder Director General of BISA, concurrent with his duties as Director General, CIMMYT. Dr Lumpkin has been associated with a number of well known professional bodies.

The Trust for Advancement of Agricultural Sciences (TAAS) has great pleasure in awarding Dr Thomas Lumpkin the prestigious "Dr MS Swaminathan Award for Leadership in Agriculture".

Dr Uma Lele receiving the award from Dr Y.K. Alagh

Ninth Award: Dr Uma Lele

The ninth 'Dr MS Swaminathan Award for Leadership in Agriculture' was given to Dr Uma Lele, by Dr YK Alagh, Former Minister of State for Planning, Science & Technology, Government of India on October 30, 2017 at Dr BP Pal Auditorium, IARI, New Delhi for her famous meta evaluation of the CGIAR and contributions towards issues related to food, agriculture and nutritional security and strong crusader of women's empowerment.

Citation : Dr. Uma Lele

Dr. Uma Lele is a highly accomplished agricultural economist known for her work on Food and Agricultural Development. She has over four decades of rich experience in research, operations, policy analysis and evaluation of development assistance. She has served in many capacities for different international organizations such as the World Bank, FAO, CGIAR, IFAD, UNICEF, UNDP, Rockefeller Foundation and Bill & Melinda Gates Foundation. Her critical evaluation of the World Bank's Forestry Policy had led the Bank to revise its strategy to lay greater focus on poverty reduction besides conservation and use. Her famous Meta evaluation of the CGIAR led to the rethinking by the World Bank and other donors of CGIAR's role in meeting emerging new challenges wherein two of the original pillars of the CGIAR had been weakened over time: the rise of genomics and of intellectual property rights, mainly due to the increasing role of the private sector in agricultural research. Her other work which has received considerable recognition has focused on the substantial geo-climactic and institutional diversity, requiring development interventions suited to particular circumstances, and the need for capacity building with a focus on 'learning by doing' approach.

A consistent underlying theme of her international work has been the divergence in the assumptions determining public interventions and the reality on the ground. Since her retirement from the World Bank, she has been contributing extensively towards issues related to food, agriculture and nutritional security. For India, her early work on foodgrains marketing in India had revealed that failures in commodity markets were the results of poor infrastructure and public policy restricting cross border trade. Through comparative analysis of structural transformation, she has shown how Indian agriculture has been falling behind neighboring Asian and other large Latin American countries who started with similar or worse initial conditions. She conducted an independent external review of work of the MS Swaminathan Research Foundation (MSSRF) which formed part of the foundation's future strategy. The GCARD Road Map in 2010 was also an outcome of a technical report prepared by a team under her leadership.

Dr Uma Lele is an ardent champion of capacity development, especially in developing countries. She had always been a strong supporter of women's empowerment and was actively involved in organizing the First Global Conference for Women in Agriculture (GCWA) held in New Delhi during 2012. To promote the cause of human resource development, she has set up a 'Mentorship Award' with the American Applied Economic Association and another 'Best Research Award on Gender in Development' with International Association of Agricultural Economists. Her work has been widely recognized through numerous awards and recognitions, especially for her innovative and analytical thinking.

The Trust for Advancement of Agricultural Sciences has great pleasure in presenting the 9th Dr MS Swaminathan Award for Leadership in Agriculture to Dr Uma Lele.

Tenth Award: Dr John Dixon

The tenth award was given to Dr John Dixon, Former Principal Adviser, Australian Centre for International Agricultural Research (ACIAR), Australia by Dr Ismail Serageldin, Former Chairman, CGIAR and Vice President, World Bank on 13th February 2019 for his contribution in farming system's research towards conservation agriculture based sustainable intensification (CASI) in a wide range of irrigated, dryland and mountain farming systems.

Dr. John Dixon receiving award by Dr Ismail Serageldin

Citation : Dr. John Dixon

Dr. John Dixon was till recently the Principal Adviser, ACIAR, Australia. Prior to this, he held senior positions in ACIAR, FAO, CIMMYT and other international organizations. He had a rich and long work experience in different regions in partnership with national systems while working in collaboration with several international organizations. During his outstanding career of more than four decades, his greatest impacts have been in farming systems' research aiming at conservation agriculture based sustainable intensification (CASI) in a wide range of irrigated, dryland and mountain farming systems. Dr Dixon provided leadership in developing a model regional FARM program of FAO/ UNDP on the implementation of Agenda 21 (from Rio Conference) in marginal areas of eight Asian countries. He also headed CGIAR System-wide Program on Participatory Research and Gender Analysis and fostered active international knowledge sharing on role of women in agricultural research for development.

Dr Dixon obtained his Ph.D. and Master of Economics as well as Master of Natural Resources from the University of New England, Armidale, Australia. He has authored a dozen books and manuals and about 100 journal and conference papers on diverse topics. He was selected as a Distinguished Alumni by the University of New England in 2017 and was elected as a Fellow of the Australian Academy of Technology Science and Engineering in 2018. He is recipient of FAO AG Department Prize for Best Publication/ Website (FAO/World Bank Study of Global Farming Systems Trends and Emerging Priorities), 2001; Zayed Prize for Millennium Ecosystem Assessment, 2005; and Wheat Warrior Award, Crawford Foundation, for Contributions to Wheat Research, 2009.

Dr John Dixon has made significant contributions in Asia and Africa by promoting the concept of Conservation Agriculture based Sustainable Intensification (CASI), for improving soil health and ensuring natural resource management (NRM) in the Indo-Gangetic Plains (IGP) involving India, Bangladesh and Nepal is outstanding. He has spearheaded the ACIAR project on Sustainable and Resilient Farming Systems Intensification (SRFSI), being implemented by CIMMYT, which has revived the hope for scaling conservation agriculture through regional collaboration, as was achieved under Rice Wheat Consortium (RWC) in late 1990s. He launched CASI projects in 12 countries in Africa, South Asia and Southeast Asia. His untiring efforts have helped in building a Regional CASI Platform involving Bangladesh, India, Nepal and Pakistan. Overall, as a result of his sincere efforts and leadership, millions of smallholder farmers in many Asian and African countries are better off and the national systems are better prepared to work for conservation agriculture for sustainable intensification and contribute towards attaining SDGs by 2030.

The Trust for Advancement of Agricultural Sciences has great pleasure in presenting the 10th Dr MS Swaminathan Award for Leadership in Agriculture to Dr John Dixon. February 13, 2019

Eleventh Award: Dr Shenggen Fan

The eleventh award is to be given to Dr Shenggen Fan, Former Director General of the International Food Policy Research Institute (IFPRI), Washington DC, USA during first half of 2021 for his major contributions in the area of transition economies and rural development in China, and ambitious program on good policy and nutritional security research in India as well as South Asia. His research also focused on analysis of the role of public and private investments in agriculture and in fighting against chronic poverty and hunger. He is a member of the Leadership Council of Compact 2025, an initiative for ending hunger and under-nutrition by 2025. In 2014, Dr Fan received the Hunger Hero Award from the WorldFood Program in recognition of his commitment to and leadership infighting hunger worldwide.

Dr Shenggen Fan (to receive Award during first half of 2021)

Citation : Dr. Shenggen Fan

Dr. Shenggen Fan is an accomplished agricultural economist renowned not only as an author of widely cited journal articles and books but also as a global leader in agricultural and food policies. Through decades of research, he has been playing a crucial role in improving food and nutrition security in several countries and regions.

Dr Fan is currently the Chair Professor at the College of Economics and Management at China Agricultural University (CAU), leading a national innovation team on food economics and policy. Prior to joining CAU, Dr Fan served as Director General of the International Food Policy Research Institute (IFPRI) from 2009 to 2019. He joined IFPRI in 1995 as a research fellow, and conducted extensive research on pro-poor development strategies in Africa, Asia, and the Middle East, especially in China and India. He led IFPRI's program on public investment before becoming the Director of the Institute's Development Strategy and Governance Division in 2005.

Dr Fan's research covers a wide range of issues such as public investment, agricultural and rural development, transition economies, poverty reduction, food security and nutrition, and sustainable food systems. He has been engaged in the agricultural development strategy for developing countries throughout his career. The econometric model he developed to measure public investment and priorities in his early years has been set as a paradigm by international agencies such as United Nations and the World Bank and adopted by many developing countries in making policies to optimize public spending and eliminate poverty. As the Director General of IFPRI, he led a strong team of researchers to provide cutting-edge evidence-based research to develop policies towards transforming the food systems for human and planetary health. Dr Fan was awarded an honorary life membership of the International Association of Agricultural Economists (IAAE) in 2018 and became a Fellow of American Applied Economics Association (AAEA) in 2020.

In addition to academic achievements, Dr Fan champions food security and nutrition and innovative food systems through his leadership role on multiple global committees. He has been a member of the Lead Group for the Scaling Up Nutrition (SUN) Movement appointed by the former UN Secretary General Ban Ki Moon, and he served as the Chair, the Vice Chair, and member of the Food and Nutrition Council of the World Economic Forum from 2012 to 2018. He also serves as an adviser to many national governments on agriculture, food security, and nutrition related matters.

Dr Fan has made tremendous contributions to eradicate hunger and to ensure food security all over the world. He received the Hunger Hero Award from the World Food Program in recognition of his commitment to and leadership in fighting hunger worldwide in 2014. In 2017, Dr Fan received a highly prestigious Fudan Management Excellence Award in 2017 - a highly prestigious award, recognizing individuals who have made outstanding contributions in the field of management, is regarded as a "Nobel Prize for Management" in China.

As Director General, IFPRI, Dr Fan tried to build a very strong and ambitious program on good policy and nutritional security research in India as well as South Asia.

The Trust for Advancement of Agricultural Sciences (TAAS) will bestow prestigious Dr MS Swaminathan Award for Leadership in Agriculture on Dr Shenggen Fan for his life time outstanding contributions during the second half of 2021 (to be announced).

10 Major Achievements and Impact of TAAS Activities

The recommendations/action points emerging out of the discussions held during various symposia/ workshops/ seminars/brainstorming sessions/dialogues have been forwarded from time to time to the concerned Government Departments/Ministries and other relevant organizations/agencies for implementation. It is encouraging that most of the recommendations have been received well and appropriate actions have been taken for their implementation. In the process, during the last one decade, TAAS as a 'Think Tank', has been able to catalyze the process of either creating an enabling policy environment or generating much required public awareness on issues of national importance. Following is a brief description highlighting the evident impact of various TAAS initiatives concerning policy advocacy, public awareness and networking etc.

Policy Advocacy

- For effective coordination and convergence of all agrobiodiversity related matters, the suggestion of a National Advisory Board on Genetic Resources Management got implemented by the ICAR. The high level board has taken steps to establish guidelines for managing plant, animal, fish, insects and microbial genetic resources by the respective Bureaux and has come out with an agreed material transfer agreement (MTA) format to transfer/share germplasm with all stakeholders concerned.
- The TAAS could raise the concern in 2005 to catalyze and accelerate the process of establishing the Protection of Plant Varieties and Farmers' Rights Authority (PPV&FRA), which was getting considerably delayed though the Act was approved by the Parliament in 2001. Also, the creation of 'Gene Fund' was emphasized which could support the farming communities engaged in *in situ* conservation of valuable genetic resources. The Authority office was established in 2006 and the Gene Fund is now functional. Also, the process of registration of farmers' varieties has made considerable headway while awareness generation campaigns by the authority as well as other concerned agencies are in full swing.
- The promotion of hybrids/HYVs in major field crops was emphasized to increase productivity through creation of a "Seed Mission" at the national level with better coordination and convergence of public and private seed organizations for faster growth, including rolling plan for 5 years in each State to ensure availability of good quality seed for higher replacement ratio in important crops. Accordingly, the Planning Commission (now NITI Aayog) had decided to create a Seed Mission in the 12th Plan period.
- With fast changing climate scenario, seed will be the key to unlock the potential of new advanced technologies to meet the challenges of both abiotic and biotic stresses. Currently, the Indian seed industry is valued at USD 3.6 billion (4.4% share of the global trade) and has emerged as the fifth largest seed market across the globe. For boosting Indian seed sector, innovative technologies, enabling policy support, cost-effective production of high quality seeds and seedlings and efficient delivery services are critical. Despite emergence of strong seed system, the informal seed sector still meets 39 per cent of total seed demand (e.g. 31% in oilseeds, 36.4% in cereals, 55.5% in pulses, etc.). The need to improve the existing seed production and quality system is quite obvious for which strong technological, institutional and policy support is paramount. Besides internal market, India also has great potential to emerge as an important player in the global seed market.
- The urgency for getting the approval for revised Seed Act has received due consideration of the Ministry of Agriculture and Farmers' Welfare (MoA&FW). The New Seed Bill 2020 has already been placed in the Parliament. In the Seed Bill, some points needed to be addressed in order to see that the New Seed Bill 2020 may be farmer-friendly. In view of this, a "Stakeholders Dialogue on Way Forward for the Indian Seed Sector" was jointly organized by the TAAS and the Indian Society of Seed Technology (ISST) with the objectives to: i) discuss major constraints and find possible solutions for faster growth of Indian seed sector, ii) to seek views of different stakeholders on the revised draft 'New Seed Bill 2020', iii) suggest measures to strengthen seed health and quality assurance system in the country, and iv) review options for promoting seed export from India. A Road Map was suggested with 26 recommendations on policies and regulatory framework; seed research, production and quality assurance systems; and

accelerating seed export. Accordingly, GoI was suggested to intervene on these suggestions, and get the 'New Seed Bill 2020' approved finally by the Parliament considering issues to make the bill farmer-friendly. Once approved, after addressing the difficulties pointed out from various concerned quarters, it is expected that the seed development related activities would get accelerated with needed provisions and incentives for quality seed production.

- Emphasis on increasing the seed replacement rate under hybrids of important crops, including vegetables, for increasing their productivity has been appreciated. Accordingly, both public and private sectors are being encouraged to play their effective roles. Thus, the recommendation to provide similar incentives to private seed sector on par with public sector institutions especially for hybrid seed production, is under active consideration of the government.
- The TAAS also discussed 'Current Challenges and Way Forward for Pesticides Management' in collaboration with the Society of Pesticide Science (SPS) India, the Indian Phytopathological Society (IPS), and the Entomological Society of India (ESI) with the objectives to : i) discuss major constraints and explore solutions for phasing out banning of certain pesticides, ii) seek views of stakeholders on 'Pesticides Management Bill 2020' already placed in the Parliament and suggest possible alternatives for accelerated growth of pesticides in India, and iii) review and suggest reorientation of pesticides management, present regulatory system, existing policies and enabling environment for growth of pesticide industry to promote botanicals and agro-chemical R&D in the country.
- In-depth discussions held around regulatory mechanisms for pesticides management including time line for processing registration application, re-registration, 'Me-Too' registration, excessive jurisprudence, regulatory data protection, pricing, and bulk ban of 27 pesticides including tricyclazole, buprofezin and glyphosate; also rationality of alternatives, ecotoxicity, reasonable data requirements on bioefficacy and toxicity, and mandatory application of glyphosate by PCO. Various issues relating to crop losses, pesticide registration system, current challenges and way forward for pesticides management sale of spurious pesticides, banning of pesticides, and an enabling environment for faster growth of pesticide industry were discussed. The discussion on issues of R&D and innovation centered around: i) development of new molecules-their search, synthesis, isolation, identification, bio-activity, product optimization (SAR, now software available), and physicochemical, preliminary safety information; ii) formulation for recipe development, product optimization (physico-chemical parameters, bio efficacy, phytocompatibility, toxicology, etc. and iii) safety aspects- mammalian, avian, environmental, non-target organisms safety/ toxicology/compatibility, and transformations, metabolism, detoxification, etc. A Road Map suggested with 26 recommendations on reorienting the regulatory mechanism, enabling environment for growth of pesticide industry, and strengthening pesticide research and innovation for development. Accordingly, the GoI was suggested to intervene and get the 'Pesticides Management Bill 2020' approved by the Parliament with the revised points inserted to make the bill farmer/industry-friendly.
- The inclusion of maize in the food security mission as well as promotion of quality protein maize (QPM) to address the problem of nutrition security has strongly been recommended for active consideration of policy planners and decision makers. Maize accordingly got included in the National Food Security Mission (NFSM) and efforts are on to double the maize production through higher coverage under high yielding single cross maize hybrids
- In view of malnutrition being a serious national problem, use of soybean as a food crop was strongly recommended to the Government to address on priority the acute protein deficiency problem in our young children. Accordingly, this recommendation is getting needed attention for use of soya milk and other products in the mid-day meal scheme of the government.
- For a single window clearance of regulatory processes relating to testing and release of GM crops, being a recommendation of the brainstorming session in 2003, the Department of Biotechnology took action to create a Biotechnology Regulatory Authority of India (BRAI).The BRAI Bill is likely to be considered soon by the Parliament for approval.
- Policy recommendation on '*khet ka pani khet mein*' through promotion of farm development activities such as bunding, field leveling, etc. has been considered for implementation for resource poor farmers under the existing national schemes such as MGNREGA, RKVY, etc.
- TAAS recommendations in the form of "Ranchi Declaration" have received due consideration by the ICAR and Department of Animal husbandry in preparing a clear roadmap for both preparation and implementation of a National Plan of Action on management and conservation of farm animal genetic resources. In this context, special focus is being laid on valuable indigenous breeds that need priority attention for both conservation and genetic enhancement. Also, a "National Mission on Livestock" has been created under the 12th FYP to accelerate livestock development in India. Further, to conserve and develop indigenous bovine breeds, the new government has launched a disruptive new initiative, the '*Rashtriya Gokul* Mission' under the National Program for Bovine Breeding and Dairy Development (NPBBD), which

was launched in 2014 with an integrated, holistic and scientific approach to improve and upgrade the genetic makeup of bovines. Other objectives of the mission include enhancing their production and productivity, including developing and conserving indigenous breeds of milch cattle and development of dairy infrastructure for improved procurement, processing and marketing.

- Suggestion to modify APMC Act in order to reform the marketing system and to link farmers directly with consumers through inclusive market oriented development (IMOD) has been well received and some states have already taken positive steps to delink sale of vegetables and fruits, being of perishable nature, from APMC Act.
- Considering the dire need for building research management cadre of scientists, with an aim to accomplish 'servant leadership' goal, the recommendation to have both mid and senior level management orientation programs (EDP and MDP) at the ICAR-National Academy of Agricultural Research Management (ICAR-NAARM) have been implemented. Also, ICAR has taken a decision to make these courses mandatory for all research management positions.
- In India, while farmers are the major producers, they also constitute the largest proportion of consumers. Hence, improving small farm production and productivity, as a major development strategy, can make significant contribution towards elimination of hunger and poverty, provided farming is made efficient and remunerative. Experience of countries that have succeeded in reducing hunger and malnutrition shows that growth originating in agriculture, through smallholder farmers, is at least twice as effective in benefiting the poorest as growth from non-agriculture sectors. The World Development Report of the World Bank (World Bank, 2008) has clearly emphasized that: 'Using agriculture as the basis for economic growth in agriculture-based countries requires a productivity revolution in smallholder farming'. As stated earlier, higher productivity requires higher investment in agriculture and agricultural research - a fact that needs to be heeded by the policy makers to make sure that 1.0 per cent of agricultural GDP is invested on ARI4D, as against present level of just 0.4 per cent. Hence, three-fold increase in resource allocation for the national agricultural research system (NARS) be considered a prerequisite to double the farmers' income.
- It is also a fact that India will remain predominantly an agricultural country during most of the 21st century. Therefore, we must have both vision and national strategy for shaping the destiny of agriculture by making it highly productive, efficient and economically attractive for the smallholder farming community. The target of doubling farmers' income by 2022, though apparently not easy yet a very laudable goal, augurs well of Government's intention to help farmers. It is also clear that if concerted efforts, as per suggested action plan, are made in a Mission Mode, chances of making agriculture an engine of national economic growth and for smallholder farmers a respectable profession are indeed much brighter.
- On futuristic needs in livestock sector, unlike earlier days, wherein smallholder livestock production has been universal in the country, recent days witness a gradual transformation to semi-commercial or commercial mode. The requirements for age old traditional production system and the current as well as future production system are not similar and the country need to equip for effective technological backstopping and efficient input delivery system besides facilitating favourable market and marketing network. Availability of superior germplasm in required numbers, quality inputs including frozen semen, feed and fodder, vaccines and other health measures, machineries for organized and large scale livestock farms and ensuring the quality of the produce are some of the areas wherein we need to have concerted efforts in terms of research, innovation and development, viz.: i) animal identification and performance recording; ii) conservation and improvement of indigenous animals; iii) climate resilient livestock production; iv) improving feed and fodder availability; v) animal health improvement and control of diseases; vi) special animal product economic zones; and vii) policy measures.
- The PJTSAU Hyderabad has initiated a unique skill-oriented enterprize building training program for young farmers under 35 years, known as 'Telangana Yuva Rythu Sagubadi' which has received high appreciation from the beneficiaries. Inspired by those successes PJTSAU, and later PAU Ludhiana Regional Workshop for motivating and attracting youth in agriculture. These workshops provided an opportunity to all stakeholders to interact and disease on this important issue and motivates them towards entrepreneurship options in agriculture.
- On retaining youth in agriculture, TAAS is working hard to motivate them. It has organized a regional workshop on 'Youth and Agriculture: Challenges and Opportunities' jointly with APAARI and the Pakistan Agricultural Research Council (PARC) in Islamabad on 23-24 October 2013, in collaboration with Global Forum on Agricultural Research (GFAR), International Maize and Wheat Improvement Center (CIMMYT), International Center for Agricultural Research in the Dry Areas (ICARDA), International Center for Research in the Semi-Arid Tropics (ICRISAT), International Food Policy Research Institute (IFPRI) and Bioversity International. The key points that emerged from the regional consultation were: (i) reorientation of agriculture to agricultural research for results (AR4R) by promoting agri-innovation; (ii) agri-business and entrepreneurship through involvement of youth at national, regional and international

levels; (iii) urgently linking agriculture with health, environment, nutrition and other basic science disciplines to address challenges by young professionals; (iv) focusing attention on capacity development of youth through vocational training; (v) inclusion of agricultural education in the school curriculum and farmers' participatory approach to technology generation; and (vi) transfer and adoption to ensure faster growth in agriculture. Innovative approaches to developing and transferring technologies, efficient funding mechanisms, openness in knowledge-sharing, much-required marketing reforms and partnership at national and regional level are important areas to pursue; and to make agriculture intellectually rewarding for youth, special emphasis is needed on secondary agriculture, diversification, protected cultivation, crop intensification and use of ICT.

- TAAS has developed an Action Plan to integrate and empower women for inclusive growth and development through an enduring global partnership program on gender in agriculture. Such Action Plan needs emphatic interventions by national and international agencies to ensure enhanced involvement and access of resources to women. It was felt that considering the urgency of addressing the gender- related issues in agriculture globally, a common knowledge sharing platform on gender 'Gender in Agriculture Platform for Gender in Agriculture Partnership (GAP4GAP) is needed, which helps in collaborative working at the national, regional and global level. The platform involves partnership from research and developmental organizations, national governments, regional and global fora, multilateral development agencies and donors and should act as knowledge repository and provide space for both policy research and advocacy on gender-related issues in farming systems and rural ecologies. The GAP4GAP can provide technical backstopping, guide for future investments, and facilitate effective networking and collaboration among partners and stakeholders. The gender-related initiatives would need generation and documentation of gender segregated data, linking women's role to health and nutritional security at the household level, enhanced visibility for role of women, generation of knowledge and evidence for support and contextualization of global issues to suit local needs. Such new programs on gender empowerment would require adequate resources for mobilizing women, forming groups, improving capacity and capability in technical, organizational and commercial (business micro-enterprises) sector and support systems (credit, inputs, markets). These should be prepared jointly in consultation with women, other relevant organizations (public, private and voluntary), which can potentially complement and supplement the efforts of other stakeholders.
- There is need for urgent action at the national, regional and international levels for collective advocacy to raise awareness of women's needs in agriculture and to ensure their visibility in terms of valuable contribution towards agricultural development. They need to be educated and empowered to make their own choices for better farming options and for responding to new opportunities for diversified agriculture and better living. Women's ability needs to be increased in order to enable them to actively participate in the development processes by changing their perceptions and increasing awareness for greater social responsibilities. There is a need for encouraging collective action and leadership among women to develop programs that directly address women's needs and to make agricultural support systems gender-sensitive. Sincere efforts need to be made for removing drudgery of farm women by ensuring access to new tools and implements that increase efficiency and higher productivity. Also, reorient agricultural research and innovation for development (ARI4D) agenda to be gender-sensitive and pro-women. An urgent attention is needed to address the discrimination through appropriate policies, legislation, enforcement mechanisms and establishing women's rights (e.g. access to markets, ownership of land). It must be ensured that the institutions and legal support mechanisms are in place to promote women's ownership and control of resources (e.g. land, bank accounts, farm implements). Social, educational and cultural institutions also must change to create an environment where women realize their full potential. Engendering farm-women thus is a high national priority. For this, investment in women's human capital through education and training for skill development is very critical for productive use of their abilities, time and energy.
- To fulfil food and nutrition needs of the growing population combined with depleting and deteriorating natural resources and emerging challenges of climate change and thereby for sustainably enhancing crop productivity and nutritional quality, the potential of biotechnology need to be harnessed. For that, there is an urgent need for appropriate policy support, enabling environment and a clear Road Map to move forward. In this context, urgent action on the following recommendations is warranted: i) prioritizing biotechnology for food and nutritional security, ii) R&D priorities, iii) biosafety regulatory and IP management, and iv) public awareness.

Public Awareness

- TAAS has been regularly publishing several strategy papers/ lectures of eminent scientists and the proceedings of national conferences/workshops/ seminars/brainstorming sessions and dialogues organized on subjects of national importance. So far, TAAS has organized 41 national/international dialogues/workshop, 6 policy dialogues and published 20 strategy papers, 11 Foundation

Day Lectures, 4 Special Lectures and 2 Success Stories. These have been circulated to all concerned stakeholders and special efforts have been made to create much needed public awareness on issues of immediate relevance. All these documents have been posted regularly on TAAS website for the benefit of scientists, farmers and other key stakeholders.

- On the basis of recommendations emerging out of a national dialogue on improving soil health conditions, needed public awareness concerning the conservation and sustainable use of natural resources, such as land, water and agrobiodiversity has been created for increased production, profitability, environmental sustainability and improved livelihood of smallholder farmers.
- The scientists, policy makers, farmers and other stakeholders have been sensitized through national debate towards sustainable diversification of agriculture through reorientation towards "farming systems' mode" by integrating crops, livestock, and fisheries to improve both farm productivity and profitability. Also,awareness about soil test based use of fertilizers to overcome existing imbalance of nutrients/micro-nutrients in the soil has helped in ensuring rational use of need based nutrients/fertilizers.
- Urgent need has been stressed for outscaling the innovations that save inputs and enhance income of the farmers such as: conservation agriculture, plastic mulching, direct seeding of rice, alternate furrow irrigation, micro-irrigation, fertigation, IPM etc. Also, attention of policy makers has been drawn towards faster adoption of small farm mechanization for achieving much needed resilience in agriculture.
- Necessary knowledge has been disseminated and awareness created about the judicious use of water through required pricing of water and agricultural diversification through scientific land use planning involving crops, horticulture, agro-forestry and silvi-pastoral approaches and promotion of micro-irrigation systems in place of existing practice of flood irrigation for improved water-use efficiency.
- TAAS was instrumental in organizing the first ever Global Conference on Women in Agriculture with participation of 760 delegates from more than 37 countries. Through this, the specific problems of women engaged in agriculture were emphasized and suitable strategies suggested to overcome their drudgery in farm operations through appropriate technological interventions, engendering (through capacity building) and empowering them with in-depth knowledge, legal rights, needed policies and proper incentives. It also became evident that empowering farm women will not only help in increasing farm production by almost 20 per cent but would ensure household nutrition security being a major concern in the present context.
- Considering the current challenge of retaining youth in agriculture, TAAS could catalyze the National Agricultural Research System (NARS), especially the ICAR, to engage youth in agriculture and evolve progressive strategies to attract them towards secondary/ specialty agriculture by ensuring much needed vocational training and bank credits. The proposal to make them technology agents/service providers and or input/implement providers, entrepreneurs for value addition and primary processing and also for linking farmers to market is currently receiving due attention of policy/decision makers.
- The researchers, policy makers, and development officials have been sensitized to up-scale and out-scale farmer led innovations, which are cost-effective, sustainable and useful to them for increasing both production and profitability. Also efforts are now on to create an Agriculture Innovation Fund by the ICAR so as to scientifically validate and promote large scale adoption of useful technologies as well as to train enterprising farmers, especially the women and youth.
- In order to address the concerns of farmers, some of the states have already been catalyzed to establish Farmers' Commission and take progressive steps to come out with state agriculture policies.
- For open access to knowledge, which farmers need urgently, a National Agriculture Information System (NAIS) is being created and efforts are on to provide need based knowledge to the farming community through use of ICT, smart phones and media. In this context, long standing recommendation of TAAS for a dedicated TV channel on agriculture has now recently been made effective so that farmer gets much need timely knowledge on all aspects from 'plough to plate'.
- In order to address effectively the adverse effects of climate change and also the weather related calamities, the recommendations to promote climate smart agriculture, crop as well as livestock insurance, seed banks, credit at low interest, immediate compensation using GIS based weather data and on the spot quick assessment are being considered critical to redress the grievances of small holder farmers.
- Importance of increasing wheat production to a level of 100 mt by 2015 was emphasized through a dialogue in 2010 and a Road Map drawn to catalyze the system. Accordingly, pushing aside the setback to crop due to weather aberrations in several states, this goal is likely to be achieved well within time.
- Awareness about importance and relevance of GM crops for Indian agriculture has been created through national dialogue and relevant publications. Efforts have also been made to change the public perception based on scientific reasoning and informed knowledge concerning the benefits of technology to both farmers and consumers.

Also the need for efficient regulatory system and specific role of ICAR in the conduct of confined field trials and ultimate release of GM crops for general cultivation in the national interest has been emphasized. Accordingly, the needed steps have now been taken in this regard by both DBT and ICAR.

- Also, the process of public-private-partnership has been catalyzed to ensure quick delivery of results to the end users. Accordingly, some institutions and universities have taken up steps for building public-private partnerships for out scaling innovations. As such, different models of PPP have been put in place.
- Awareness concerning use of soybean as a food crop to overcome protein malnutrition, being very important concern in India, has been generated. Also its use through various food products (flour, *tofu*, milk, oil, puffs, biscuits, ice cream etc.) through promotion of small scale industry and producer companies has been advocated, for which role of research institutions/universities/KVKs has been highlighted. Also, the need for the creation of a Soybean Board has been emphasized.
- Twenty strategy papers brought out on topics of considerable importance which include crucial information on subjects like increasing productivity growth rate in agriculture, imperatives of Global climate change for agricultural research in Asia-Pacific, efforts for food and nutrition security, revitalizing Indian seed sector for accelerated agricultural growth, Implementing International Treaty to managing PGR, a way forward for Indian seed sector, managing water resource for increased efficiency, Challenges and opportunities in Indian oilseeds, linking research with extension for accelerated agricultural growth in Asia, on doubling maize production, livestock development, achieving sustainable development goals (SDGs), strategy for doubling farmers' income, women empowerment for agricultural development, motivating and attracting youth in agriculture,scaling agricultural innovations to meet SDGs, horticulture for food and nutritional security, and crop biotechnology for ensuring food and nutritional security. Most of them are authored by Dr. R.S. Paroda who is an accomplished plant breeder and geneticist and is known for his analytical thinking as well as vision on agriculture related matters. His vast experience at national, regional and global level is reflected in these strategy papers which TAAS has been fortunate to publish and disseminate widely. A few strategy papers were attempted by other eminent experts and research managers as well. The detailed strategy papers are also available on the TAAS website: www.taas.in.
- Recently, a new feature to convey research results of successful entrepreneurs in the form of success stories. A success story is a valuable learning tool to the rest of the team. It may also give insights into how customers used the given solution and how it impacts their business. Success stories are also the ones which encourage other people to keep walking on their own chosen paths. TAAS has so far developed two success stories and several are in pipeline which will be published in due course of time. Success story on 'Biofertilizers and Biopesticides for Enhancing Agricultural Production' Farmer-Friendly Initiatives of Developing Products" have resulted in ensuring sustainability with productivity and profitability through well-developed R&D efforts, Criyagen has developed a wide range of solutions to give farmers the needed confidence to grow more low cost and high quality ecofriendly products. The innovative products are the result of constant improvement and the investment in the R&D. The R&D Department at Criyagen seeks new solutions to existing problems keeping farmers' needs and sustainability in mind. The strong research orientation ensures that implementation of tomorrow's solutions is planned today. The avowed vision in establishing Criyagen as an Agri and Biotech Company has been to finding right solutions for making agriculture a sustainable business proposition with a farmer becoming an entrepreneur. The success story on "Fish farming in North India" describes background information of fish farming, about its initial establishment, infrastructure and strengthening, production scenario, value addition and marketing, economic returns, constraints observed and lesson learnt, key factors of success, impact of work and possible suggestions etc. Being a farmer Shri Sultan Singh, Padma shri awardee, believes that every farmer of India has got some hidden talent in the field of agriculture. To bring out this talent, he shares his experience and expertise with other farmers to boost their morale and adopt fish farming as a profession. Since 1983 when fish farming was adopted as a profession and convinced with his achievements in this business, more than 20,000 farmers started fish farming throughout the country. They all are highly satisfied with this endeavor and earning their livelihood comfortably. Around 20,000 farmers from all over India have been trained from 2001-2020 free of cost in innovative fisheries technologies. They all are benefitted by seeing the infrastructure and also gaining knowledge on various aspects of fish farming.

Networking for Harnessing Science

- The TAAS has networking of various players and stakeholders, and organizes number of activities through National/International Consultations/ Brainstorming Sessions/Symposia/Seminars/ Dialogues/Workshops on topics of contemporary importance in collaboration with national, regional and international organizations, foundation day/ special lectures by the leading scientists/social workers, with established record of scientific

and agro-social achievements, bringing out publications on policy/strategy papers/success stories on thematic areas of national importance, conferring specific awards to encourage young scientists in different fields of agricultural science, and recognising innovative practices developed by the farmers that have led to improved farming practices/higher yields and farmers' income/ resource conservation/ environment protection, etc.

- TAAS also discusses issues of national importance such as genetic resource conservation through use, regulatory mechanisms for GM crops, increasing farm productivity, outscaling conservation agriculture (CA), promoting farmer-led Innovations, linking farmers to markets, promoting Public-Private Partnerships (PPPs), soybean and QPM maize, linking research with development, role of women in agriculture, promoting agricultural innovations and value chains, retaining youth in agriculture, building leadership, agricultural knowledge management and sharing, managing climate change and soil health, policy advocacy for creating enabling environment for GAP and resilience in agriculture, regional and sub-regional partnerships for ARI4D; and discussion on national Issues, such as, New Seed Bill/Pesticide Management Bill, Weed Management, etc. among several others.

Conferring Awards for Outstanding Achievements in Agriculture

- The TAAS has instituted an award known as "Dr. M.S. Swaminathan Award for Leadership in Agriculture" in recognition of immense service rendered by Dr. M.S. Swaminathan, a great visionary and the father of Green Revolution in India, as also acknowledged in Hon'ble Prime Minister's speech at the 88th Indian Science Congress (ISC). The award is given annually to an eminent scientist across the world (either from India or abroad) for his/her leadership qualities and outstanding contributions towards overall agricultural growth in the developing countries, especially in India. TAAS has conferred so far ten (10) such awards and the eleventh and twelfth awards will be conferred during first half of 2021. Eleventh and twelfth awards are to be conferred during mid-2021. Details are available in Chapter 9 and on TAAS website (www.taas.in).

Box 5: HIghlights of Achievements and Impact of TAAS Activities

- DHAD&F took action to create a 'National Mission on Livestock' in the 12th Five Year Plan for accelerating livestock development in India. Further, a 'Rashtriya Gokul Mission' was launched in 2014 by the new government, in line with the 'Ranchi Declaration' to conserve and develop indigenous bovine breeds, including through financial and technical support to Goshalas.
- DBT initiated action to create a Biotechnology Regulatory Authority of India (BRAI) for a single window regulatory clearance of GM crops in India. The Bill was introduced on April 22, 2013 and is currently lapsed thus reiterating the need for a fresh action. Similarly the Agricultural Biosecurity Bill, 2013 has lapsed, which requires another attempt. Overall, there was swing in the moods and environment for the acceptance of GM food crops in the country despite tremendous success of cotton. This needs perseverance and enhanced awareness generating campaign to develop a congenial environment for the acceptance of GM technology products in food crops as well.
- DoAC initiated action on the revision of Seeds Act. The Revised Seed Bill was introduced in Parliament on December 9, 2004 and amended on November 9, 2010. It is still under consideration of Parliament. In the meantime, the Protection of Plant Varieties and Farmers Rights Act, 2001 was passed and implemented; the National Seeds Policy, 2002 was brought out and a National Biotechnology Development Strategy (in agriculture) was prepared.
- Actions by DoAC and the Protection of Plant Variety and Farmers' Rights Authority (PPV&FRA) have catalyed the functioning of PPV&FRA, establishment of Gene Fund under the Act, and the implementation of Farmers' Rights.
- Action taken by ICAR led to the establishment and successful implementation of a 'National Advisory Board on Genetic Resources Management' under the chairmanship of Dr. R.S.Paroda. This has prompted in the development and implementation of guidelines for managing plant and animal genetic resources through SMTA, and promotion of systematic genetic resource management of fish, and agriculturally important insects and microbes.
- Actions by DoAC and ICAR have resulted in the mass scale adoption of ICT for knowledge dissemination and extension/communication with farmers. ICAR has established a super computer 'ASOKA' for contributing to the national agricultural information system (NAIS).

- Action by ICAR in the development of IPR management guidelines and technology commercialization has been instrumental in developing and promoting Public-Private Partnerships in agricultural research and technology transfer.
- Actions by DoAC and ICAR have been instrumental in the inclusion of quality proteing maize (QPM) in Food Security Mission, and promotion of Soybean for Nutritional Security besides the promotion of hybrids and replacement of hybrid seeds.
- Action by the National Academy of Agricultural Research Management (NAARM) resulted in the launching of Executive Development Programme (EDP) and Management Development Programme (MDP) for the middle level and senior research managers.
- Actions by some of the states have led to the establishment of State Farmers' Commission and/or Agricultural Advisors to Chief Ministers for taking progressive steps to address the concerns of farmers, pp-scaling the farmer-led Innovations, linking farmers to markets, and come out with state agriculture policies.
- Educating public on critical issues has been addressed in many ways, including through the dissemination of TAAS strategy papers.
- The Protection of Plant Varieties and Farmers' Rights Act, 2001 was passed by the Parliament and the same is being implemented. The process for creation of office and proper functioning of PPV&FRA was also accelerated by DoAC when urgency for same was highlighted especially when it was getting delayed for more than 5 years after the approval of PPV&FRA. Also a Seed Mission has been launched in the 12th Plan by the Government to improve crop productivity.
- The Revised Seed Bill was introduced by Department of Agriculture and Cooperation (DoAC) in the Parliament on December 9, 2004 and subsequently amended on November 9, 2010. Same as under consideration for approval.
- Maize has been included in the Food Security Mission by the DoAC based on strong recommendations made by TAAS. Accordingly, maize production is showing highest growth rate now among cereals.
- Efforts have been accelerated to promote Public-Private Partnership (PPP) by ICAR and the State Agricultural Universities (SAU) for non-exclusive licensing of innovations in agriculture.
- Open access for knowledge sharing to the farmers through ICT and other communication means has been given high priority both by DoAC and ICAR. The demand to have a dedicated channel for agriculture has recently been met by the Government.
- Some States have taken progressive steps to establish State Farmers' Commission for addressing the concerns of farmers and to provide needed incentives for out-scaling innovations for improving their livelihood.
- Promoting soybean as a food crop and to ensure nutritional security Necessary steps have been taken by the Government to promote soybean and quality protein maize (QPM) as food crops to address the major current concern of protein malnutrition of children below 5 years of age.
- To accelerate growth of animal sector and to ensure genetic enhancement of indigenous livestock breeds, Ministry of Agriculture has launched a Livestock Mission under the 12 Five Year Plan.
- In order to link farmers to market, the Agricultural Produce Marketing Committee (APMC) Act is being revised by the State Governments especially to delink perishable items such as vegetables, fruits and flowers.
- Promotion of hybrids/ HYVs in major field crops should be a high priority to bridge the productivity gap and increase production. In this context, the private sector has to play a major role, as seen in case of maize.
- Partnership between the public research institutions and private sectors are also desired in establishing Technology Parks in different regions to outscale innovation and disseminate technologies for the benefit farmers.
- Doubling of production is needed due to demand pull for meeting feed, food and industrial requirements and it can be achieved by comparative strong techno- economic competitiveness to export grains and seeds by developing climate resilient single cross maize hybrids suitable for kharif season and by bridging gap between realized yield and potential yield

- A recent study indicated that the overall consumption of pulses would increase by 10 per cent by 2020 and 23 per cent by 2030. The increased demand for consumption would necessitate yield increase of 70 kg/ha by 2020 and by 120 kg/ha by 2030. Application of science and technology, along with effective technology transfer and policy and institutional support to farmers, should make this target reachable.
- BISA's key areas of research like those expressed in this paper have included genomic selection for heat stress tolerance in maize and wheat, conservation agriculture in wheat based cropping systems, water saving technologies, and the development of farm machinery.
- Ensuring meaningful engagement of all stakeholders in the formulation of national strategies, implementation plans and monitoring of the progress towards achieving SDGs, using baseline data for defined goals to be a national priority.
- A National Mission on 'FARMERS' First', with an annual allocation of INR 10,000 crores to begin with and by merging/clubbing of various central schemes as well as through some new initiatives to empower farmers need to be initiated soon. This will help in catalyzing the activities/ programs specifically designed for scaling innovations that will increase farmers' income and have direct impact on smallholder farmers through adoption of three pronged strategy defined earlier.
- The success of 'Yellow Revolution', achieved through mission mode approach of TMOP during eighties, fully justifies revival of Oilseeds Mission approach with greater zeal and commitment of all to tide over the present crisis of large scale import of edible oils. Hence, we must have clear national policy of bridging the yield gaps and increased oilseeds production with specific aim to reduce our vegetable oil imports.
- There is an urgent need for updating knowledge of stakeholders on the importance and recent developments in indigenous breed conservation and improvement for wider dissemination and application of frontier technologies to conserve the valuable germplasm in the modern era of intellectual property right (IPR) and climate change.
- Policy proposals to overcome the world food and agricultural crisis are composed of three sets of needed complementary actions: i) promotion of agricultural growth, ii) reduction of market volatility, and iii) expansion of social protection and child nutrition action.
- In horticulture, initiatives like exploitation of genetic materials, achieving self-sufficiency in healthy planting materials, improving availability of horticultural produce, increasing productivity, reducing cost of production, risk management, improving quality and food supply, promoting alternate horticulture systems/ urban and peri-urban horticulture, pre and post harvest management &value addition, horticulture for health and nutrition /emphasis on settling-up of Farmers' Producers Organization, and improving transfer of technology and skill development in horticulture have been suggested.
- There is a need for collective advocacy to raise awareness of women's needs in agriculture and to ensure their visibility in terms of valuable contribution towards agricultural development. Women need to be educated and empowered to make their own choices for better farming options and for responding to new opportunities for diversified agriculture and better living.
- There is an urgency to have a 'National Mission on Youth in Agriculture' with an aim to impart better knowledge and skill to youth on: i) sustainable, secondary and specialty agriculture, ii) efficient knowledge dissemination, including information communication technology (ICT), iii) technical backstopping for innovative farming, iv) new agribusiness models, and v) entrepreneurship as well as linking farmers to markets through value chain
- There is need for a paradigm shift from narrow focus on 'youth as a farmer' to 'youth for value chain development'. To provide better economic opportunities for rural youth in the changing agricultural scenario, there is an obvious need to move beyond the plot/field level agriculture i.e. from production to post-production level and to link with market for better income opportunities.

11 TAAS Publications

2021

1. Policy Brief : Harnessing Genome Editing for Crop Improvement - An Urgency. May, 2021
2. Accelerating Science-Led Growth in Agriculture: Two Decades of TAAS. May, 2021
3. A Road Map on Stakeholders Dialogue on Strategies for Safe and Sustainable Weed Management, January, 2021

2020

4. Fish Farming in North India-A Success Story by Dr Sultan Singh, December 2020
5. Dr MS Swaminathan Award for Leadership in Agriculture-A Compendium, October 2020
6. A Road Map on Stakeholders Dialogue on Current Challenges and Way Forward for Pesticide Management, September, 2020.
7. A Road Map on Stakeholders Dialogue on Way Forward for the Indian Seed Sector, June, 2020.
8. Biofertilizers and Biopesticides for Enhancing Agricultural Production – A Success Story by Dr Basavaraj Girennavar, June, 2020.

2019

9. A Road Map on Policy Framework for Increasing Private Sector Investments in Agriculture and Enhancing the Global Competitiveness of Indian Farmers, December, 2019.
10. Crop Biotechnology for Ensuring Food and Nutritional Security – Strategy Paper by Dr J.L. Karihaloo and Dr R.S. Paroda, December, 2019.
11. National Dialogue on Land Use for Integrated Livestock Development –Proceedings and Recommendations, 1-2 November, 2019.
12. Horticulture for Food and Nutritional Security - Strategy Paper by Dr K.L. Chadha and Dr V.B. Patel, October, 2019.
13. Urgency for Scaling Agricultural Innovations to Meet Sustainable Development Goals (SDGs) – Strategy Paper by Dr R.S. Paroda, April, 2019.
14. Tenth Foundation Day lecture on "Can India Achieve SDG 2 – Eliminate Hunger and Malnutrition by 2030" by Dr Prabhu Pingali, Professor in the Charles H. Dyson School of Applied Economics and Management at Cornell University, January 24, 2019.

2018

15. Motivating and Attracting Youth in Agriculture - Strategy paper by Dr R.S. Paroda, November, 2018.
16. Road Map on Motivating and Attracting Youth in Agriculture (MAYA), November, 2018.
17. Regional Conference on Motivating and Attracting Youth in Agriculture (MAYA) - Proceedings and Recommendations, August 30-31, 2018.
18. Brainstorming Meeting on Harnessing Intellectual Property to Stimulate Agricultural Growth – Proceedings and Recommendations, July 27, 2018.
19. Women Empowerment for Agricultural Development - Strategy Paper by Dr R.S. Paroda, May, 2018.
20. Policy Brief on Agricultural Policies and Investment Priorities for Managing Natural Resources, Climate Change and Air Pollution - April, 2018.
21. Strategy for Doubling Farmers' Income - Strategy Paper by Dr R.S. Paroda, February, 2018.
22. Livestock Development in India - Strategy Paper by Dr A.K. Srivastava, Member, ASRB & Trustee, TAAS, February, 2018.

2017

23. Policy Brief on Scaling Conservation Agriculture in South Asia, December 2017.
24. Indian Agriculture for Achieving Sustainable Development Goals -Strategy Paper by Dr R.S. Paroda, October, 2017.
25. Retrospect and Prospect of Doubling Maize Production and Farmers' Income – Strategy Paper by Dr N.N. Singh, September 10, 2017.
26. Regional Policy Dialogue on Scaling Conservation Agriculture for Sustainable Intensification, Dhaka, Bangladesh, September 8-9, 2017.
27. Policy Brief on Efficient Potassium Management in Indian Agriculture,August 28-29, 2017.
28. National Conference on Sustainable Development Goals: India's Preparedness and Role of Agriculture, May 11-12, 2017.

2016

29. Delhi Declaration on Agrobiodiversity Management – Outcome of International Agrobiodiversity Congress 2016, November 6-9, 2016.
30. Awareness-cum-Brainstorming Meeting on Access and Benefit Sharing –Striking the Right Balance – Proceedings, October 22, 2016.
31. Round Table Discussion on Promoting Biotech Innovations in Agriculture and Related Issues - Proceedings & Recommendations, August 4, 2016.

2015

32. National Dialogue on Innovative Extension Systems for Farmers' Empowerment and Welfare - Road Map for an Innovative Agricultural Extension System, December 17-19, 2015.
33. Regional Consultation on Agroforestry: The Way Forward - New Delhi Action Plan on Agroforestry, October 8-10, 2015.
34. National Dialogue on Efficient Management for Improving Soil Health -Soil Health Declaration, September 28-29, 2015.
35. The Ninth Foundation Day Lecture on "21st Century Challenges and Research Opportunity for Sustainable Maize and Wheat Production" by Dr Thomas A. Lumpkin, Former DG, CIMMYT, September 28, 2015.
36. Recommendations of Brainstorming Workshop on "Up-scaling Quality Protein Maize (QPM) for Nutrition Security", May 20-21, 2015.

2014

37. Strategy Paper on "Need for Linking Research with Extension for Accelerated Agricultural Growth in Asia" by Dr. R.S. Paroda. September 25, 2014.
38. The Eighth Foundation Day Lecture on "Sustainable Agricultural Development – IFAD's Experiences" by Kanayo F. Nwanze, President, IFAD, August 5, 2014.
39. Recommendations of Brainstorming Workshop on "Soybean for Household Food and Nutrition Security", March 21-22, 2014.
40. Proceedings of Brainstorming Workshop on "Strategy for Conservation and Productivity Enhancement of Farm Animal Genetic Resources", January 10, 2014

2013

41. Proceedings and Recommendations of National Workshop on "Outscaling Farm Innovation", September 3-5, 2013.
42. Strategy Paper on "The Indian Oilseed Scenario: Challenges and Opportunities" by Dr. R.S. Paroda. August 24, 2013.
43. Proceedings and Recommendations of Brainstorming on "Achieving Inclusive Growth by linking Farmers to Markets, June 24, 2013.
44. A Brief report of Dr. M.S. Swaminathan Award function, June 24, 2013.
45. Strategy Paper on "Managing our Water Resource for Increased Efficiency" by Dr. R.S. Paroda, May 28, 2013.
46. Proceedings and recommendations of "Foresight and Future Pathways of Agricultural Research through Youth", March 1-2, 2013.
47. Special lecture delivered at Indian Seed Congress 2013 on "Indian Seed Sector: The Way Forward" by Dr. R.S. Paroda, February 8, 2013.
48. The Seventh Foundation Day Lecture on "Ensuring Food and Nutrition Security in Asia: The Role of Agricultural Innovation" by Dr. Shenggen Fan, DG, IFPRI, January 11, 2013.

2012

49. Proceedings and Recommendations of Global Conference on "Women in Agriculture", March 13-15, 2012.
50. The Sixth Dr. M.S. Swaminathan Award Lecture on "Challenges and Opportunities for Food Legume Research and Development" by Dr. M.C. Saxena, January 25, 2012.
51. Strategy Paper on "Implementing the International Treaty to Address Current Concerns about Managing our Plant Genetic Resources" by Dr. R.S. Paroda, January 23, 2012.

2011

52. Proceedings of Farmers' Led-Innovation, December 23-24, 2011.
53. Proceedings of International Conference on "Innovative Approaches for Agricultural Knowledge Management: Global Extension Experiences", November 9-12, 2011
54. TAAS Foundation Day Lecture on "Harnessing Knowledge for India's Agricultural Development" by Dr. Uma Lele, August 12, 2011.
55. Recommendations of Stakeholders' Interface on GM Food Crops May 19, 2011.

2010

56. Proceeding and Highlights of Brainstorming Session on Prospects of Producing 100 million tons of Wheat by 2015 and presentation of Fifth Dr. M.S. Swaminathan Award for leadership in Agriculture, December 18, 2010.
57. NSAI Foundation Day Lecture on "Revitalizing Indian Seed Sector for Accelerated Agricultural Growth", by Dr. R.S. Paroda, October 30, 2010.
58. Proceedings and Recommendations of National Dialogue on Building Leadership in Agricultural Research Management, Hyderabad, August 27-28, 2010.

59. TAAS Foundation Day Lecture on "Climate Change and Food Security: From Science to Sustainable Agriculture" by Dr. Mahendra M. Shah, May 7, 2010.
60. Proceedings and Recommendations of National Seminar on "Quality Seed for Food Security through Public-Private Partnership", April 13-14, 2010.
61. Millions Fed: Proven Successes in Agricultural Development jointly published by IFPRI, APAARI and TAAS, January 19, 2010.

2009

62. Intensive Efforts Needed for Food and Nutrition Security - Strategy Paper by Dr. R.S. Paroda, November, 2009.
63. Imperatives of Global Climate Change for Agricultural Research in Asia-Pacific - Strategy Paper by Dr. R.S. Paroda, November, 2009.
64. Proceedings and Recommendations of Brainstorming Workshop on "Climate Change, Soil Quality and Food Security", August 11, 2009.
65. Ranchi Declaration - Brainstorming Workshop on 'Strategy for Conservation of Farm Animal Genetic Resources', 10th – 12th April, 2009.
66. Proceedings and Recommendations of Brainstorming Workshop on "Emerging Challenges before Indian Agriculture - The Way Forward", March 6, 2009.
67. Fourth Foundation Day Lecture on "Overcoming the World Food and Agriculture Crisis through Policy Change, Institutional Innovation and Science" delivered by Dr. Joachim von Braun, Director General, International Food Policy Research Institute, Washington, March 6, 2009.

2008

68. Proceedings and Highlights of National Symposium on Quality Protein Maize for Human Nutritional Security and Development of Poultry Sector in India and Presentation of the Third Dr. M.S. Swaminathan Award for Leadership in Agriculture, May 3, 2008.

2007

69. Proceedings of Symposium on "Farmer-Led Innovations for Sustainable Agriculture", December 14-15, 2007.
70. Highlights and Recommendations of Brainstorming Session on "Models of Public-Private Partnership in Agricultural Biotechnology ", April 7, 2007

2006

71. Highlights and Recommendations of Farmer-Led Innovations Towards Plant Variety Improvement, Conservation and Protecting Farmers' Rights", November 12 - 13, 2006.
72. A brief report on the Second Dr. M.S. Swaminathan Award for Leadership in Agriculture, October 9, 2006.
73. Strategy for Increasing Productivity Growth Rate in Agriculture" - Strategy Paper by Dr. R.S. Paroda, August, 2006.

2005

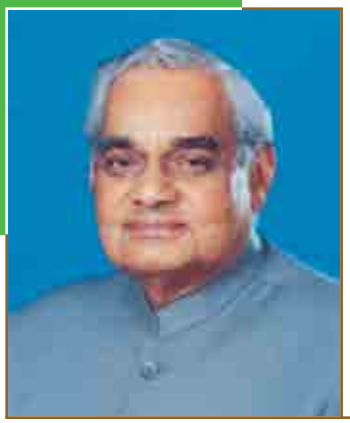
74. Highlights and Recommendations of Brainstorming Session of Farmer-Led Innovations for Increased Productivity, Value Addition and Income Generation -, October 17, 2005.
75. Second Foundation Day Lecture on "Public-Private Partnership in Agricultural Biotechnology" delivered by Dr. Gurdev S. Khush, Adjunct Professor, University of California, Davis, USA, October 17, 2005.
76. Highlights of First Dr. M.S. Swaminathan Award for Leadership in Agriculture, March 15, 2005.
77. Recommendations of National Workshop on Role of Information Communication Technology in Taking Scientific Knowledge/Technologies to the End Users, January 10 - 11, 2005.
78. Highlights and Recommendations of Brainstorming Session on Role of Science and Society towards Plant Genetic Resources Management - Emerging Issues, January 7 - 8, 2005.

2004

79. Special Lecture on Challenges in Developing Nutritionally Enhanced Stress Tolerant Germplasm delivered by Dr. S.K. Vasal, Distinguished Scientist, CIMMYT, Mexico, January 15, 2004.

2003

80. Brainstorming Session on Enabling Regulatory Mechanisms for Release of Transgenic Crops, October 18, 2003.
81. First Foundation Day Lecture on Regulatory Measures for Utilizing Biotechnological Developments in Different Countries, delivered by Dr. Manju Sharma, Secretary, Department of Biotechnology, Government of India, October 17, 2003.



FORMER PRIME MINISTER OF INDIA | SHRI ATAL BIHARI VAJPAYEE

Speech

January 3, 2001, New Delhi

Prime Minister Shri Atal Bihari Vajpayee Inaugurates 88th Session of Indian Science Congress

The following is the text of the speech of the Prime Minister, Shri Atal Bihari Vajpayee at the inauguration of the 88th Session of Indian Science Congress here today:

It gives me great pleasure to participate in this important annual event of Indian science and be in the midst of a distinguished assembly of scientists. I convey my best wishes to all of you for the New Year that has just begun.

Of the many forces that will shape human history in the new millennium, science and technology will perhaps be the most potent. We know how science and technology have changed the complexion of the world in the last couple of centuries of the last millennium. But this is just the beginning of a long and exciting voyage. All the discoveries of science and all the inventions of technology so far amount to the arrival of just a couple of stars in a sky of countless stars that are yet to appear.

How true was Newton when he confessed, in spite of all his epochal discoveries, that he felt like a boy on the seashore who found just a pebble or a shell, whilst the great ocean of knowledge lay all undiscovered before him.

The sky of science belongs to the entire mankind. No part of it can be a monopoly of any single nation. That is how it should be. If science has the power to benefit man, then that power should be accessible to men all over the world. Nevertheless, every nation on this planet, and certainly a big and ancient nation like ours, is required to ask itself: 'How many stars in the sky of science have we caused to appear? How much have we contributed to the advance of scientific knowledge and to the betterment of life? And what plans have we drawn up for its progress in the future?'

Today we pay our tributes to all the visionaries of the past century who built a strong edifice of science and technology in India. We should pledge to not only strengthen the institutional base that they have created, but also to further expand it to make India a front-ranking scientific power in the new century.

Since the theme of your session is 'Food, Nutrition & Environmental Security', I cannot but remember with deepest gratitude and admiration the name of my friend, Bharat Ratna C. Subrahmaniam, who passed away recently. He, along with Dr. M.S. Swaminathan, who is in our midst today -- was the principal architect of the Green Revolution, which ensured India's self-reliance in food production. Subrahmaniam retained his interest in new developments in science and technology until the very end of his long life and used to regularly give me useful suggestions. India needs many more such top-class administrators with a multi-dimensional vision.

The theme of your session this year is most appropriate for it simultaneously impacts on many of India's critical developmental priorities. I compliment our hard-working kisans for steadily increasing the country's food production. Today we are facing a shortage not of food, but of facilities to store food. If India was able to withstand economic sanctions following Pokharan-II, a major part of the credit must go to our talented scientists, including our agriculture scientists.

Having achieved food sufficiency, our aim now is to achieve food security for all our citizens. The percentage of our population living below the poverty line has come down, and we have overcome starvation. Our objective now is to overcome malnutrition. The new century will be the Century of Knowledge and the Century of Mind. However, if the brain does not develop properly in nearly one-third of our children who are undernourished, how will we be able to create those young minds that are essential to build India of our dreams in the 21st century? More than 50 percent of the pregnant women and children are anaemic. Vitamin and protein deficiencies are rampant. These realities overshadow our achievements and burden our national conscience.

At another level, the increases in food production that we have achieved in the past 3-4 decades have come at a cost to the agricultural environment. There has been both qualitative and quantitative degradation of land, water, and bio-resources. I have seen fertile lands that have become uncultivable due to waterlogging and salinization. I have seen areas where yields have come down because of wrong cropping pattern and faulty usage of fertilisers. I have also seen how excessive pumping of water has caused such acute depletion of water table that even drinking water has become scarce.

Environmental security is, therefore, no longer peripheral to the issues of food and nutritional security. Neglecting it yesterday has proved costly today; and could prove far costlier tomorrow. We must, therefore, step up our programmes on soil and water management, renewable energy sources, forest management, containment of chemicals and other pollutants, waste management, and conservation of bio-diversity for sustainability of Indian agriculture.

I urge the participating scientists to come up with comprehensive and useful recommendations to deal effectively with all the issues relating to food, nutrition, and environmental security. Accomplishing this task requires massive efforts in many areas that range from increasing crop yields to improving rural infrastructure; preventing huge wastage and losses that now characterise our food economy.

The government has taken some steps in this direction. The ambitious national rural roads project, which aims at providing all-weather road connectivity to over one lakh unconnected villages in the country in the next seven years, is one of them. Another recent initiative in food security is the Antyodaya Anna Yojana, under which wheat and rice will be provided at Rs. 2 and Rs. 3 per kg respectively to one crore poorest of the poor families.

The Government has unveiled a National Storage Policy under which private sector investment is encouraged for the construction of modern silos at 20 locations to take care of buffer stocks. We shall soon initiate steps to restructure the Food Corporation of India in order to reduce costs and introduce greater efficiencies in the procurement, storage, and distribution of foodgrains. I recognise, however, that many more steps are necessary to resolve the long-neglected problems at all points in the food chain. Towards this end, the Government has recently set up a high-level inter-ministerial Group on the Food Economy to unlock its huge potential to create employment, generate wealth at the grassroots and boost our agricultural exports. The group, which is headed by the Finance Minister, will consult experts from various fields.

The task of ensuring food, nutrition, and environmental security in a vast country like India is gigantic. And not all solutions to the problem lie in science technology, although your contribution will certainly be invaluable. What is needed is a collective and coordinated action among all those who are associated with our agriculture and the rest of the food economy. We know that Mother Nature yields the best crop only when all the necessary conditions are properly fulfilled. Similarly, kisans and rural credit institutions, Agriculture Universities and Krishi Vigyan Kendras, meteorological offices and marketing cooperatives, all have to work in perfect concert for us to achieve best results in the task before us.

In this endeavour, we will have to fully mobilise the vast pool of our people's traditional wisdom and knowledge, just as we have to employ new frontiers of scientific knowledge such as information technology, bio-technology, space science, nuclear science and genetic engineering. We should not be afraid to experiment with bold ideas. Green Revolution, for example, would not have been successful if our scientists had yielded to the resistance they faced. We are now entering the era of what is called 'precision agriculture', which is knowledge-intensive and uses the latest that science has to offer. India should take the lead in this.

We also have to close the vast distance that still separates the scientist from the kisan. Despite some commendable efforts of the Indian Council of Agriculture Research, 'Lab to Land' has still largely remained a nice-sounding slogan. I think that it needs to be supplemented with the reverse initiative of 'Land to Lab'.

For instance, I often wonder why there are so few facilities even for our most progressive farmers, who otherwise might have very little exposure to the formal educational system, to improve their theoretical and practical knowledge. If business executives and professionals can have short-term retraining courses specially designed for them, why not for our knowledge-hungry farmers? Lack of formalised agricultural education to practising farmers is, in my view, the weakest link in our farm strategy. There seems to be a well-entrenched misconception that a farmer needs no formal education in farm management. We must rectify this lacuna urgently to enrich the human resource in Indian agriculture.

Distinguished Scientists, let me now turn to some other critical issues before Indian science. During the last Science Congress Session in Pune, I had pledged that the Government would hike investments in R&D from the present level to 2% of GDP over the next five years. We have taken some specific steps in this direction, and many more will follow. The Finance Minister has earmarked Rs.50 crores for the India Millennium Missions to be executed by Technology Information, Forecasting and Assessment Council (TIFAC) and an additional Rs.50 crores for the New Millennium Technology Leadership Initiatives by CSIR. The message of these initiatives is clear and simple: India should be ahead of, and not lag behind, other nations in at least some areas of technology in the 21st century.

The challenges and opportunities of global competition in the emerging Knowledge Economy have placed a major task before the nation. It is the creation of a vast army of top-class professionals in science and technology, especially in information technology and bio-technology, to meet the demands of both the domestic and international markets. However, the ever-increasing demand for the Indian software professionals in India and abroad, along with the opening up of new career opportunities, has resulted in a lack of enthusiasm among young students for higher studies in science and careers in scientific research. Such a trend, if not arrested at this stage, may result in serious shortages of good quality teachers and research scientists.

To bridge this gap between demand and supply, the Government is seriously considering setting up a National Mission for Technology Education. It will aim to ramp up, on a crash basis, the facilities at IITs, RECs and other premier science and engineering colleges. It will also seek to bridge the gap between academia and industry on the one hand, and between teaching and research institutions on the other. To realise these objectives, we will take necessary measures to radically reform the governance structures of our higher education institutions and encourage the flow of philanthropic funds from alumni and the Indian Diaspora abroad.

In this context, I would like to make a special mention of the proposal by a group of highly successful Indian IT entrepreneurs in the United States to set up Global Institutes of Science and Technology. The Government will actively facilitate this and other such initiatives.

Removing the controls of bureaucrats is one of the pressing reforms needed to improve the governance structure of our research and higher education institutions. For Indian science to flourish, the administration and government officials should serve as facilitators of science and not as masters of scientists. I have said this before, but I feel it bears reiteration.

We need bold and unconventional initiatives also to seize the big new opportunities arising on the horizon. One of them is the information generated by the Human Genome Project in the open domain. It is now available to Indian scientists. Once the 'base' is established, it is the knowledge of 'variation' over the base that matters. India's vast human genetic diversity provides that knowledge, like no other country does. India already has a superb IT manpower and also people trained in biosciences. Thus, 'bioinformatics' is the next wave in which India should be in the vanguard. India caught up with the 'Silicon Valley' phenomenon rather late. Can we not create the new 'Genomic Valleys' of the twenty-first century?

I understand that these initiatives need huge investments, which cannot come from the traditional budgetary route alone. But the funding needs of Indian science can be adequately met by promoting an innovative public-private partnership. I am happy to note that the physical and intellectual infrastructure developed by the government at long last is being tapped by the Indian private sector to take a global lead. Indian businesses are beginning to respond to the opportunities in knowledge industry, rather than being oblivious to global S&T developments as in the past.

Distinguished Scientists, our goal to make India a leading scientific nation in the world in the new century hinges critically on how successfully we take science to the people and create a stronger scientific temper in our society. I appreciatively recall that last year's session at Pune turned out to not just 'Science Congress' but a 'People's Science Congress'. The 'Children's Science Congress', which was held simultaneously, was also a novel initiative. I am happy that this initiative has been taken forward by mobilising kisans in large numbers in this Session of the Indian Science Congress. I am sure that this trend will be further strengthened in the future.

With these words, I am happy to announce the formal inauguration of the 88th Session of the Indian Science Congress.

Thank you.

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Vision Document

VISION

on

Food, Nutrition and Environmental Security

Indian Science Congress

88TH SESSION

2001

88th Session of Indian Science Congress
January 3, 2001

VISION
on
Food, Nutrition and Environmental Security

Preamble

Achievements

Stepping into the 21st century, India can legitimately take pride in the remarkable progress it has achieved in every area of human endeavour over the last 50 years. Synergy between science, technology, organization and public policy, has helped bring about a sea change in the areas of agriculture, food, and the environment. Food grain production has increased four fold, to support a rapidly increasing population. Per capita income has doubled. There is an impressive increase in life expectancy and decline in infant mortality. Thanks to cutting-edge science and technology, India has moved from chronic shortages to an era of surpluses in most food products, erasing the memories of famine and mass starvation.

Inequities

However, problems particularly those relating to ecology, gender and social equity, employment, energy and economics continue to persist. Sizeable sections of the population–particularly labour households, in rural areas and urban slums, who lack resources and skills—are still illiterate, poor, and malnourished. Almost half of the children of pre-school age still suffer from moderate to severe malnutrition. More than 50% of pregnant women and children are anaemic. Every third child born in the country has low birth weight, running the risk of impaired health and brain development. Vitamin and micronutrient deficiencies are widespread. These realities overshadow the achievements, and weigh heavy on the national conscience.

Environment

Rising population, persisting poverty, rapid urbanization, industrialization, deforestation, intensification of agriculture, and lack of appropriate policies are putting enormous pressure on our natural resource base. This has led to both quantitative and qualitative degradation of land, water, air and bioresources, endangering the ecological foundations that are essential for sustainable advances in the productivity of major farming systems. The problems are compounded by dwindling non-renewable resources. In some areas, such degradation threatens even livelihood prospects.

Food, nutrition and environmental security cannot be attained without an immediate check on the runaway population growth. To keep pace with the changing trends, we need an extra 5 million tonnes of foodgrains annually, besides significant increases in the production of livestock, fish and

horticultural products. This has to be accomplished in the present scenario of declining total factor productivity growth, shrinking arable land and farm size, growing regional disparity, depleting natural resource base, increasing biotic and abiotic stresses, an outdated knowledge transfer system, and the likely adverse impact of global climate change. Availability of energy and good quality water to meet the rising overall demand would become critical in future. The slow growth of employment in the agriculture and other sectors threatens the income base and food entitlement of the poor. Health and education deficiencies, female illiteracy and gender inequities, and growing feminization further restrict both income and employment opportunities. Agriculture continues to lose ground to other professions considered more attractive by the younger generation. Declining capital investment and resource availability constrains the development of physical and social infrastructure, particularly in the rural sector. Domestic market imperfections, price volatility, food quality, and safety and phytosanitary concerns are critical. The World Trade Organization (WTO) and emerging Intellectual Property Rights (IPR) regime affect the free flow of advanced technology and knowledge. The globalization of markets will influence domestic production, employment and price stability. The country's trade prospects hinge on such factors as price competitiveness, quality, and consistency of supply. Another threat is the use of new kinds of barriers in the guise of food safety and social concerns.

Uncommon opportunities

India's strong institutional and human resource base in science and technology is fully capable of bringing about a technological transformation of agriculture, paving the way for an ever-green revolution. The country has invaluable assets—enormous diversity of bioresources and production environment, high precipitation, long coast line, large marine potential, vast natural resource base for agriculture and industrial growth, and rich traditional knowledge. Moreover, its vast renewable energy source (solar, wind, biomass and biogas), large pool of trained personnel, vast irrigation network, emerging private sector, and the rapidly growing domestic market are vital ingredients for improving productivity, quality, value addition, diversification and trade. With major advances in space, nuclear energy, information and communication, medical, biotechnology, management and other sciences, the country is now in a position to translate its physical and biological resources into economic wealth and prosperity.

Vision

By 2020, India will be free of poverty, hunger and malnutrition, and become an environmentally safe country. This, we believe, will be possible to achieve through accelerated social and economic development — by harnessing the advances in science, and blending them with our indigenous knowledge, wisdom and unique sociocultural ethos. We believe India can banish poverty and emerge as a developed nation by promoting growth through efficient and sustainable use of our human, natural and other resources.

Strategy

Since 1920, more than 120 international declarations, conventions and resolutions have focussed on population, food, nutrition, and environmental issues. These have led to a global consensus and commitment. India is a signatory and a strong advocate of fulfilling these commitments. It is imperative that we tap complementaries and harness synergies through global partnerships in science and technology. India will continue to support the use of science and technology, to achieve equitable growth of all nations and narrow the current divide between the rich and the poor.

While food, nutrition and environmental security are directly linked to agriculture, other related sectors — industry, health, education, space, etc. — will play an important role in achieving sustainable food self-sufficiency. We are convinced that sector-based prescriptions will not be adequate to meet the demands of emerging complex challenges. The strategy must therefore focus on intersectoral, inter-disciplinary and inter-institutional interactions.

The strategy accords priority to synergy among science and technology, organisation and public policy in order to improve the productivity of major farming systems through sustainable intensification, diversification and value addition. Substituting knowledge for capital should be the unique mission of Indian science. We also need to eliminate technology dissemination losses through total reorganization of technology transfer systems, making it client controlled and driven. The future will undoubtedly witness revolutionary changes and new horizons opened up by cutting-edge science. We need to coalesce the efforts of the entire scientific community and commit ourselves to fulfilling the vision in a socially relevant and participatory mode. Raising our capability and excellence in science is the most effective and relevant long-term strategy for overall national progress. The National Agricultural Policy emphasizes the strategic role for science and technology to ensure growth with food, nutrition and environmental security.

Commitment

It is our consensus view that a vibrant, responsive and globally competitive science system is crucial to attaining sustainable food, nutrition and environmental security. This calls for strong social support and commitment to science. The following will require specific attention:

- Orient publicly supported science towards poverty, employment, livelihood, environment and other public good related issues on a priority basis.

- Make concerted efforts in all related areas of science and humanities, drawing strength from new frontiers as well as from our vast pool of traditional knowledge and wisdom.
- Evolve and implement an integrated science plan which is multi-faceted, multi-disciplinary and inter-institutional, focusing as much on population, education, gender, poverty, employment, nutrition and environment, as on production, sustainable growth and trade.
- Double public and private investments in research in the next five years. Ensure that private investments in proprietary science and technology do not hurt science and society.
- Focus scientific efforts on eco-regional and farming system basis to develop efficient technologies for enhanced productivity, post-harvest management, diversification and value addition, and rural craft and industry to provide remunerative options to and raise employment of small-scale farmers, women and the landless in rural India.
- Initiate strong programmes on utilization of renewable energy sources, monsoon management, forest management, containment of chemicals and other pollutants, waste management, conservation and upgradation of physical resources and harnessing of bioresources for environmental sustainability.
- Form a consortium of scientific institutions at the regional or local level involving stakeholders and local organisations to make rural upliftment an interactive development process.
- Accelerate national, regional and international collaboration for technology generation, assessment and transfer through information and communication technologies, while safeguarding against the attendant risks of globalization in science and technology.
- Ensure that science for meeting basic human needs becomes the bottom line of our national science policies and strategies.

Affirmation

Hunger free India is an idea whose time has come. Let us launch a science-based crusade for elimination of hidden hunger and malnutrition by 2007 when the country will celebrate the 60 years of independence.

Indian Science Congress - 2001

T.V. Padma

The curtains came down on this millennium's first Indian Science Congress on January 7, bringing to an end five days of deliberations on the most crucial problem facing India – how to feed its teeming billion plus people.

The focal theme of the congress, the 88th to be held in the country, was "Food, Nutrition and Environment Security", an issue of not just national but also contemporary global concern. It was all the more relevant keeping in view the country's target of a "Food Secure India by 2015" and the Government's announcement to double food production in this decade. In keeping with the theme, the congress was held in the sprawling campus of India's premier Indian Agricultural Research Institute in New Delhi, where the seeds of India's Green revolution were first sown.

The congress opened on January 3 with the traditional ceremonial address by Prime Minister Atal Bihari Vajpayee and attended by Minister for Science and Technology Murli Manohar Joshi, Minister for Agriculture Nitish Kumar, Chief Minister of Delhi Shiela Dixit. The pace of the congress was set by the Prime Minister who asked scientists to come up with comprehensive and useful recommendations to deal effectively with food, nutrition and environment security. In his inaugural address Vajpayee reminded scientists that the three factors simultaneously impacted several critical areas of India's development. India today is not facing a shortage of food, but of facilities to store food, he pointed out. Having achieved food sufficiency, the country's aim is to achieve food security for all its citizens and overcome malnutrition.

The new century will be the century of knowledge and India cannot afford to have under-nourished children with poor brain development. Nearly one-third of Indian children are undernourished, more than half of the pregnant women and children are anaemic, and protein and vitamin deficiencies are rampant, Vajpayee warned. "These realities overshadow our achievements and burden our national conscience".

The task of ensuring food, nutrition and environment security in a vast country like India is gigantic. What is needed is a collective and coordinated action among scientists, and those associated with agriculture and food economy. Accomplishing this task requires massive efforts in many areas that range from increasing crop yields to improving rural infrastructure, preventing huge wastage and losses that now characterise Indian food economy, Vajpayee said.

From the Government's side, the Prime Minister reiterated his pledge to hike investments in research and development to 2 per cent of the Gross Domestic Product (GDP) over the next five years. He said the government was considering setting up a National Mission for Technology Education and announced that Centre would initiate steps to restructure the Food Corporation of India to reduce costs and introduce more efficiency in procurement, storage and distribution of foodgrains.

The Prime Minister also urged scientists to take bold and unconventional initiatives and seize opportunities arising on the horizon. One is the information generated by the Human Genome Project and the country's rich biodiversity. India already has a superb information technology (IT) manpower as well as people trained in biosciences. India should be in the vanguard of the new wave of bioinformatics and create new "Genome Valleys" on the lines of the Silicon Valleys, he said.

Earlier in his presidential address, the General President of the Science Congress, Dr R S Paroda, who also heads the Indian Council of Agricultural Research (ICAR), reminded the gathering about India's long march towards attaining food sufficiency. India has since then achieved Blue, White and Yellow Revolutions and is on its way to a new "rainbow revolution" in nutrition.

But, Paroda pointed out, the great Indian paradox continues. On one hand, the country has had a record harvest of 206 million tonnes, is the second largest producer of milk with 76 million tonnes, and the second largest producer of rice, wheat, fruits and vegetables in the world. On the other hand, the country also has the world's largest number of poor people of about 250 million, who do not get two square meals a day.

Paroda outlined what he described as the "Panch Sutra" strategy consisting of five 'Ps' to realize India's vision of being rid of poverty, hunger and malnutrition and become environmentally safe by 2020. These are: People, Productivity, Permanency, Policy and Partnership.

A Vision statement released during the inauguration pledged that "By 2020, India will be free of poverty, hunger and malnutrition and become environmentally safe. This, we believe, will be possible to achieve through accelerated social and economic development – by harnessing the advances in science, and blending them with our indigenous knowledge, wisdom and unique socio-cultural ethos. We believe India can banish poverty and emerge as a developed nation by promoting growth through efficient and sustainable use of our human, natural and other resources."

The statement called for a science-based crusade for elimination of hidden hunger and malnutrition by 2007 when the country will celebrate 60 years of Independence.

Principal Scientific Advisor to the Government, Dr A P J Abdul Kalam, in a special lecture said India should aim at a Gross Domestic Product (GDP) growth of 9-11 per cent annually and reduce the people below the poverty line to negligible levels. The country should work for a 4th or 5th position in terms of GDP and world competiteveness by 2020, he said.

Kalam also stressed the need to network five areas – agriculture and food processing; electric power; education and health care; information technology; and strategic sectors such as nuclear, space and defence technologies – for economic strength and national security.

The crop and food focus of the congress continued in the plenary sessions, public fora discussions and sectional addresses thereafter. But what made this congress unique was the participation of farmers from different parts of India, as well as students who joined the scientists. Addresses by three innovative farmers specially invited to talk at the congress – D P Yadav from Bihar, Raju Yadav from Andhra Pradesh and Krishna Vir Choudhary from Delhi – added to the predominantly agricultural flavour of this science congress.

The congress attracted several international experts including Dr Peter Raven from Missouri Botanic Garden in the USA, Dr Franklin Zweig from Einstein Institute of Science, Health and The Courts in Chevy Chase in USA, Anand M Chakravorty from USA who received the first patent on an artificially created life form – a microbe – and Gurdev Khush from International Rice Research Institute (IRRI) in the Philippines, and Dr S K Vasal from Centre for Improvement in Maize Yield (CIMMYT) in Mexico. Other international experts included J M Lenne from International Crops Research Institute and C D Thatte from International Commission on Irrigation and Drainage, Dr S Shantaram from International Food Policy Research Institute (IFPRI) in Washington and Prof Krishna R Dronamraju from Foundation for Genetci Research in Texas

A highlight of the congress was Dr Swaminathan's advise to the Government to issue a White Paper on Indian agriculture in context of the World Trade Organisation (WTO). Such a White Paper would help dispel misgivings and reassure 70 per cent of India's population that their livelihood options are not being mortgaged without adequate consultations and consensus. Dr Swaminathan also suggested a National Federation of Agricultural Organisations to give voice to their views on macroeconomic policies which are so far only oriented towards big business houses.

The five days of deliberations led to several key recommendations on research and policy issues. On the research front, scientists agreed on the need to unshackle research and educational institutions from bureaucratic control, new initiatives to set up genomic valleys and enhance investment in agricultural R and D to at least 2 per cent of agricultural GDP to achieve the targeted growth of 4 per cent in agriculture. Other key recommendations included integration of frontier technologies such as space (where satellites aid in a range of activities ranging from estimating crop acreage to fishing zones), atomic energy (where irradiation can create high yielding crop mutants) and biotechnology.

Scientists also called for a "rainbow" revolution" by 2020 that will make India free of poverty, hunger and malnutrition.

On the policy front, scientists recommended new initiatives to cope with WTO, especially by improving efficiency of domestic production, processing and marketing; and creating a "livelihood box" while renegotiating to allow developing countries to impose quantitative restrictions on import of agricultural commodities if they are likely to damage livelihood opportunities. Other major suggestions included networking multiple technologies for nation building, precision farming, transforming scientific institutes into "new age" institutions, and revamping agricultural extension system.

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Conferences/Symposia/Workshops/ Brainstorming Sessions/Dialogues Organised by TAAS (2003-2021)

S. No.	Title	Date
1.	Brainstorming Session on 'Enabling Regulatory Mechanisms for Release of Transgenic Crops'	October 18, 2003
2.	Brainstorming Session on 'Role of Science and Society towards Plant Genetic Resources Management - Emerging Issues'	January 7-8, 2005
3.	National Workshop on 'Role of Information Communication Technology in Taking Scientific Knowledge/Technologies to the End Users'	January 10-11, 2005
4.	Brainstorming Session on 'Farmer-Led Innovations for Increased Productivity, Value Addition and Income Generation'	October 17, 2005
5.	'Farmer-Led Innovations Towards Plant Variety Improvement, Conservation and Protecting Farmers' Rights'	November 12-13, 2006
6.	Brainstorming Session on 'Models of Public-Private Partnership in Agricultural Biotechnology'	April 7, 2007
7.	Symposium on 'Farmer-Led Innovations for Sustainable Agriculture'	December 14-15, 2007
8.	National Symposium on 'Quality Protein Maize for Human Nutritional Security and Development of Poultry Sector in India'	May 3, 2008
9.	Brainstorming Workshop on 'Emerging Challenges before Indian Agriculture - The Way Forward'	March 6, 2009
10.	Brainstorming Workshop on 'Strategy for Conservation of Farm Animal Genetic Resources'	April 10-12, 2009
11.	Brainstorming Workshop on 'Climate Change, Soil Quality and Food Security'	August 11, 2009
12.	National Seminar on 'Quality Seed for Food Security through Public-Private Partnership'	April 13-14, 2010
13.	National Dialogue on 'Building Leadership in Agricultural Research Management'	August 27-28, 2010
14.	Brainstorming Session on Prospects of Producing 100 million tons of Wheat by 2015	December 18, 2010

S. No.	Title	Date
15.	'Stakeholders' Interface on GM Food Crops'	May 19, 2011
16.	International Conference on 'Innovative Approaches for Agricultural Knowledge Management: Global Extension Experiences'	November 9-12, 2011
17.	'Farmers' Led-Innovation'	December 23-24, 2011
18.	Global Conference on 'Women in Agriculture'	March 13-15, 2012
19.	'Foresight and Future Pathways of Agricultural Research through Youth'	March 1-2, 2013
20.	Brainstorming on 'Achieving Inclusive Growth by linking Farmers to Markets'	June 24, 2013
21.	National Workshop on 'Outscaling Farm Innovation'	September 3-5, 2013
22.	Brainstorming Workshop on 'Strategy for Conservation and Productivity Enhancement of Farm Animal Genetic Resources'	January 10, 2014
23.	Brainstorming Workshop on 'Soybean for Household Food and Nutrition Security'	March 21-22, 2014
24.	Brainstorming Workshop on 'Up-scaling Quality Protein Maize (QPM) for Nutrition Security'	May 20-21, 2015
25.	Regional Consultation on 'Agroforestry: The Way Forward'	October 8-10, 2015
26.	National Dialogue on 'Innovation Extension Systems for Farmers Empowerment and Welfare- A Road Map'	December 17-19, 2015
27.	Round Table Discussion on 'Promoting Biotech Innovations in Agriculture and Related Issues'	August 4, 2016
28.	Awareness-cum-Brainstorming Meeting on Access and Benefit Sharing –Striking the Right Balance	October 22, 2016
29.	Delhi Declaration on Agrobiodiversity Management – Outcome of International Agrobiodiversity Congress 2016	November 6-9, 2016
30.	Implementation of Delhi Declaration for Agrobiodiversity Management in India-A Strategies	August 28, 2017
31.	National Conference on Sustainable Development Goals: India's Preparedness and Role of Agriculture	May 11-12, 2017
32.	Underutilized Crops for Food and Nutritional Security in Asia and the Pacific	November 13-15, 2017
33.	Brainstorming Meeting on Harnessing Intellectual Property to Stimulate Agricultural Growth	July 27, 2018
34.	Regional Conference on Motivating and Attracting Youth in Agriculture – A Road Map	August 30-31, 2018
35.	Dryland Agrobiodiversity for Adaptation to Climate Change	February 13, 2019
36.	Regional Workshop on Youth as Torch Bearers of Business Oriented Agriculture in South India	October 21-22, 2019

S. No.	Title	Date
37.	National Dialogue on Land Use for Integrated Livestock Development	November 1-2, 2019
38.	Stakeholders Dialogue on Way Forward for the Indian Seed Sector-A Road Map	February, 22, 2020
39.	Regional Workshop on Motivating and Attracting Youth in Agriculture (MAYA) in North India (in collaboration with PAU & ICAR-ATARI, Ludhaina)	February 28-29, 2020
40.	Stakeholders Dialogue/Webinar on Current Challenges and Way Forward for Pesticides Management- A Road Map	July 24, 2020
41.	Stakeholders Dialogue on Strategies for Safe and Sustainable Weed Management: A Way Forward	December 9, 2020

Forthcoming Events to be Organized by TAAS During 2021

1.	Enabling Policies for Harnessing the Potential of Genome Editing in Crop Improvement	17 March, 2021
2.	Regeneration Agriculture for Soil Health, Food and Environment Security	To be announced shortly
3.	National Workshop on Bridging the Yield Gaps to Enhance Food Production : A Way Forward	To be announced (Second half of 2021)
4.	Eleventh (11th) Dr M S Swaminathan Award for Leadership in Agriculture 2020 to be given to Dr Shenggen Fan, Former Director General, IFPRI	To be awarded during second half of 2021
5.	Nominations invited for 12th Dr M S Swaminathan Award for Leadership in Agriculture. (Screening of nominations under process)	To be awarded during second half of 2021

List of Policy Briefs

Policy Brief 1 :	Efficient Nutrient Management for Improving Soil Health (A National Dialogue in collaboration with IPNI, CSISA, ICAR, CIMMYT and FAI New Delhi)	September 28-29, 2015
Policy Brief 2 :	Efficient Potassium Management in Indian Agriculture	August 28-29, 2017
Policy Brief 3 :	Scaling Conservation Agriculture for Sustainable Intensification in South Asia (in collaboration with ACIAR, AusAID and CIMMYT) Dhaka Bangladesh	September 8-9, 2017
Policy Brief 4 :	Incentives and Strategies for Scaling out Innovations for Smallholder Farmers	October 30-31, 2017
Policy Brief 5 :	Agricultural Policies and Investment Priorities for Managing Natural Resources, Climate Change and Air Pollution (in collaboration with CIMMYT, ICAR, CGIAR, CCAFS and World Bank)	April 9, 2018
Policy Brief 6 :	Framework for Increasing Private Sector Investments in Agriculture and Enhancing the Global Competitiveness of Indian Farmers (Roundtable Discussion: New Delhi, 4 December, 2019)	December 4, 2019

List of Strategy Papers

S. No.	Title	Month & Year
1	Strategy for Increasing Productivity Growth Rate in Agriculture *Dr RS Paroda*	August 2006
2	Overcoming the World Food and Agriculture Crisis through Policy Change, Institutional Innovation and Science *Dr Joachim von Braun*	March 2009
3	Imperative of Global Climate Change for Agricultural Research in Asia-Pacific *Dr RS Paroda*	November 2009
4	Intensive Efforts Needed for Food and Nutritional Security *Dr RS Paroda*	November 2009
5	Revitalizing Indian Seed Sector for Accelerated Agricultural Growth *Dr RS Paroda*	October 2010
6	Implementing the International Treaty to Address Current Concerns about Managing Plant Genetic Resources *Dr RS Paroda*	January 2012
7	Indian Seed Sector: The Way Forward *Dr RS Paroda*	February 2013
8	Managing our Water Resources for Increased Efficiency *Dr RS Paroda*	May 2013
9	The Indian Oilseed Scenario: Challenges and Opportunities *Dr RS Paroda*	August 2013
10	Need for Linking Research with Extension for Accelerated Agricultural Growth in Asia *Dr RS Paroda*	September 2014
11	Reorienting the Agricultural Research for Development Agenda for Sustainable Livelihood Security of Smallholder Farmers *Dr RS Paroda*	March 2017
12	Retrospect and Prospect of Doubling Maize Production and Farmers' Income *Dr NN Singh*	September 2017

S. No.	Title	Month & Year
13	Indian Agriculture for Achieving Sustainable Development Goals *Dr RS Paroda*	October 2017
14	Strategy for Doubling Farmers' Income *Dr RS Paroda*	February 2018
15	Livestock Development in India *Dr AK Srivastava*	February 2018
16	Women Empowerment for Agricultural Development *Dr RS Paroda*	May 2018
17	Motivating and Attracting Youth in Agriculture *Dr RS Paroda*	November 2018
18	Urgency for Scaling Agricultural Innovations to Meet Sustainable Development Goals *Dr RS Paroda*	April 2019
19	Horticulture for Food and Nutritional Security *Dr KL Chadha and Dr VB Patel*	October 2019
20	Crop Biotechnology for Ensuring Food and Nutritional Security *Dr JL Karihaloo and Dr RS Paroda*	December 2019

List of Foundation Day lectures and Special Lectures Organized by TAAS

Foundation Day Lectures

S. No.	Title	Date
1	First Foundation Day Lecture on Regulatory Measures for Utilizing Biotechnological Developments in Different Countries, delivered by Dr. Manju Sharma	October 17, 2003
2	Second Foundation Day Lecture on "Public-Private Partnership in Agricultural Biotechnology" delivered by Dr. Gurdev S. Khush	October 17, 2005
3	Third Foundation Day Lecture on "Global Efforts for Improving Quality Protein Maize (QPM)" by Dr. S.K. Vasal	May 3, 2008
4	Fourth Foundation Day Lecture on "Overcoming the World Food and Agriculture Crisis through Policy Change, Institutional Innovation and Science" delivered by Dr. Joachim von Braun	March 6, 2009
5	Fifth Foundation Day Lecture on "Climate Change and Food Security: From Science to Sustainable Agriculture" by Dr. Mahendra M. Shah	May 7, 2010
6	Sixth Foundation Day Lecture on "Harnessing Knowledge for India's Agricultural Development" by Dr. Uma Lele	August 12, 2011
7	Seventh Foundation Day Lecture on "Ensuring Food and Nutrition Security in Asia: The Role of Agricultural Innovation" by Dr. Shenggen Fan	January 11, 2013
8	Eighth Foundation Day Lecture on "Sustainable Agricultural Development – IFAD's Experiences" by Kanayo F. Nwanze	August 5, 2014
9	Nineth Foundation Day Lecture "21st Century Challenges and Research Opportunity for Sustainable Maize and Wheat Production" by Dr. Thomas A. Lumpkin	September 28, 2015
10	Tenth Foundation Day Lecture "Dynamics of Technology Led Exclusion and Inclusion" by Dr. R.A. Mashelkar	June 6, 2016
11	Eleventh Foundation Day Lecture "Can India Achieve SDG 2 – Eliminate Hunger and Malnutrition by 2030" by Dr. Prabhu Pingali	January 24, 2019

Special Lectures

Special Lecture 1 :	Challenges in Developing Nutritionally Enhanced Stress Tolerant Germplasm (Dr. S.K. Vasal, 3 May, 2004)
Special Lecture 2 :	Global Perspective of Wheat Improvement (Dr. Sanjay Rajaram, 18 December, 2010)
Special Lecture 3 :	Challenges and Opportunities for Food Legume Research and Development (Dr. M.C. Saxena, 25 January, 2012)
Special Lecture 4 :	Enhancing Smallholder Farmer Participation in Markets: The IMOD Way (Dr. William D Dar, 24 June, 2013)

List of Recipients of Dr. MS Swaminathan Award for Leadership in Agriculture

S. No.	Award	Recipient	Presented by	Date
1	First Dr MSS Award for Leadership in Agriculture	Dr. Norman E. Borlaug	Dr. A.P.J. Abdul Kalam, Hon'ble Former President of India	March 15, 2005
2	Second Dr MSS Award for Leadership in Agriculture	Dr. Gurdev S. Khush	Dr Manmohan Singh, Hon'ble Former Prime Minister of India	October 9, 2006
3	Third Dr MSS Award for Leadership in Agriculture	Dr. S.K. Vasal	Prof. M.G.K. Menon, Former Member, Planning Commission (now NITI Aayog)	May 3, 2008
4	Fourth Dr MSS Award for Leadership in Agriculture	Prof. Rattan Lal	Dr. Montek Singh Alhuwalia, Former Deputy Chairman, Planning Commission (now NITI Aayog)	August 11, 2009
5	Fifth Dr MSS Award for Leadership in Agriculture	Dr. Sanjay Rajaram	Dr. A.P.J. Abdul Kalam, Hon'ble Former President of India	December 18, 2010
6	Sixth Dr MSS Award for Leadership in Agriculture	Dr. M.C. Saxena	Dr. Balram Jakhar, Former Union Minister of Agriculture & HE Governor of Madhya Pradesh	January 25, 2012
7	Seventh Dr MSS Award for Leadership in Agriculture	Dr. William D. Dar	Dr. K. Kasturirangan, Former Member, Planning Commission (now NITI Aayog)	June 24, 2013
8	Eighth Dr MSS Award for Leadership in Agriculture	Dr. Thomas Lumpkin	Padma Vibhushan Dr MS Swaminathan, World Food Laureate	September 28, 2015
9	Ninth Dr MSS Award for Leadership in Agriculture	Dr Uma Lele	Dr YK Alagh, Former MoS (Planning, S&T), GoI	October 30, 2017
10	Tenth Dr MSS Award for Leadership in Agriculture	Dr John Dixon	Dr Ismail Serageldin, Former Chairman CGIAR &VP, World Bank	February 13, 2019
11	Eleventh Dr MSS Award for Leadership in Agriculture	Dr Shenggen Fan	To be awarded	Second half of 2021

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