FORESIGHT AND FUTURE PATHWAYS OF AGRICULTURAL RESEARCH THROUGH YOUTH

PROCEEDINGS AND RECOMMENDATIONS

NASC Complex, Pusa, New Delhi
1-2 March, 2013

Organized by

Indian Council of Agricultural Research (ICAR), New Delhi, India
Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand
Trust for Advancement of Agricultural Sciences (TAAS), New Delhi, India

Foresight and Future Pathways of Agricultural Research Through Youth: Proceedings and Recommendations

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Editors

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The Organizers

ICAR (Indian Council of Agricultural Research) is an autonomous organization under the Department of Agricultural Research and Education (DARE), Ministry of Agriculture, Government of India. Formerly known as Imperial Council of Agricultural Research, it was established on 16 July 1929 as a registered society under the Societies Registration Act, 1860 in pursuance of the report of the Royal Commission on Agriculture. The ICAR has its headquarters at New Delhi. The Council is the apex body for coordinating, guiding and managing research and education in agriculture including horticulture, fisheries and animal sciences in the entire country. With 99 ICAR institutes and 47 agricultural universities spread across the country, this is one of the largest national agricultural systems in the world. The ICAR has played a pioneering role in ushering Green Revolution and subsequent developments in agriculture in India through its research and technology development that has enabled the country to increase the production of food grains by 4 times, horticultural crops 6 times, fish 9 times (marine 5 times and inland 17 times), milk 6 times and eggs 27 times since 1950-51, thus making a visible impact on the national food and nutritional security. It has played a major role in promoting excellence in higher education in agriculture. It is engaged in cutting edge areas of science and technology development and its scientists are internationally acknowledged in their fields. For details, please visit: www.icar.org.in.

APAARI (Asia-Pacific Association of Agricultural Research Institutions) is a regional association that aims to promote the development of NARS (National Agricultural Research System) in the Asia-Pacific region through inter-regional and inter-institutional cooperation. The overall objectives of the Association are to foster development of agricultural research in the Asia-Pacific region so as to : promote exchange of scientific and technical information, encourage collaborative research, promote human resource development, build up organizational and management capabilities of member institutions, and strengthen cross-linkages and networking among diverse stakeholders. To meet these needs, the Association:(i) convenes General Assembly once in two years, holds regular Executive meetings yearly and organizes consultations, workshops, trainings etc, (ii) collects, collates and disseminates research findings, (iii) maintains links with other fora in the region and outside through meetings/participation and information exchange, and (iv) promotes need based collaboration in research projects among member institutions, analyzing priorities and focusing on regional agricultural development. For details, please visit: //www.apaari.org/.

TAAS (Trust for Advancement of Agricultural Sciences) came into existence as a follow up action of the 88th session of Indian Science Congress at Indian Agricultural Research Institute, New Delhi in January 2001 under the Presidentship of Dr RS Paroda. This was the first Congress of the New Millennium and the theme of the Congress was "Food, Nutrition and Environmental Security". During the Congress, Hon'ble Prime Minister of India, Shri Atal Bihari Vajapaye released an important Vision Statement as under: "By 2002, 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 stating "Hunger free India is an idea whose time has come. Let us launch a science-based crusade for elimination of hidden hunger and malnutrition". Also, the Prime Minister exhorted the scientists by saying: "Our goal is to make India a leading nation in the world in the new century hinging critically on how successfully we take science to the people and create a stronger scientific temper in our society". In response to the above, and considering the fact that the congress should not be seen as an end in itself, a movement for harnessing, in particular, the agricultural sciences for the welfare of the people, the National Organising Committee decided to form a Trust for Advancement of Agricultural Sciences (TAAS). The Trust was established on 17 October 2002. For details, please visit: www.taas.org.in.

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Foreword

AGRICULTURE has played a key role in the development of human civilization. Development of agricultural techniques has steadily increased agricultural productivity and widespread diffusion of these techniques has led to various agricultural revolutions. A remarkable shift in agricultural practices was observed in the last century in response to new technologies. However, the modern face of agriculture will confront many challenges in the coming years. With available resources, our young agri-professionals will face a major challenge of global food insecurity. Accordingly, they will have to utilize their skills in an exceptional manner. The human resource development particularly young professionals must ensure: (a) effective communication of science in agriculture, (b) integration of social media in agriculture, (c) promotion of agriculture as a career path, and (d) a networking to influence national agenda. While agriculture needs to address these complex problems by focusing resources on youth development needs, such an initiative should also aim at communicating a more positive image of agriculture to young people and reaching and creating a larger pool of youth through high school agriculture, and related agriculture literacy programs for youth, guidance counsellors, science teachers, parents, and policymakers.

In this context, I am happy to note that the Indian council of Agricultural Research (ICAR), Asia-Pacific Association of Agricultural Research Institutions (APARRI), and the Trust for Advancement of Agricultural Sciences (TAAS) came together to organize the National Workshop on Foresight and Future Pathways of Agricultural Research Through Youth in India. This document encrypting the proceedings of the two-day workshop has come out with useful recommendations and suggestions that we need to mainstream in the ongoing efforts of the Indian Agricultural Research System so as to ensure agricultural growth vis-a-vis food security in the country.

(Sharad Pawar)

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Acronyms and Abbreviations

ADG	Assistant Director General
AHP	Analytic Hierarchy Process
AMMAI	Agriculture Machinery Manufacturers' Association of India
APAARI	Asia Pacific Association of Agricultural Research Institutions
ARD	Agricultural Research for Development
ARS	Agricultural Research Scientist
ARSSF	Agricultural Research Service Scientists' Forum
ASRB	Agricultural Scientists Recruitment Board
ATFC	Agricultural Technology Forecasting Centre
CA	Conservation Agriculture
CAS	Career Advancement Scheme
CCAFS	Climate Change, Agriculture and Food Security
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CGIAR	Consultative Group on International Agricultural Research
CIBA	Central Institute of Brackishwater Aquaculture
CIFA	Central Institute of Freshwater Aquaculture
CIFE	Central Institute of Fisheries Education
CIMMYT	International Maize and Wheat Improvement Center
CIPHET	Central Institute of Post-Harvest Engineering and Technology
CPDD	Centre for Pest Detection and Diagnosis
CPRI	Central Potato Research Institute
CRIDA	Central Research Institute for Dryland Agriculture
DARE	Department of Agricultural Research and Education
DDG	Deputy Director General
DG	Director General
DIVA	Differentiation of Infected and Vaccinated Animals
DNA	Deoxyribo Nucleic Acid
ETS	External Transcribed Spacer
FMD	Foot and Mouth Disease
FTO	Freedom to Operate
GHG	Greenhouse

GIS	Geographic Information System
GPS	Geo-Positioning System
GSS	Genome Survey Sequences
GWS	Genome Wide Scan
HRD	Human Resources Development
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICT	Information and Communications Technology
IGFRI	Indian Grassland and Fodder Research Institute
IIHR	Indian Institute of Horticultural Research
IIVR	Indian Institute of Vegetable Research
IPM	Integrated Pest Management
IPNI	International Plant Nutrition Institute
IRRI	International Rice Research Institute
IVRI	Indian Veterinary Research Institute
IWMI	International Water Management Institute
KAB	Krishi Anusandhan Bhawan
MARS	Marker Assisted Recurrent Selection
MAS	Marker Assisted Selection
miRNA	Mitochondrial RNA
MSW	Municipal and Sewage Waste
NAARM	National Academy of Agricultural Research Management
NAEP	National Agricultural Education Project
NAIP	National Agricultural Innovation Project
NARES	National Agricultural Research and Education System
NARS	National Agricultural Research System
NASC	National Agriculture Science Centre
NBAII	National Bureau of Agriculturally Important Insects
NCAP	National Centre for Agricultural Economics and Policy Research
NCIPM	National Centre for Integrated Pest Management
NDRI	National Dairy Research Institute
NDVI	Normalized Differential Vegetative Index
NET	National Eligibility Test
NGO	Non-Governmental Organization

NIASM	National Institute of Abiotic Stress Management
NRCPB	National Research Centre on Plant Biotechnology
NRCSS	National Research Centre on Seed Spices
NRM	Natural Resource Management
OMR	Optical Mark Recognition
PAU	Punjab Agricultural University
PCR	Polymerase Chain Reaction
PDFSR	Project Directorate for Farming Systems Research
PG	Post Graduate
PGP	Plant Growth Promoting
PHM	Post-harvest Management
PME	Priority setting, Monitoring and Evaluation
PPR	*Peste des Petits Ruminants*
PUP	Promotion, Uptake and Pathways
QTL	Quantitative Trait Loei
RFD	Result Framework Document
RNA	Ribo Nucleic Acid
SAU	State Agricultural University
SNP	Single Nucleotide Polymorphism
SOC	Soil Organic Carbon
SSNM	Site Specific Nutrient Management
SVBPUAT	Sardar Vallabh Bhai Patel University of Agriculture and Technology
TAAS	Trust for Advancement of Agricultural Sciences
TF	Technology Forecasting
TIA	Trend Impact Analysis
UAS	University of Agricultural Sciences
UG	Under Graduate
UPSC	Union Public Service Commission
VC	Vice Chancellor
VIGS	Virus-induced Gene Silencing
WUE	Water Use Efficiency
WT	Wheel Tractor
YPARD	Young Professionals in Agricultural Research for Development
YPs	Young Professionals

Foresight and Future Pathways of Agricultural Research through Youth

Introduction

New paradigms of agricultural research in the 21st century revolve around two critical issues: (i) imparting ecological integrity for sustainability, and (ii) reducing costs, enhancing income and mitigating risks. The risk reduction strategies have to take into account ecological, financial, social and techno-legal dimensions. Returns of agricultural research and development activities in India are well documented and acknowledged, but agricultural challenges are much more severe considering the limitations of resources, interlinked challenges of rapidly increasing globalization. Furthermore, experienced scientific manpower is retiring due to superannuation and young professionals are joining resulting in lack of experiences researchers. The trends suggest that agriculture is an aging and undervalued profession which needs special attention to attract and encourage young professionals. In such a complex scenario, it becomes clear that no individual unit or organization can meet the expectations of all stakeholders.

The agriculture in developing world demands a paradigm shift in mind set, shifting from agriculture as means of livelihood to a business orientation, and revitalizing the young workforce in agriculture. During the Second Global Conference on Agricultural Research for Development held at Punta del Este, Uruguay from 28 October-1 November 2012, the National Agricultural Research Systems (NARS), Consultative Group of International Agricultural Research (CGIAR), Young Professionals in Agricultural Research for Development (YPARD) and other agricultural stakeholders accepted that empowering youth in agriculture is the harbinger for change. The NARS in India also emphasizes on the wider involvement of young professionals for enhancing productivity, profitability and sustainability of agriculture in India to feed the billions.

At present, nearly 35 percent of Indian population is in the age group of 20-35 years, and out of country's nearly 7,000 agricultural scientists about 27 percent are below 40 years of age. An in-depth analysis of research themes to provide the future roadmap to Indian agricultural research and accordingly enhancing knowledge and skill of the young scientists/agricultural professionals is critical. The way forward demands an integrated approach for in-depth analysis of research themes, innovations and new science with technological up-gradation through cutting edge research, to bring qualitative change and cultivate a new generation of agricultural professionals, who are the future torch bearers. Keeping in view these challenges and opportunities, the Indian Council of Agricultural Research (ICAR) New Delhi, India; Asia-Pacific Association of Agricultural Research Institutions (APAARI), Bangkok, Thailand; and Trust for Advancement of Agricultural Sciences (TAAS), New Delhi, India organized a foresight process through National Workshop on "*Foresight and Future Pathways of Agricultural Research through Youth in India*" at New Delhi on 1-2 March 2013.

The National Workshop focused on the ways and modalities to engage young agricultural professionals into satisfying and cutting edge research for Agricultural Innovation System of India's NARS, and chalk out their role in research prioritization, decision making and policy formulation. Major emphasis was put on to delineate the needs of capacity development and engagement of youth at different levels within the system. The dialogue process was also initiated on better public-private-entrepreneur partnership through youth in India. The National Workshop was structured in eight

sessions: (i) natural resource management research, (ii) crop improvement and protection research, (iii) plant biotechnology and molecular biology, (iv) horticulture and post-harvest technology, (v) livestock and fishery science, (vi) technology application, ICTs and socioeconomics, (vii) agricultural engineering and emerging science tools, and viii) institutional perspectives. The sessions were further divided into two to three sub-themes in each session. The foresight of agricultural research within a particular theme was presented by a young agricultural professional from NARS. The experts of particular themes also deliberated during the session and chalked out the cross-cutting issues from sessions. About 300 participants from different ICAR institutes, state/central agricultural universities, private sector, farmers and students attended the workshop. Out of these, 200 participants were young agricultural professionals from NARS and private sector. The NGOs and farmers also presented their views and needs during the workshop. All presentations were followed by in-depth discussions. This report provides the outcomes of deliberations and key recommendations for implementation by the scientific community and policy makers for young professionals in India.

Inaugural Session

Dr S Ayyappan, Secretary DARE and DG ICAR delivered Chairman's address and emphasized that the workshop was organized mainly to delineate the long-term vision of the young agricultural professionals about future of agricultural research in India. He outlined that agricultural development strategy for 2050 needs change i.e. from subsistence agriculture to profitable farming. In this change, the youth (50% of total population) must play a pivotal role.

In the inaugural address, Dr Raj Paroda, Executive Secretary, APAARI, Chairman-Haryana Kisan Aayog, and Chairman, TAAS, outlined the importance, genesis and necessity of this National Workshop. Highlighting the glorious past of Indian agriculture and endorsing the significant contribution of agricultural researchers, he stressed that today's agricultural challenges are much more severe considering the need for ever-increasing food consumption and production requirements. To mitigate the challenges, knowledge and skills of our young professionals is critical. He exhorted the young agricultural professionals to commit themselves to meaningful inter-institutional and interdisciplinary agricultural research to make it more relevant to the needs of small and marginal farmers. Dr Paroda further highlighted the global efforts of Youth in agriculture by organizations like YPARD. He emphasized that we must be happy with our past accomplishments and the policy support, institutional and inter-institutional partnership and capacity development which are like a dream come true. But to accomplish success, we need competent young human resource as well as to work with a theory of "*Think Globally and Act Locally*". He asked the youth to keep farmer first and emphasized on research for innovations.

Dr Thomas Lumpkin, Director General, CIMMYT, emphasized that linkages with different national and international institutions, and partnerships with the private sector are the real needs of the day. Dr HS Gupta, Director, Indian Agricultural Research Institute, stressed on the need to serve small and marginal farmers of the country through cutting edge research and novel technologies. Two days' deliberations by young and senior agricultural professionals covered wide range of disciplines and components of Indian agriculture, viz., natural resource management, crop improvement and protection, horticulture, postharvest technology, livestock and fish, ICTs and socioeconomics, and agricultural engineering and tools. In-depth deliberations resulted in the agreement that there is an urgent need to analyze the research gaps across disciplines and redesign the agricultural research relevant to current and future needs of the small and marginal farmers of India. The group realized that agriculture today is under threat of several constraints such as depleting natural resources, biotic and abiotic stress factors, decrease in total factor productivity due to climate change, stagnation

of yield, increasing cost of production, decreasing farm labor, volatile market, agricultural policies, etc. Therefore, agricultural research is to be articulated according to the requirements of Indian agriculture. Also, there is an urgent need for paradigm shift from project to program mode to best fit in different agricultural systems to solve the problems of small, marginal and resource poor farmers. Basic and strategic research in agricultural sciences was also emphasized to cater the future needs of food and nutrition of growing Indian population. Dr Ayyappan and senior executives of the ICAR and other institutions expressed their satisfaction and confidence in the young agricultural professionals about their concerns, competence, and commitment to farmers' problem solving agricultural research, and termed them as the future torch bearers of agricultural research. The workshop was also graced by the presence of Dr RB Singh, President, NAAS and Dr Ashok Gulati, Chairman, Agriculture Price Commission in the Plenary Session and highlighted the need for greater involvement of youth in agriculture in order to meet the emerging challenges.

Technical Session I: Natural Resource Management Research

Co-Chairs : **ML Jat**
Cropping System Agronomist, CIMMYT

: **VK Singh**
ICAR National Fellow, PDFSR

In recent years, Indian agriculture has made a significant progress. However, currently it faces the challenges of degrading natural resources (land, water, energy) and soil health; plateau yield levels; stagnating net sown area; reduction in per caput land availability and abreactions of climate change. The task for providing food and nutrition to 1,439 million people by 2020 and 1,619 million by 2050 is very challenging. The challenge is aggravated as more than 80 percent of Indian farmers are marginal (cultivating agricultural land area up to 1 ha) and small (cultivating between 1 ha and 2 ha) with poor coping capacity. The farms are diverse, heterogeneous and unorganized. Indian agriculture, with almost 60 percent of its net cultivated area as rainfed, is exposed to stresses arising from deteriorated natural resource base, climatic variability and climate change. Rapid industrialization and urbanization in different parts of the country are leading to generation of untreated wastewater, which is often disposed-off untreated in soil and water bodies. Industries and automobiles result in emission of large amounts of particulate matter, aerosol, oxides of C, N and hydrocarbons. All these are increasingly causing problems of soil, air and water pollution, affecting structure and functioning of the agro-ecosystems. To sustain food and nutritional security of the country, it is imperative that Indian agriculture is made more resilient to environmental degradation and climate change. India should recognize that for ensuring the country's food security both in the short and long-term and making agriculture sustainable and climate-resilient, appropriate strategies for efficient management of natural resources such as water, soil, microbes, forests, agrobiodiversity and crop residues have to be developed. The challenges, research gaps and future pathways identified for various aspects of natural resources management are given below:

1. Conservation Agriculture (CA)

Challenges and Research Gaps

- Tillage and crop establishment–Major emphasis on tillage rather than establishment
- Cultivar choices for specific regions and crops–G x M interactions, systems approach, adapting genotype to agronomy rather than developing agronomy for genotypes
- Crop rotations/systems–Cropping system optimization
- Nutrient use/management–Soil fertility management/SSNM/sensor based approaches
- Water use/management–Satisfying crop water demand

- Biocide use/management–Seed bank management, abiotic and biotic stresses
- Crop biomass/residue management–Soil health and microbial activity management

Future Pathways

- Multi-disciplinary and multi-stakeholder basic research: planting dates, cultivar types, irrigation scheduling and nutrient application
- New plant types adapted to CA system
- Research on water x nutrient interactions and water and nutrient management strategies for CA based systems
- Basic understanding of dynamics of weed, disease, insect and pests under CA
- Environmental footprints of CA systems
- Design and develop CA machinery suited to diverse farmer typologies and ecologies
- Studies on crop-livestock interactions and crop residue tradeoffs
- Analysis of adoption pattern and behavioural change of farmers under different typologies to understand adoption of CA
- Define recommendation domains of component technologies suited to basic elements of CA under different production environments, ecologies and resource endowments–Use of remote sensing, GIS, ICTs, system based modelling
- Define institutional arrangements, policy needs and developmental needs for scaling-up and scaling–out of CA systems
- Capacity development at different scales and levels
- New course in CA system at university level
- Database management, curation, sharing strategy

2. Climate Change and Carbon Sequestration

Challenges and Research Gaps

- Increasing threats of climate change and climatic variability on food security: Short- and long-terms
- Increasing demand for information and technology by the stakeholders (farmers, researchers, planners)
- The interactive effects of elevated CO_2 and residual N (legume or fertilizer N) on subsequent grain crop growth, C and N dynamics
- It is likely that terrestrial ecosystems will provide a positive and amplifying feedback in a warming world, albeit uncertain magnitudes
- Could global gardening fix climate change?
- The impacts of agricultural soil erosion on the global carbon cycle

Future Pathways

- Monitoring and mitigation of greenhouse gases (GHGs) emission
- Phenomics-aided crop improvement for enhancing climatic stress tolerance
- Simulation modeling for vulnerability assessment
- Adaptation and mitigation through improved soil and crop management
- Development of a routine methodology to measure the SOC pools at the landscape, farm or watershed scale non-destructively and economically considering of all gases (CO_2, CH_4 and N_2O), hidden C costs of input and the baseline. This would develop global warming potential (in turn carbon sequestration potential) of different management practices, projects, farms, watersheds, etc.
- Waste management would contribute to reduction in sources of GHG emission by both direct and indirect ways
- The real target is to holistically identify location–specific crop productivity systems that would improve C gain intensity in relation to net primary productivity, land use, multi-enterprises that are interdependent, and their implementation by investing which rural development that would benefit the small and marginal farmers by developing climate resilient agriculture

3. Nutrient Management and Soil Health

Constraints

- Decline in factor productivity
- Greater nutrient losses and fixation
- Decline in soil health (organic matter)
- Receding groundwater table
- Sub-surface soil compaction
- Greater use of non-renewable energy sources
- Decrease in biodiversity
- Increase in global warming
- Soil degradation

Challenges and Research Gaps

- Ensuring food and nutritional security from shrinking land and water resources (per caput land availability 0.48 ha in 1951 to 0.08 ha in 2050, and per caput water availability 1,820 m^3yr^{-1} in 2001 to 1,140 m^3yr^{-1} in 2050)
- Achieving self reliance in crop fertilization through indigenous material and by-product sources (presently importing 5.57, 4.26 and 2.55 mt N, P_2O_5 and K_2O, respectively)
- Characterizing and conserving large soil biodiversity for improving soil health (1% bacteria and 5% fungi are culturable)
- Clean and safe environment by developing efficient technologies for waste recycling (MSW, organic resources, crop residue and livestock wastes)
- Sustaining soil quality/health for sustainable agriculture (total land degradation-114 m ha, water ersion-23.62 m ha, wind erosion-8.89 m ha, chemical degradation-22.76 m ha, physical degradation-46.57 m ha, and others-12.17 m ha)
- Nutrient management strategies for climate resilient agriculture
- Heavy metal loading limits in soils through application of different solid and liquid wastes have to be formulated
- Proper soil protection policy through research intervention has to be formulated for restricting heavy metal build-up through application of solid and liquid waste.
- Development of biosensors for identification of polluted/contaminated soils and water

Future Pathways

- Can we develop weather based real time N management (remote sensing and NDVI protocols)?
- Exploitation of endophytic microbes
- Development of nano-fertilizers
- Innovative N fertilizer materials
- Fertilizer management in new farming systems (conservation agriculture and precision farming
- Develop efficient methods for waste cycling total waste generated in urban India 68.8 million t yr^{-1}, if this rate is continued, the waste generated in 2041 would be 230 million tyr^{-1} and would be occupying an area totaling the area of Mumbai, Chennai and Hyderabad
- Speciation of contaminants in soils and development of models that will accurately predict the rate, fate and transport of contaminants on soil components are important in rhizosphere chemistry and soil remediation.

4. Views on Natural Resource Management Research by Resource Persons

Dr IP Abbrol suggested that there is a strong need to build system perspective in research for development and relate research to broader objectives. He also emphasized that the research focus should be on local/ regional/ national issues/ problems and should relate it to global perspective, build the research concepts based on existing knowledge base both scientific and traditional, contribute to capacity for decision making, and relate research to policy imperatives. Dr AK Bhardwaj emphasized that there is a need to develop marginal lands, and conduct research on basic materials and technological research for soil and water conservation. Dr Himanshu Pathak emphasized on climate prone to climate proof research and basic research on plant, animal and soil C and N. Dr Umed Singh was of the opinion that there are very few state-of-the-art laboratories to work on NRM research and there is a

need to streamline the agricultural education system through introduction of PG teaching courses in leading ICAR institutes. Dr Sobha emphasized on development of neutraceuticals, nanosensors, and very short duration varieties. Dr Satyanarayana from private sector suggested better future collaborations between the public and private sectors and transform research into innovation perspective. Dr BP Bhatt opined that we need– technologies to solve the food scarcity problem at the grass root level, ecosystem services for different production systems, biodiversity conservation with detailed studies on soil biota, and to carry out the impact of NRM research. Dr Venkteswarlu pointed out lack of discussion on water and other natural resources, and suggested to commit a pool of human resources for long-term on a thematic area and understand socio-economic issues at ground level. Dr Minhas emphasized on the need for shift from project to programme mode, systems biology research, defining soil depth of different areas. He also pointed out that young scientists contribute largely in publishing their outcomes but they are not concentrating in the farmers' fields, and we need to do it in way that the young scientists can be integrated in the programme mode. Dr Alok Sikka talked about lack of inter-disciplinary mode of research, and suggested that the focus of conservation agriculture should be more on rainfed areas, harnessing the synergy between agriculture and forests for sustainable resource management, working out integrated soil health index instead of individual component indices, and developing decision support tool for farmer and policy makers.

Recommendations and Future Strategies

In the very beginning of the session, concerns about increasing production target and declining resource use efficiency were highlighted by different key speakers. To achieve these goals, enhancing input use efficiency was an important issue. It was opined that NRM has to play an important role in it. To bridge such gaps, there is need of convergence from commodity based research to system perspective, and our target should be national/ regional issues. For this, production scientists need to work in collaboration with the socio-economic and policy research specialists. Since more than 86 percent farmers are small and marginal in the country, the NRM technologies must be focused for such target group to enhance production profitability and livelihood security. The studies are to be framed from farm level to landscape level and simultaneously the capacity building is required at different levels and scales. In this session, five presentations focused on different NRM aspects. Apart from these important views of young scientists, opinions of senior research managers and private entrepreneurs were also sought. During these presentations and discussions, the following important future pathways were identified:

- In the era of declining natural resources and changing climate, significance of conservation agriculture (CA) is increasing more and more. It was realized that improved agronomic management practices can play important role to achieve the immediate goals like attaining productivity and bringing sustainability of a system. For this, cropping system optimization involving all parameters starting from crop establishment to harvest is urgently needed. Although CA has played significant role to overcome the many emerging problems related to natural resources, these practices have to be evaluated on long-term basis for their further extrapolation in larger domains. Since CA technologies are location specific, these have to be evaluated in site-specific farming system perspective. An integration of CA with modern tools like GIS, remote sensing and component specific modelling will further add the value. The footprint of CA has to be taken for its better depiction and situation specific strategic planning. Studies on reported ill effects of CA and solution for them have to be attempted for fruitful outcome.

- Nutrient use efficiency is a key concern in crop production, therefore, research on the use of new amendments, fertilizer products, nano-particles of insoluble compounds/ materials, agronomic management practices and its interaction with crop and water management has to be emphasized. Crops and cropping system based nutrient management system needs to be developed to uphold the nutrient use efficiency and sustained soil health. Cropping system based soil fertility maps using GIS and its inter-linking with nutrient management system will play greater role.
- With intensive cropping/ multi-nutrient deficiencies are emerging and importance of micronutrients is increasing for enhancing the crop productivity. Hence, there is need to–revisit the critical limits of micronutrients and develop options for enhancing micronutrient use efficiency. Study on micronutrients' role in soil-plant human system is another important area of research. To attain the maximum productivity and profits along with sustainable soil health, a package of site-specific nutrient management taking into consideration all deficient nutrients for a given yield target has to be developed.
- Since most of the P and K fertilizers are imported in the country and because of these fertilizers cost is increasing at a very fast rate, hence efforts should be made to develop the technologies for initializing low grade indigenous P and K deposits in India.
- With increasing threats of global warming, there is a need for regular monitoring of GHG emission in a larger domain area. Accordingly, adoptive strategies have to be developed. Studies on developing crop improvement and integrated modelling approach for adoption and mitigation strategies for GHG have to be made. Emphasis should also be given to study the cause and effect relationship in climate change and carbon sequestration. Accordingly, agronomic management practices need to be developed.
- Geo-informatics in agricultural research is still at infancy stage, its potential needs to be explored in improving the input use efficiency, managing natural resources and precision agriculture. For this, strong network in NARS is needed. More and more training and budgeting provisions are to be made to enhance the capacity of NRM scientists in this regard.
- There is a need of holistic research on developing waste management technologies and its cost analysis. In this context, studies on 'contaminant hydrology', heavy metals and soil-water pollution dynamics are to be researched in detail.
- Some of the other key issues like–research on fertilization potentials of weed and its efficient utilization, studies on ecosystem services, determination of soil biota and its impact on natural resources, role of soil depth on crop productivity, *in-situ* recycling of sugarcane trashes and developing decision support system in farmers' perspectives were also flagged. Since organic matter is considered the key of soil health, there is a need to unravel the chemistry of organic matter.
- To enhance the capacity of scientific manpower involved under NRM, there is a need to provide regular training in India/abroad, say at 3-5 years' intervals, so that scientists can get acquainted/ exposed with newer tools and techniques for further advancement in their respective fields.
- It was expressed that many NRM scientists feel that their quality works do not get published in reputed high impact (open access journals having page charges) due to non budgetary provision for such publications by ICAR. A budget provision for research publications in open access journals (having page charges) is essentially required.
- It was opined that as NRM technologies do not have apparent immediate impact, focused emphasis on delivery mechanisms of NRM technologies are required and well defined road maps have to be developed. For deriving quality

soil research, integrated disciplinary team work is essentially required.

Technical Session II: Crop Improvement and Protection Research

Co-Chairs : **Chinnusamy Viswanathan**
Principal Scientist, Plant Physiology and Molecular Biology, IARI, New Delhi

: **KK Dwivedi**
Senior Scientist, IGFRI, Jhansi UP

The five major challenges faced by the Indian agriculture are (i) Hunger, (ii) Malnutrition, (iii) Dwindling natural resources, iv) Low farm income, and (v) Energy crisis. Although currently we have sufficient food, further improvement in the yield of food crops and enhancing the nutritive value of food crops are required to address hunger and malnutrition problems. Natural resources, specifically freshwater availability is decreasing, and this problem is expected to be exacerbated by global climate changes. Input use efficiency such as of nitrogen is very low now, which can be addressed through genetic improvement of input use efficiency and abiotic stress tolerance. In both normal and stress environments, crop protection is critical for yield realization. In-built resistance/ tolerance in crops to biotic stresses is imperative to reduce the losses, and reduce the use of chemical pesticides. Conventional food crops cannot enhance the farm income to a level that can support the dreams of small and marginal farmers. This is one of the major reasons for migration of youths to non-agriculture sectors. A possible way to retain youth in agriculture sector is transformation of farming into more remunerative industry through development of plant bio-factories for pharmaceuticals, bio-chemicals and nutraceuticals, and industrial raw materials. Genetic improvement of non-conventional food crops and domestication of new plants are envisaged to address generation of biomass based energy. The participants of this session and research managers of NARES system have identified following constraints, and vis-à-vis suggested future pathways, and strategies to address the challenges through crop improvement and protection research.

1. Plant Biotechnology and Molecular Biology

Challenges and Research Gaps

- Non-existence of centralized facilities for conducting advanced biotechnology research
- Non-existence of controlled environment phenotyping centres
- Biotic and abiotic stress tolerance

Future Pathways

- Germplasm mining for traits and genes
- Controlled environment phenotyping centres
- Identifying new traits for future research
- Resistance to biotic stresses: More basic research to understand basis of resistance, broad spectrum resistance/ non-host resistance, more attention to partial resistance, and plant secondary metabolism for insect resistance
- Tolerance to abiotic stresses: Breeding objectives to be dissected into component traits, identification of individual component traits and genes from crops, molecular basis of stress–induced alterations in phenology, development of non-destructive high throughput phenotyping methods, and understand cross-talk between multiple stresses

Crop functional Genomics Resources

- **Genotypes:** Germplasm cores and mini-cores (genotypic variability; trait based), wild relatives, mutants (T-DNA/transposon tagged lines, TILLING Populations)
- **Genomic resources:** Whole genome sequences, Markers, ESTs, GSS, OMICS platforms, etc.
- **Bioinformatics:** Develop adequate expertise on gene discovery/function prediction/simulation of protein function due to SNP, service based

centres rather than funding to individual scientist, and competence in collating OMICS data towards pathway association

- **Tools and techniques:** Vectors, promoters, markers with FTO, high-throughput transformation facility, methods for RNAi/VIGS, targeted gene modification, and model system for validation of gene function
- **Adequate infrastructure:** Functional climate controlled greenhouse facilities and service based transformation centres

Research Environment

- Infusion of trained and competent manpower
- Better support from administration
- Initial support as seed money to the newly appointed scientists
- Competitive mode of funding
- Encouragement to undertake challenging research objectives

2. Genetics, Cytogenetics and Plant Breeding

Challenges and Research Gaps

- Genetic enhancement of yield
- Resistance to biotic stresses
- Abiotic stresses (soil moisture stress/WUE)
- Quality traits (high protein and oil content)
- Increasing nutrient use efficiency
- Climate change

Future Pathways

- Integrated approach in molecular breeding: transcriptome, proteome, genome sequence, marker data, phenotypic data, cytogenetic studies
- Infrastructure development for high throughput technologies
- New database to navigate from maps to genes to traits
- Training of scientific/technical manpower
- Plant breeders, genome scientist, computational crop protectionists, statisticians, and agronomists, join together as a team

3. Crop Protection: Entomology, Pathology and Nematology

Challenges and Research Gaps

- Lack of sufficient pest/ pathogen/vector profiling data, mostly due to the lack of state-of-the-art diagnostic facilities for crop pests/ pathogens
- No organizational set-up to tackle the problems created by invasive pest species and the plant viruses transmitted by insect vectors, bioterror attacks
- No research on newer and safer chemical pesticides
- Much focus on applied aspects, complete neglect of basic research
- Poor understanding on insect-plant interactions at proteo-metabolomic and molecular levels
- Poor awareness of policy makers and general public about disease/pest-resistant transgenic crops
- Impact of climate change on pests/pathogens, futuristic scenarios/models, emerging pests/ pathogens, etc
- Lack of location specific decision support system for crop protection services
- Lack of collaboration-between state and central agencies working for similar goals

Future Pathways

- Setting up of a Centre for Pest Detection and Diagnosis (CPDD) to identify pest /pathogens / vectors using conventional and molecular methods
- Improve pest detection methodology through research, and upload protocols in public domain
- Pest monitoring/survey/forecasting networks should be created, updated and improved through use of geographical information system and geostatstical tools
- Discovery of newer and safer chemicals for pest management with high effectiveness, time controlled release, enhanced targeted activity,

safety, easy delivery. Explore nano-pesticides/ nano-formulations

- Basic research on all aspects of pest management
- Research on chemical ecology, which is totally neglected in India.
- Host-insect/pathogen interactions using systems biology approaches
- Studies on long-term effects of transgenic crops on non-target organisms and environment, public awareness
- Studies on changing disease/pest dynamics in changing climate, development of models, future scenarios, strategies
- Investigations on influence of climate change on pollinators, beneficial arthropods, pests and natural enemies
- Cropping system research in order to harmonize the crop, pests, natural enemies, cropping practices and patterns to improve decision making for profitable and sustainable IPM
- Location specific climate resilient economic IPM
- Create better trained scientists: Raise the standards for a PhD degree from NARS. PhD plus a quality research experience should be an essential requirement for the recruitment of the scientists
- Identify performing scientists and encourage them positively
- More flexibility/freedom to the scientists to work and implement his/her imagination and ideas
- Encourage brilliant scientists to come together to create high quality work environments and foster multi-institutional and multi-disciplinary projects to tackle important issues of plant protection research in India
- Facilitate enhanced international collaboration

4. Views on Crop Improvement and Protection Research by Resource Persons

Dr MK Dhillon emphasized that the entomological research needs to be carried out on: (i) understanding insect vis-à-vis host plant biochemistry and metabolic pathways for the management of insect pests in important field crops through HPR approach, (ii) development of insect resistant crop genotypes with appropriate conglomeration of conventional, biochemical and molecular approaches, (iii) insect phenomics, population structure and genetics, and functional genomics, (iv) long-term effects of transgenic crops on non-target organisms, v) insecticide resistance management strategies in both transgenic and non-transgenic crops, (vi) cropping system engineering in order to harmonize the insect pests – natural enemies' equivalence for their better management. Dr Ganesh Behere also emphasized that the research on insect genomics, insect genetic diversity/genetic structure of insects, molecular systematic/DNA bar coding should be undertaken on priority basis in India. Dr Sangeeta Yadav suggested need for characterization of alternative oilseed plant germplasm resources to meet the increasing oil demand in the country. Dr Mayank Rai was of the opinion that the NARES should have pre-breeding research platform. Dr C Chatopadhayay emphasized on development of technology leadership in agriculture and quality management in biopesticides. Dr SR Bhatt suggested that there is an urgent need to integrate different technologies for sustainability of farmers and agriculture, and create awareness about technologies. Dr TP Rajendran strongly opposed the proliferation of professional societies in different ICAR institutes/divisions, which are becoming parasitic on the ICAR system, and should find a way out to stop these activities in the premises of the ICAR institutions.

Recommendations and Future Strategies

Application of crop functional genomics to identify bottlenecks in various component traits for input use efficiency, biotic and abiotic stress tolerance, and yield. The components of functional genomics such as model systems, core, mini-core and mutant resources, service centres for OMICS and bioinformatics should be developed holistically.

- Analytical breeding approach should be used to break the current stagnation in the potential yield levels in optimal environment, enhance yield under input deficient and stress environments
- Development of mapping populations, high-density linkage maps for target traits and crops to enhance the pace of gene/ QTL mapping and their use in MAS, MARS and GWS. A NARES data base for plant breeding resources including genotypic data, linkage maps, etc. will speed up the molecular breeding
- Programs on wide hybridization and mutagenesis in crops with narrow genetic base such as legumes
- Initiation of research on domestication and genetic improvement of non-crop ephemerals and extremophiles as sources of bioenergy
- Establish state-of-the-art laboratories for understanding the insect-plant interactions at proteo-metabolomic and molecular levels, insect phenomics, population structure and genetics, and functional genomics
- Development of high value crops such as plant pharmaceuticals, plant chemical factories and nutraceuticals to increase the farm income significantly and thus retain youth in agriculture
- Development of herbicide resistant crops to reduce cost and problem of labour scarcity
- Establishment of CPDD in each agro-climatic zone of the country to identify pest/ pathogens/ vectors
- Pest monitoring and forecasting networks should be created and linked to geographical information system and geostatstical tools for real time update. Development of pest and disease free zones (exclusion zones) to produce healthy propagules and promote exports
- Development of nano-pesticides, biopesticides and chemical attractants of natural enemies based on plant secondary metabolites
- Pest genomics, genetic diversity, molecular systematic/DNA barcoding
- Basic research on the aspects of chemical ecology, plant-insect and plant-pathogen-vector interactions
- Development of models to predict changing disease/pest dynamics in changing climate and management strategies
- Development of disease epidemic models and decision support systems for the farmers
- Integration of cropping system in IPM research to improve decision making for profitable and sustainable IPM measures
- To develop science leadership, more emphasis and investment in basic research is needed

Technical Session III: Horticulture and Post Harvest Technology

Co-Chairs : **Eguru Sreenivasa Rao**
Senior Scientist, IIHR

: **Shamina Azeez**
Senior Scientist, IIHR

1. Horticultural Research

Challenges and Research Gaps

- Changing climate
- Biotic and abiotic stresses
- Growing demand of organic food
- Lack of quality seed and planting materials to end users
- Old and senile orchards
- Huge post-harvest losses
- Lack of trait specific germplasm ready for utilization in breeding programme

Future Pathways

A. Genetic Enhancement

- Identification/breeding of climate resilient crops/genotypes
- Trait specific breeding, pre-breeding and genetic enhancement
- Development of core and mini-core of the fruit genetic resources

- Potential of indigenous ornamentals and MAP to be explored
- Phytomedicine rich varietal development
- Research on plant based insulin, edible vaccines

B. Production System

- Fool proof technology for organic horticulture
- Improved production technology to reduce production cost, meeting the quality and safety standard, grafting technology in vegetables
- Explore the possibilities to deploy nanotechnology such as nano-fertilizer, nano-pesticides, precision farming using nano-sensor, etc.
- Aeroponics and hydroponics

C. Innovation in Plant Health Management

- Major emphasis on management of diseases and pests of national importance
- Innovative pest control strategies such as RNAi silencing of target genes, sterile insect technology, etc.
- Development of PCR based diagnostic kit
- Gene pyramiding for durable resistance

D. Collaboration with Medical Science to Harness the Medicinal Value of Horticultural Crops

2. Post-Harvest Research

Challenges and Research Gaps

- Continuous availability of high quality fruits and vegetables
- Improving nutritional quality of fruits and vegetables after harvest

Future Pathways

- To develop novel foods (fermented/ unfermented) with functional ingredients
- Develop evidences of food fermentation processes with functional benefits accrued along with added phytochemicals
- Food processing with appropriate techniques

3. Views on Horticulture and Post-Harvest Technology Research by Resource Persons

The resource persons from horticulture and post-harvest technology group flagged several researchable issues. Dr Anju Bajpai pointed out that mango malformation and guava wilt are long standing problems, which need to be addressed on priority either of deem fit approaches such as introduction of wild species, mapping population and confirming associations through pedigree analysis. Dr Niranjan Prasad opined that there is a need for developing scientific methods of tapping natural resins and gums, launching massive afforestation programmes to replace trees and give employment opportunities, and deployment of natural resins and gums for safe, bio-degradable, eco-friendly packing material. Dr Elain Aphshara emphasized on detailed studies on phytoplasma resistant genes, tapping of dwarfing and early fruit bearing genes in coconut, and development of yellow leaf disease diagnostic kit. Dr R Selvarajan emphasized need for research on bunchy top disease in banana for its exclusion at field level through development of diagnostic kits, and some other neglected areas such as plant-disease epidemics models, host-virus-vector relationship, and their functional genomics. Dr AK Sharma emphasized upon procuring more strains of wine yeast and by-product utilization of winery waste products. Dr AN Jyothi stressed development of natural and environment friendly biopolymers for various end uses and residue management through value addition.

Dr N Krishnakumar, DDG (Horticulture) appraized the group that scientists are well aware of problems in their mandate crops, however, they should fine-focus the research in horticultural crops on seed production technology, development of male-sterile lines, water–cum–nutrient and integrated resource management, arid and temperate horticultural crops, research on phytoplasma, mango fruit and plant physiology, and socio-economic analysis of horticultural crops. Dr Prakash S Naik, Director, IIVR suggested that for production and supply of quality planting material

production the parental lines can be developed by research institutes and multiple production private sector can undertaken by. He also emphasized on micropropagation research in perennials and genomics of indigenous crops. Dr US Shivhare emphasized on reduction of post-harvest losses by modifying atmosphere of packaging and value addition research with low cost and mechanization. Dr BP Singh suggested that to harness the potential of horticultural crops for food and nutritional security–disease free planting materials should be made available; methodologies for increasing productivity through increase in cropping area to non-traditional areas should be developed; and focus should be given on biopesticide research mainly on quality aspects. Dr Balraj Singh emphasized on management of pollination in protected cultivation through apiculture, development of varieties for protected cultivation, exploration of the opportunities of tissue culture in vegetable crops, identification of the specifications of seed standards, and investigation of opportunities of cluster approach in production, processing and marketing of vegetables. As per the point of view of private sector, Dr Das Gupta suggested that as horticultural crops are dominated by private sector, greater interaction and exchange of scientists between the public and private sectors need to be encouraged.

Recommendations and Future Strategies

Genetic Enhancement

- Germplasm management and characterization for trait discovery, bioprospecting and allele mining, and pre-breeding for linking genetic resources and breeding programmes
- Trait specific breeding especially for pyramiding multiple traits mainly stresses, which occur simultaneously, and also specialty traits like seedlessness, biofortification, herbicide tolerance, etc
- Shortening the breeding cycle in terms of generation time (especially in perennial crops) and also the number of generations/cycle. Emphasis should be on techniques like MAS and harnessing latest advances like Cenh histone based haploidy
- Efficient exploitation of heterosis and generating genomic information in indigenous crops

Production Systems and NRM

- Research on comprehensive organic production systems and safe production systems
- Reducing the cost of production
- Rootstock breeding and technology for grafting vegetable crops especially to overcome soil-borne diseases
- Improving the resource use efficiency including water productivity, residues management, PGP microbial consortia, efficient delivery systems like nano composites
- Plant architecture engineering including canopy management, solar energy harvesting, management of flowering physiology, exploiting dwarfing genes and rootstocks in fruit crops for ultra high density cropping systems in fruit trees and polyhouse cultivation of vegetable crops

Plant Health Management

There are several national challenges like Tospo viruses in vegetables, pomegranate bacterial blight, banana bunchy top, guava blight, phytoplasma in perennial crops like coconut, etc. Therefore, there is a need to have a programme on surveillance, field based diagnostic kits, developing forecasting models, decision support systems, and ecogenomics for understanding host-pathogen-vector interaction at gene expression level.

Post Harvest Technology

- Stable natural pigments to replace synthetic colors
- Nutrition in terms of bioavailability
- Fermentation technology and bioreactors
- Neutraceuticals and speciality foods

Technical Session IV: Livestock and Fishery Science

Co-Chairs : **Manish Mahawar**
Senior Scientist, IVRI
: **KN Vishwas**
Senior Scientist, IVRI

1. Fishery Science

Challenges and Research Gaps

A. Genetics and Breeding

- Genetic improvement programmes–few widely farmed species
- Genetic or biodiversity impacts–introduction, movement or escapees
- Need for intensification: current techniques–not cost effective/environmentally sustainable

B. Health management

- Emergence of new diseases
- Trans-boundary diseases

C. Social

- High production costs–rising cost of feeds/ energy/labour/inputs
- Negative consumer perception

Future Pathways

- Impact of climate change on aquaculture
- Remote sensing for aquaculture management
- Identify and prioritize new marine model organisms
- Develop marine–derived molecules such as enzymes, biopolymers and biomaterials
- Genomic analyses of marine organisms
- Culture and isolation of uncultivated microorganisms
- Cell lines/ tissue culture–production of active compounds
- Innovative photo-bioreactors
- Bio-refinery: biofuel production–alternative to petrochemistry
- Integrated databases for marine organisms and communities
- Bioinformatics resources

2. Animal Science

Challenges and Research Gaps

- Lack of appropriate resources like stem cell banks
- Perfect differentiation protocol absent
- Biological limitations like longer generation interval
- Skilled personnel difficulties in pronuclear injection and skill for embryo micromanipulation
- Insufficient organized effort to promote translational and biomedical research
- Inadequate supportive administration
- Ethical and legal issues: on use of animals and approval especially for use large animal in experiments

Future Pathways

- Basic research in animal genomics such as genetic engineering, nutrigenomics, silicogenomics, and reproductive technology
- Basic research in transgenic animal production, viz. augment transgenic large-animal production, animal disease models through transgenic research, transgenic animals for production of veterinary biologicals, and transgenic animals for enriching human food quality and therapeutics
- Develop and maintain animal stem cell bank
- Establish stem cell mediated transgenic animal models and value addition to animal products through this research
- Develop therapeutic applications and disease models
- Biomaterial research for scaffold and artificial organ development

3. Veterinary Science

Challenges and Research Gaps

- Infectious diseases such as viral, bacterial and parasitic are a threat to animals
- Diseases especially foot and mouth disease (FMD), *haemorrhagic septicaemia* (HS), *peste des petits ruminants* (PPR), bluetongue, brucellosis,

clostridial infections, mastitis, rabies, blood protozon diseases, etc. are major threats
- Transboundary animal diseases
- Lack of specialized and reliable epidemiological information on the diseases for successful control/preventive programme
- Lack of information on disease threat in different agro-climatic regions for help in forecasting disease outbreaks and develop early warning systems
- Lack of appropriate programmes to train highly-skilled human capital
- Lack of emphasis on basic research
- Limited investment in research and higher education

Future Pathways

A. Disease Diagnosis

- Novel systems for rapid, pen-side and efficient pathogen detection
- Specific and sensitive pre-clinical diagnosis tools
- Companion diagnostics for differentiation of infected and vaccinated animals (DIVA), for example: Swine fever, FMD, PPR, etc
- Molecular diagnostics, for example: Nanobeads application in virus detection, miRNA signature/ biomarkers

B. Vaccines

- Combination vaccines to reduce vaccination cost
- Long duration of protection by stimulating memory responses
- Marker vaccines with DIVA approach
- Improving efficacy of inactivated vaccines through new generation adjuvants/immune modulators
- Development of vaccine(s) targeting major pathogens of mastitis
- Development of genetically detoxified vaccines against bacterial infections that produce toxins

C. Therapeutics

- Micro/nanoparticle based antigen delivery
- Needle free vaccine delivery
- Mucosal vaccination
- Generating monoclonal antibodies for immunotherapy, for example: for rabies
- Development of RNAi therapeutics

D. Basic Research

- Understanding the host-pathogen interactions
- Understanding how pathogens evade and neutralize the host immune system
- Research emphasis on innate immunity
- Expression profiling of miRNA associated with infections, to identify biomarkers for early detection of infections

4. Views on Livestock and Fishery Science Research by Resource Persons

Dr Aparna emphasized on transgenic research in fisheries, for which regulations and required facilities are not in place and need to sort out this problem. Furthermore, marker assisted selection and sex determination which has not been taken up in India need to be emphasized. Dr Sanath Kumar suggested that efforts needs to be made to exploit solar energy in fish on cooling. Dr K Brinda emphasized on the research work on livestock health, diagnostics, reproduction biology, embryo transfer programme, and in house production system for biologicals and resources for veterinary research. Dr Muthuchelvan emphasized on biosafety and fish safety policies, antibody engineering and antiviral research. Dr Shiva Chandra was of the opinion that the research on diseases of wild life and pet animals also need to be carried out. He also suggested to exploit herbs pertaining to native immunity of animals, anesthesia availability for wild life animals, standard drug release, database quality, and a program to trace the trans-boundary movement of animals in the border areas. Dr WS Lakra emphasized that there should be some funds earmarked for the national and international

mobility of scientists, plan to meet out the shortage of critical mass human resource, exploit the opportunities of inland saline aquaculture and ornamental fisheries, and establishment of innovative research centres. Dr AK Srivastava, Director, NDRI, Karnal, emphasized that there is a strong need to focus on increasing the potency of the cattle using stem cell research through semen dose improvement, reduce puberty age of good breeds of Indian animals, produce animal milk which is immune to human diseases, and impart international training in the national interest. Dr B Prakash, ADG (Animal Sciences), ICAR suggested for exploration of opportunities of high meat production in animals through stem cell research, deploy herbs for animal immunity, develop diagnostics to identify meat using molecular tools, and work to increase the digestibility of the animals. Dr AG Ponniah emphasized on water management for aquaculture, food safety of aquaculture/sea foods, and use of agriculture wastes for aquaculture. Dr B Meenakumari, DDG (Fisheries), ICAR suggested to increase production of aquaculture through increase in fisheries, multiple use of water used in fish rearing/aquaculture, devise methods to stop illegal fishing, explore new fish stocks for human use, identify omnivorous/herbivorous fish species for aquaculture, and to arrange for health management doctors for aquaculture. Dr K Narayan Gowda was of the opinion that the research programmes need to be reoriented to cater to the needs of the farmers, strengthen research in extension sciences, and prioritize marketing research.

Recommendations and Future Strategies

A. Fishery Sciences

Researchable Issues

- Next generation aquaculture encompassing bioremediation, diagnostics, alternative preventives and therapeutics, genomics and proteomics of fish through inter-disciplinary approach involving agriculture, medicine, etc
- Basic research on food safety and food preservative issues should be emphasized
- Biodiversity management and DNA barcoding of fishes
- Waste water management and efficient use of water from fishery ponds
- Use of plant and animal protein based feed for fish
- Increasing fish production by employing new fishing systems

Policy Issues

- Grants for young researchers should be initiated
- Grants for attending international symposia or conferences should be given
- To make-up the shortage of manpower in fishery sciences, student intake needs to be increased
- Young scientists should have commitment and accountability
- Autonomy to the researchers should be ensured
- Measures should be taken for stoppage of illegal fishing using scientific tools
- Fish doctors are needed for prescribing the suitable drugs for fish diseases
- Regulations and guidelines for transgenic fish need to be developed
- Issue of wild catch of fishes has to be dealt with appropriately

B. Animals and Veterinary Sciences

Research Issues

- Develop and maintain animal stem cell bank
- Reinforce basic and translational research including reprogramming
- Value addition to animal products through stem cell research
- Establish stem cell mediated transgenic animal models
- Develop therapeutic applications and disease models
- Biomaterial research for scaffold and artificial organ development

- Establishment of institute of animal stem cell and translational research
- Novel systems for rapid, pen-side and efficient pathogen detection
- Specific and sensitive pre-clinical diagnosis tools
- Companion diagnostics for differentiation of infected and vaccinated animals (DIVA)
- Combination vaccines to reduce vaccination cost
- Long duration protection by stimulating memory responses
- Marker vaccines with DIVA approach
- Improving the efficacy of inactivated vaccines through new generation adjuvants/immune modulators
- Development of vaccine(s) targeting major pathogens of mastitis
- Development of genetically detoxified vaccines against bacterial infections that produce toxins
- Generating monoclonal antibodies for immunotherapy
- Development of RNAi therapeutics
- Research on wildlife and companion animal diseases should be strengthened
- GPS enabled tools for animal movement, disease monitoring and surveillance
- Application of stem cell technology towards better semen production
- Intervention of biotechnological tools towards reduction in puberty age in animals
- Reduction of methane emission using nano-technological tools
- Research on traceability of adulteration in meat and meat products

Policy Issues

- More scientific and administrative freedom should be given to researchers
- Fund provision for publications
- Programmes for international collaborative research
- Easier and quicker approval for the large animal experimentation
- Provision for necessary infrastructure to carry out research in veterinary and animal sciences
- Establishment of facilities for in-house production of antibodies, hormones and other biologicals
- Formulation of Indian Veterinary Pharmacopoea
- Provision for training of researchers on biosafety and fire safety issues
- Policy on management of biohazard waste disposal
- Improvement of research work environment
- Pool the entire research experts in areas like genomics, proteomics etc. together in one institute so that valuable products can be developed and delivered

Technical Session V: Technology Application and ICTs and Socio-economics

Co-Chairs : **PN Ananth**
Senior Scientist, CIFA
: **RR Burman**
Senior Scientist, KAB-1

1. Technology Applications and Use of ICTs

A. Challenges and Research Gaps (ICTs)

Demand Side

- Major limitation is that not all farmers can be reached through language other than their local language
- Many women farmers who are the actual practitioners and users of the agricultural technologies in the real field situations are yet to accept ICT tools for communicating with extension system

Supply Side

- Limitations of lack of connectivity, non-availability of gadgets that support local language, exorbitant costs in developing and commercializing software that enable rural farmers to accept modern ICT tools.

B. Challenges and Research Gaps

Strategies and avenues that stimulate use of ICT tools for extension within the above supply and demand side constraints. Little evidence is available on the utility of these ICT tools in improving technology adoption.

Future Pathways

- Mainstreaming extension research and be part of technology development process in NARS
- New models of innovation: diffusion and adopter categories
- Affiliation with general streams viz., development studies, rural development, anthropology and other sciences and harness the synergistic and positive effect for agricultural extension research
- Alternative approaches to technology application, translation and commercialization
- Utility of ICTs in extension – in terms of content, delivery, impact

2. Socio-economics

Challenges and Research Gaps

- Forecasting or creating the future?
- One should learn to work in an inter-institutional and multi-disciplinary mode and at the same time contribute to our subject over and above the existing knowledge
- Need for evolving such a system wherein due credit is given to all those persons who have contributed their subject knowledge and expert opinion but are not part of the project/ scheme/ centre
- Dearth of bibliometric databases/ software and databases pertaining to technology forecasting/ monitoring
- It is expected that the pace of the work related to Technology Forecasting will gain momentum once a dedicated scheme/ project/ establishment is ensured

Future Pathways

- Not just TF, but technology foresight - can shape or create the future
- Technology road mapping, analytic hierarchy process (AHP), trend impact analysis (TIA) etc
- Soft computing techniques such as neural networks, fuzzy logic, etc. in combination with the TF methods such as AHP, TIA etc
- Bibliometric analysis and patent data analysis– patent citation analysis, patent co-citation methods, patent networks, etc
- Bass diffusion and grey forecasting models; combination of time-series models with diffusion models
- e-Pest and disease surveillance and advisory services on major crops of various states; Development of weather and climate based agro-advisory services through GIS
- ATFC–Agricultural Technology Forecasting Centre

3. Views on Technology Application and ICTs and Socio-economics Research by Resource Persons

Dr Himadari Ghosh opined that there is a need to identify gaps between goods and consumption, undertake work on non-linear time serial models, conduct more research on volatizing price, conduct studies on the consequence of technological changes, develop methodologies for the estimation of growth, and develop forecasting volatility method. Dr Subhash Chand explained that there are several examples towards the use of ICT in agriculture and allied sectors such as fishermen have been benefitted with the data generated by Potential Fishing Zone (PFZ) in India. Dr Asha Latha suggested maintaining electronic database of weather parameters at the grass root level for use of such data by the farmers. Dr Suresh Pal suggested putting efforts to reduce resource endowments i.e., labour and water, linking farmers and market, and think about linking past data to make future projections. Dr Ramesh Chand suggested that there is a

demographic dividend in science and the role of youth in agriculture will be significant in the future. Dr KD Kokate indicated that the 'Extension Research' should take a new shape with new areas of research, and emphasized that the extension research data should be published in high impact factor journals.

Recommendations and Future Strategies

- New institutional arrangements are required to get the flow of farmers' problems into technology development process
- Developing a mechanism and to systematize the process to communicate with ICAR Institutes about the concerns of farmers for meaningful research, and thrust on promotion, uptake and pathways (PUP) of technologies generated by the research system
- Software and network driven mechanism needs to be developed so that these problems are automatically categorized according to the domain of each institute and fall into their e-mail box for use in research activities
- Scientists from Agricultural Extension or Agricultural Economics have to take a lion's share in the PME Cell of the institute
- Result Framework Document (RFD) of ICAR institutes is mostly handled by professionals who are not trained and well versed in social science, wherein trained social scientists should shoulder this responsibility
- Proposal for establishing a specialized institute for extension research
- Develop strategies for the commercialization of technologies through farmers rather than depending on corporate sectors
- Adoption of the concept of "tracer studies"
- Appropriate steps and strategies need to be adopted by the extension system to earn back the lost credibility

Technical Session VI: Agricultural Engineering and Emerging Science Tools

Co-Chairs : **Baldev Singh**
President, AMMAI
: **Minakshi Grover**
Senior Scientist, CRIDA

1. Farm Mechanization

Challenges and Research Gaps

- Degradation of natural resources (soil, water and environment)
- Stagnation in the crop yield
- Declining farmers' income
- Scarcity of farm labour
- Mechanization for small farmers
- Climate change and sustainability of agriculture

Future Pathways

- 2 wheel tractor v/s small 4 wheel tractor
- Front PTO/ auxiliary hydraulics and three point linkages
- Standardization (narrow tires, rims (9.5-38))
- Multi-crop and multi functional models
- Band/differential placement of fertilizer and variable rates
- Capacity building for scientist, local manufacturer, custom operator and farmers
- Combine harvesting and laser land levelling (B Model)
- Low adoption rate for proven technologies

2. Nano-technology in Agricultural Research

Challenges and Research Pathways

- Lack of advanced research facilities for nanotechnology science
- Lack of collaborative, integrated and inter-disciplinary environment for nano-technology research
- Lack of trained manpower on nano-technology research
- Effect of nano-particles in food chain

Future Pathways

- Advanced research facilities on nano-materials, nano-sensors and its biosafety
- Characterization, functionalization and assembly of nano-sensor their applications as pheromone sensor for pest management
- Formulations of pheromones of important borers, other crop pests and kairomones for natural enemies using nano-technology
- Nano-vaccines using nano-capsules and ultrasound methods for livestock and fisheries
- Gold nanoparticle-based probe for rapid and ultrasensitive detection of mercury in soil, water, and fish

3. Geo-informatics in Agricultural Research

Future Pathways

- Interaction of EMR (electro magnetic research) with soil, crop, water, atmosphere
- Spectral library and sensor development, quantification of biophysical parameters, identification of horticultural/orchard crops, and crop growth monitoring system and soil moisture modeling
- Crop yield prediction/forecasting
- Identification, declaration, monitoring and vulnerability mapping, early warning system for drought
- Modeling land use/cover changes and their impacts on agro-ecosystem
- Water productivity modeling
- Redefining agro-ecological zones for crop diversification / adoption of resource conservation technologies
- Precision farming in Indian context
- Long-term sustainability of agro-ecosystem / land degradation
- Networking between ICAR institutes, SAUs, ISRO Centers, other research / academic institutions to collate and synthesize information on various identified thematic areas, and developing a web portal.

4. Views on Agriculture Engineering and Emerging Science Tools by Resource Persons

Dr Dipika emphasized on using the good processing and preservation strategies such that the consumption of non-thermal and non-chemical is minimal. Dr KP Singh emphasized on development of sensors for nano- and bio-materials for precision farming, development of précised input delivery system, and basic research on nanoparticles.

Technical Session VII: Institutional Perspectives

Chair : **Gurbachan Singh**
Chairman, ASRB

Co-Chair : **Poonam Jasrotia**
Senior Scientist, DGR

1. Advanced Research Institute Perspective

Dr Malavika Dadlani, Joint Director (Research), IARI presented perspectives of advanced research at institute's level referring mainly to IARI, a premier institute of agriculture for research and education. Main remarks were as follows:

- It is expected that scientists should consider fulfilling research mandate of the serving institute while working for their personal excellence in research. Both aspects should get due attention simultaneously.
- Often there is a lack of clarity of goals and no road map is usually defined to attain the targets that can lead to the fulfillment of the institutional mandate. A strong desire for individual excellence and recognition, which at times results in excellent individual performance, but sometimes the team feeling suffers.
- Sometimes, the true potential of a scientist does not get recognized or promoted because of wrong placement. Research managers have to recognise the interest and aptitude of an individual before her/his placement. The gap can also be bridged by regular interactions of the scientists with fellow colleagues, respective heads of divisions and research managers. Periodic meetings to discuss the progress of

ongoing projects and plan for future research will also help in narrowing the gap. To break inhibitions, occasional social meetings could be organized where young scientists can express their views freely.

2. State Agricultural Universities Perspective

Dr HS Gaur, Vice-Chancellor, SVBPUAT, Meerut raised the following issues from the SAU perspective:

- The SAUs are playing a great role in shaping and nurturing the young minds of the country by providing them basic education and are directly involved in reckoning the regional problems through interdisciplinary and integrated approach.
- Their major responsibility is to uplift the agrarian wealth of a region. The young scientific community plays a pivotal role in achieving this goal.
- There is a need to expose the young generation of scientists to real field situations so that they can better understand the problems and work towards a comprehensive solution.
- Imagination levels of youth need to be increased through proper mentoring so that he/she is able to connect different concepts and technologies to tackle a problem. More focused education is required along with sound knowledge of basic concepts.
- Innovation centres may be established, which may have greater freedom of experimentation on new ideas in contrast to highly regulated structured predefined projects where accomplishing preset targets get priority over innovation.
- The achiever faculty should be rewarded and encouraged by providing them all the necessary facilities and should be introduced as role models to young students for motivation. A component of optional under-graduate research projects should be considered for bright students and integrated degree programmes may be introduced to retain talented students. To have more diversity among students, central quota in admission may be increased to 25 percent in UG and 35 percent in PG.
- Budget support should be increased for both salaries and contingencies from state and central sources and the vacant faculty and staff positions should be filled on priority basis. Local interference in recruitments and admissions should be discouraged. Therefore, a better and more transparent system of faculty recruitment is necessary. Some proportion of the faculty may be centrally recruited to stop inbreeding and provision for inter-university faculty mobility may be considered.

3. Agricultural Scientists Recruitment Board (ASRB) Perspective

Dr VN Sharda, Member ASRB, presented his views on the recruitment policy of ICAR as under:

- The Agricultural Scientists Recruitment Board (ASRB) mission is to recruit scientists at different levels either through an All-India Competitive Examination (ARS) or by Direct Recruitment Scheme. Besides, the board also assesses scientists for promotions under Career Advancement Scheme (CAS).
- Score card system has been introduced to determine the suitability of a candidate for different positions based on his/her achievements and further aid in deciding the eligibility of a candidate to be finally called for an interview.
- The board is continuously and rigorously engaged in improving the present system of examination and selection. Optical mark recognition (OMR) based test has been introduced for ARS-NET examination which is efficient, time saver and eliminates the chances of human errors. Web based tools are being devised for online filling of application and for downloading admit card and net award certificates. These will be made available shortly.
- Model qualifications for direct recruitment to all scientific positions have been completely revised by giving appropriate weightage to the

components of different attributes. The board is putting major emphasis in selecting competent employees based on organizational goals and individual expertise.

- To meet long-term and broad organizational goals the ASRB is collecting, compiling and analysing manpower data. Efforts are underway to establish research and analysis cell for scientific database for effective manpower and organizational planning.
- For smooth running, it is pertinent that the board should function independently without any interference and pattern of UPSC may be followed.

4. NAARM Perspective

Dr NH Rao, Joint Director, National Academy of Agricultural Research and Management (NAARM), while expressing academy's perspectives conveyed following key points:

- NAARM is engaged in strengthening human resource and institutional capacities of National Agricultural Research System (NARS) like leadership, governance and innovation capacities through capacity strengthening, education, research, consultancy and policy support.
- The programme portfolio of NAARM includes foundation courses for newly recruited scientists and leadership and management development programmes for helping scientists to make the transition to management positions.
- These programmes assist individual scientists to evaluate and plan their professional development to contribute to achieving institutional mission as they make the difficult transition from scientist to manager. Need based specific competencies are needed as these research managers at institute level have to lead, design strategies and mentor people at different levels.
- He pointed out that NAARM as a management institute has a continuous commitment to develop human resource and institutionalizing a HRD strategy for nurturing leaders but at the same time the individuals must have a strategy for self-development and only then these trainings can be useful to them.

5. ICAR Education Division Perspective

Dr Ravinder Kumar (Education Division, ICAR) expressed his ideas on the perspectives of agricultural education as under:

- Human resource is a critical engine of an organization and competent manpower generated as a result of quality education can generate technologies that can have wider impact on farming community and finally can lead to policy reforms.
- The Education Division of ICAR is dedicated to planning and development related to education and human resource and is also responsible for quality assurance and reforms.
- The challenges of present agricultural education system are multifaceted. Some of these are lack of competent faculty, extensive inbreeding, weak research networking/linkages and non-availability of modern research facilities.
- An organization like ICAR is investing huge resources to address these issues. Funds have been allocated to different universities for faculty development, renovation and creation of new well equipped laboratories, e-learning courses, modern hostels with sports and internet facilities. Student cells have been established in many universities for counseling, personality development and career placements. Many incentives in the form of awards and grants for participation in meetings are regularly given to faculty members.
- Some of the new promising initiatives that are underway include creation of governance cell in each university, fellowships to young talents and Ph.D. degree holders, and provision for sandwich/ exchange programmes for research scholars.
- To address capacity building issues, the centres of faculty excellence will be opened in

agricultural universities and competitive research grants will be provided to faculty. International fellowship programme will be introduced to develop skills and to expose faculty to international scientific work culture.

- Programmes like adjunct and visiting faculty, resident scholar scheme, emeritus professor scheme, teaching associates/assistants may come in place to tackle faculty shortage.
- In days to come the National Agricultural Innovation Project (NAIP) will get into a new phase i.e National Agricultural Education Project (NAEP) which will primarily focus on (i) promotion of academic excellence in critical/ emerging areas, (ii) increasing scope and effectiveness of networking with educational institutions and research organization, (iii) enhancing reach and effectiveness of agricultural education to farmers, rural women and agribusiness, and (iv) establishment of model colleges for rural development education.

6. NARES Perspective

Dr JC Katyal, former VC, CCSHAU Hisar, and Ex-DDG (Education) highlighted the role of NARES in strengthening agricultural research with the following points:

- With over-stressed natural resources, over imposing climate change and burgeoning PHM, problems of agriculture are multi-faceted today compared to what they were yesterday. Institutions need to recognize that past approaches and solutions need to be revisited, recasted and adjusted.
- An institution ploughing its lone furrow will not be able to find solutions to contemporary multifaceted problems. Involvement of scientists at all levels is required but at the same time infusion of local, regional and global knowledge and learning by sharing and networking to find holistic answers is also essential.
- Partnerships and networks may be utilized to foster mutual strengths for shared inter/intra-institutional programmes. Research consortia can produce a multiplier effect on advancement of competitive and efficient agriculture and can lead to up-scaling, up-skilling of new research approaches and methods.
- There is an urgency to inspire people to move and involve, make objectives that are real and relevant, build collaborations, work towards skill improvement and above all communicate technology. Let technology not clutter serious communications; a direct approach is the best approach.
- Time is up for no-work chatters. Uphold with your actions and results. Undoubtedly, actions and outcome speak louder than words.

7. YPARD Perspective

Dr YS Saharawat briefed about role of young agricultural professionals, while speaking for the role of YPARD. The brief video message of Ms Courtney, Global Director, YPARD was played and webcast during the session. Ms Courtney highlighted the role, importance and achievements of the YPARD globally.

- Young Professionals in Agricultural Research for Development (YPARD) is an international movement by young professionals (YPs) for young professionals in agricultural research for development (ARD).
- It operates as a network where on-line and off-line communication and discussions occur globally to enable YPs all over the world to express their views and realize their full potential towards a dynamic ARD.
- Youths are assets of an organization and yet they are often viewed as inexperienced and therefore, their views/ideas are repeatedly neglected in decision making process at different levels. YPARD's objective is to facilitate exchange of information and knowledge among young professionals across disciplines, professions, age and regions by broadening opportunities so that they can contribute to strategic ARD.
- There is a need to develop programmes that engage youth and use their expertise. In this

direction, ICAR/NARS have taken a few initiatives on similar lines and programmes like ARYA (Attracting and Retaining Rural Youth in Agriculture), Students READY, and Farmer's First have recently been introduced.

8. Post Graduate Student's Perspective

Ms Trisha Roy of the Postgraduate School of IARI gave her views as follows:

- The youth of today has got a daunting task of solving problems like increasing population and need to produce more food and fibre with scarce resources; water, arable land and labour.
- With so many challenges surrounding them, the present generation is confused as to which research area they can choose for their studies so that they can contribute the maximum while at the same time can be innovative also.
- Working on field problems on a broader scale which involves direct involvement with farmer fascinates them.
- The present youth wants to compete globally. Therefore, youths are interested in getting trainings at different institutes and if possible abroad for development of skills required for– pursuing research experiments, scientific writing by getting enhanced knowledge of statistics for data analysis.
- They want to work in a collaborative matter through group and interdisciplinary approach to avoid repetitive research. Emphasis should be given to develop entrepreneurship and managerial skills among students.

9. Farmers' Perspective

Mr. Vikas Chaudhary, a progressive farmer from Karnal, Haryana spoke on this issue. His views are as under:

- Some of the critical challenges today's farmers are facing include increasing input cost and low profits due to low quality produce as a result of unpredictable weather and abrupt market fluctuations for farm produce.
- To deal with situation, the farmers are in dire need of timely and farmer friendly information on inputs, weather conditions and technologies suited to specific needs of the farmers.
- To address these issues in a better way, the national and international institutes need to work in harmony with local people for a comprehensive solution to the challenges that farmers are facing.
- One such initiative was taken and a society named "Society for Conservation of Natural Resources and Empowering Rural Youth" was launched. Through this society, farmers are exposed to new farm machinery of conservation agriculture. But, these machines are not accessible to all the farmers because of high cost and they are not economically feasible.
- There is urgency for farmer-led research and extension programmes through graduate students that involve problem identification to methodology development, result assessment, evaluation and final recommendations of the best evolved technology to other farmers. Due acknowledgments or rewards for the involvement of farmers should be given from time to time in publications and meetings.

Chair's Remarks

Dr Gurbachan Singh, Session Chair and Chairman, ASRB in his concluding remarks emphasized that there is a need to increase the fund for research in state agricultural universities (SAUs). The state agricultural university scientists should interact more with national as well as international scientists for enhancing their knowledge and should concentrate more on the basic and strategic research. He further emphasized that there is an urgent need for online teaching modules in agriculture as well as to identify the business models for research in ICAR institutes and SAUs. He asked the young researchers to introspect that Why same scientist perform better in USA/UK/developed world and not here? Why scientist loose interest after 3-5 years? As ASRB chairman, he asked SAUs to fast track the mode of promotion and stop inbreeding.

Plenary Session

Chair : **S Ayyappan**
Secretary, DARE and DG, ICAR

Chief Guest : **RB Singh**
President, NAAS

Guest of Honour : **Ashok Gulati**
Chairman, CACP

During the plenary session, Co-Chairs highlighted the key outcomes of sessions. The discussion in Technical Session I on 'Natural Resource Management Research' discussions emphasized on bridging the yield gaps while sustaining the natural resources through focusing on the basic, strategic and applied research on conservation agriculture and climate change phenomenon. The session highlighted on the option to produce more with lesser and judicious use of inputs, through integration of innovative crop management practices integrated with crop improvement and modern tools like GIS, remote sensing and component specific modeling. The discussions also highlighted the urgent need of improving nutrient and water use efficiency to sustain soil health and enhance factor productivity. With increasing threats of global warming, there is a need for regular monitoring of GHG emission in a larger domain area. The group also emphasized on the regular capacity development of NRM scientific cadre through training in India and abroad. The Technical Session II on 'Crop Improvement and Protection' highlighted the integration of plant and biotechnological tools for both biotic and abiotc stress tolerance. Germplasm mining for trait genes and developing centralized facilities for phenotyping was also emphasized during the session. For future research pathways, the group highlighted the need of basic research to understand basis of resistance, broad spectrum resistance/ non-host resistance, pay more attention to partial resistance, and plant secondary metabolism for insect-resistance. For tolerance to abiotic stresses, the group highlighted the breeding objectives dissection into component traits, identification of individual component traits and a gene from crops, molecular basis of stress induced alterations in phenology, development of non-destructive phenotyping methods, and understand cross-talk between multiple stresses. The group also highlighted on nutritional security through crop improvement programmes.

The Technical Session III on 'Horticulture and Post-Harvest Technology' emphasized on integration of horticultural research with cereal crop research. The major emphasizing points of the session were on germplasm management of horticultural crops, pyramiding multiple traits, breeding for development of large scale population, stripping in breeding cycles, generating information for plant architecture and developing forecasting model and biodegradation management schemes. There is a need to emphasize on the techniques like MAS and harnessing the latest advances like Cenh histone based haploidy. Improving the resource use efficiency including water productivity, residues management, PGP microbial consortia, efficient delivery systems like nano-composites need special emphasis in horticultural crops too. The post-harvest technology emphasized on stable natural pigments to replace synthetic colours, nutrition in terms of bioavailability, fermentation technology and bioreactors and nutraceuticals and specialty foods. The Technical Session IV on 'Livestock and Fishery Science' emphasized on the fish genomes research, development of animal gene bank, and developing new vaccines and endotherapy technology. In the Technical Session V 'Technology Application, ICTs and Socio-economics', the social scientists emphasized on the integrated role of social scientists in all projects, and also on the appropriate mechanisms for feedback, promotion, uptake and marketing pathways. In the Technical Session VI 'Agricultural Engineering and Emerging Science Tools', special stress was laid on the farm mechanization due to labour shortage and increasing labour costs, smart delivery systems and better public-private partnership as an urgent need in the present context. In the Technical Session VII 'Institutional perspectives', major emphasis was put on increasing funds for research in state agricultural

universities (SAUs), enhancing interactions between national as well as international scientists for imposing knowledge and putting more concentration on basic and strategic research. Advanced tools like online teaching modules in agriculture need to be identified. The senior experts during the session also asked the young researchers to introspect that. Why same scientist perform better in USA/UK/developed world and not here? Why scientist loose interest after 3-5 years?

In the concluding remarks, Dr S Ayyappan, emphasized on role of youth for achieving ICAR vision. He encouraged the young scientists to have individual aspirations, vision, passion and strategy to attain their excellence for farmers' good. He desired the foreign trained young scientists to have more international collaboration and develop better science communication strategies. He declared that ICAR will provide conducive environment, support system, and training facilities to young researchers but at the same time would expect better accountability, scientific integrity and emphasis on innovative science. In his concluding remarks, he lauded professional conduct of the workshop and appreciated efforts of the organizers. Dr Ashol Gulati, Chairman, CACP in his remarks highlighted the agricultural challenges by 2050 to produce enough food but how much will be economically accessible to poor? He emphasized on need to have higher AR4D investments and compared those between India and China. He further highlighted that China is investing much more on R&D as well as on higher education. Dr RB Singh, President, NAAS in his address highlighted that India is having maximum concentration of malnutrition, and agriculture is the mainstay for reducing poverty and hunger. But, the natural resources in themselves are not enough their effective use is extremely important. He further stressed the importance of human resource and compared it with China. Today's agriculture demands a merger between invention and innovation to feed 220 million hungry people. He stressed on basic, strategic and translational research for technology development and outscaling by adopting with socio-ecological support. He further emphasized that young minds should lead agriculture in future in India.

Key Recommendations

Research Oriented

- There is an urgent need to reorient agricultural research towards farming systems' mode by ensuring inter-institutional and inter-disciplinary collaboration, 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 (10-15 lakh) for the newly recruited scientist to encourage them to initiate research in a programme 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 Oriented

- Short-to long-term trainings for young scientists at advanced research institutions in 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 programmes at NAARM for young and mid-carrier scientists for building scientific research leadership qualities
- Provision for institutional grant and administrative freedom to encourage

presentation of research work in International Conferences and its publication in referred journals

Policy Oriented

- 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 outscaling for impacts
- National HRD strategy to address the concerns of smallholders through reorienting R&D efforts towards farming systems

Technical Programme

Day 1: March 1, 2013 (Friday) **Time: 09.00- 10.15 hrs**

INAUGURAL SESSION

09:00 – 09:10	Welcome and Introduction	**S Mauria,** ADG (IP&TM) ICAR
09:10 – 09:25	Introduction of Participants	
09:25 – 09:35	Address	**S Ayyappan,** Secretary DARE & DG ICAR
09:35 – 09:50	Inaugural Address	**RS Paroda,** Chairman, Haryana Kisan Ayog and TAAS; and Former Secretary DARE & DG ICAR
09:50– 09:52	Vote of Thanks	**YS Saharawat,** Senior Scientist
09:52– 10:15	Tea Break	

TECHNICAL SESSION-I
Natural Resource Management Research (10.15 - 13.00 hrs)

Session Coordinators: **ML Jat**
Cropping System Agronomist, CIMMYT

VK Singh
ICAR National Fellow, PDFSR

10:15 – 10:30	Conservation Agriculture	YS Saharawat, ML Jat
10:30 – 10:45	Climate Change and Carbon Sequestration	Arti Bhatia, Ranjan Bhattacharyya
10:45 – 11:00	Nutrient Management and Soil Health	AK Shukla
11:00 – 11:15	Geo-informatics in Agricultural Rsearch	RN Sahoo
11:15 – 12:30	Foresight and Future Pathways in NRM Research: Views by (2-5 mins each):	Ajay Kumar Bhardwaj, Himanshu Pathak, Ummed Singh, Shobha Sondhia, Others
12:30 – 13:00	Interaction and Delineation of Future Strategy by:	AK Singh, VC RVSKVV; Alok Sikka, DDG, NRM, PS Minhas, Director, NIASM; IP Abrol, Former DDG, NRM; B Vekateswarlu, Director, CRIDA; BP Bhatt, Director, ICAR-RCER; BS Dwivedi, Head, SSAC, IARI; PK Aggarwal, CCAFS, IWMI; Kaushik Majumdar, IPNI, Others
13:10 – 14:00	Lunch	

TECHNICAL SESSION-II
Crop Improvement and Protection Research (14.00 - 16.50 hrs)

Session Coordinators : **Chinnusamy Viswanathan,** Principal Scientist, Plant Physiology and Molecular Biology, IARI
KK Dwivedi, Senior Scientist, IGFRI

14:00 – 14:15	Plant Biotechnology and Molecular Biology	RC Bhattacharya
14:15 – 14:30	Genetics, Cytogenetics and Plant Breeding	Milind B. Ratnaparkhe
14:30 – 14:45	Crop Protection: Entomology, Pathology & Nematology	Vishal Somvanshi
14:45 – 16:00	Foresight and Future Pathways in Crop Improvement and Protection Research Views by (2-5 mins each):	Ajai Kumar Singh, Ashutosh Kumar Mall, Sangita Yadav, Mukesh K. Dhillon, Poonam Jasrotia, Gajanan T. Behere, Savarni Tripathi, Arvind Kannan, Others
16:00 – 16:30	Interaction and Delineation of Future Strategy by:	BS Dhillon, VC PAU; Swapan Dutta, DDG (CS); HS Gupta, Director, IARI; TP Rajendran, ADG (PP); C. Devakumar, ADG (EPD); C. Chattopadhyay, Director, NCIPM; Malavika Dadlani, JD(R), IARI; SR Bhatt, PS NRCPB, Others
16:30 – 16:50	Tea Break	

TECHNICAL SESSION-III
Horticulture and Post-Harvest Technology (16.50 - 19.00 hrs)

Session Coordinators : **Eguru Sreenivasa Rao,** Senior Scientist, IIHR
Shamina Azeez, Senior Scientist, IIHR

16:50 – 17:10	Horticultural Research	JK Ranjan
17:10 – 17:25	Post-Harvest Research	Sunita Singh
17:25 – 18:30	Foresight and Future Pathways in Horticultural & PHT Research Views by (2-5 mins each):	Anju Bajpai, Niranjan Prasad, S. Elain Apshara, R Selvarajan, Alka Gupta, Ajay Kumar, AN Jyothi, Others
18:30 – 19:00	Interaction and Delineation of Future Strategy by:	NK Krishna Kumar, DDG (Horticulture); Parkash S Naik, Director, IIVR; US Shivhare, Director, CIPHE; Bir Pal Singh, Director, CPRI; Balraj Singh, Director, NRCSS, Others

Day 2: March 2, 2013 (Saturday)

TECHNICAL SESSION-IV
Livestock and Fish Science (09.00 - 11.00 hrs)

Session Coordinators : **Manish Mahawar,** Senior Scientist, IVRI

KN Vishwas, Senior Scientist, IVRI

09:00 – 09:15	Fishery Science	Sherly Tomy
09:15 – 09:30	Animal Science	SK Dhara
09:30 – 09:45	Veterinary Science	SH Basagoudanavar
09:45 – 10:30	Foresight and Future Pathways in Livestock and Fishery Research Views by (2-5 mins each):	SK Otta, Aparna Chaudhary, Sanath Kumar H, K Brindha, Pranab Jyoti Das, D Muthuchelvan, Shiva Chandra, Naveen Kumar, MA Ramakrishnan, Others
10:30 – 11:00	Interaction and Delineation of Future Strategy by:	KML Pathak, DDG (Animal Science); SK Bandyopadhyay, Member, ASRB; B. Meenakumari, DDG (Fisheries); WS Lakra, Director CIFE; AK Srivastava, Director, NDRI; Gaya Prasad, Director IVRI and ADG (AH); AG Ponniah, Director, CIBA, Others
11:00 – 11:20	Tea Break	

TECHNICAL SESSION-V
Technology Application, ICTs and Socio-economics (11.20 - 13.00 hrs)

Session Coordinators : **PN Ananth,** Senior Scientist, CIFA

RR Burman, Senior Scientist, KAB-I

11:20 – 11:35	Technology Applications and use of ICTs	M J Chandre Gowda
11:35 – 11:50	Socio-economic	Ramasubramanian V
11:50 – 12:30	Foresight and Future Pathways in Technology Application and Socio-economics Views by (2-5 mins each):	Himadri Ghosh, Subhash Chand, Asha Lata, Others
12:30 – 13:00	Interaction and Delineation of Future Strategy by:	KD Kokate, DDG (Agriculture Extension); K Narayana Gowda, Vice Chancellor UAS, Ramesh Chand, Director, NCAP; AM Narula, Zonal Director Zone-I; Suresh Pal, Head, Agril. Economics, IARI; RK Malik, CIMMYT India, Others
13:00 – 14:00	Lunch	

TECHNICAL SESSION-VI
Agriculture Engineering and Emerging Science Tools (14.00 - 15.00 hrs)

Session Coordinators : **Baldev Singh,** President AMMAI

Minakshi Grover, Senior Scientist

14:00 – 14:15	Farm mechanization	HS Sidhu
14:15 – 14:30	Nanotechnology in Agricultural Research	Deepa Bhagat
14:30 – 14:45	Foresight and Future Pathway, Views by (2-5 mins each):	PK Sahoo, Dipika Agrahar, Kuna Aparna, KP Singh, Minakshi Grover, Others
15:45 – 15:00	Interaction and Delineation of Future Strategy by:	MM Pandey, DDG (Agriculture Engineering); Pitam Chandra, Director, CIAE; A K Sharma, Director NBAII; Rameshwar Singh, Project Director, DKMA, Others

TECHNICAL SESSION-VII
Institutional Perspectives (15.00 - 16.10 hrs)

Chair : **Gurbachan Singh,** Chairman, ASRB

Facilitator : **Poonam Jasrotia,** Senior Scientist

15:00 – 15:10	Public: Advanced Research Institute Perspective	HS Gupta, Director, IARI
15:10 – 15:20	Public: State Agricultural University Perspective	BS Dhillon, Vice Chancellor, PAU
15:20 – 15:30	ICAR Education Division Perspective	Arvind Kumar, DDG (Education)
15:30 – 15:40	ASRB Perspective	VN Sharda, Member, ASRB
15:40 – 15:50	NAARM Perspective	SL Goswami, Director, NAARM
15:50 – 15:55	International/CGIAR Perspective	JK Ladha, IRRI, Rep. India & Nepal
15:55 – 16:00	YPARD Perspectives	Sridhar Gutam, Senior Scientist
16:00 – 16:05	Student Perspective	Trisha Roy, IARI
16:05 – 16:10	Entrepreneur Perspective	Vikas Chaudhary, Farmer, Haryana
16:00 – 16:20	Tea Break	

PLENARY SESSION

Time: 16.20 - 17.35 hrs

Chief Guest	:	**RB Singh,** President, NAAS
Guest of Honour	:	**Ashok Gulati,** Chairman, CACP
Chair	:	**S Ayyappan,** Secretary DARE and DG ICAR
Facilitator	:	**YS Saharawat,** Senior Scientist, IARI

16:20 – 16:25	Reporting of Technical Session-I	Session Coordinator
16:25 – 16:30	Reporting of Technical Session-II	Session Coordinator
16:30 – 16:35	Reporting of Technical Session-III	Session Coordinator
16:35 – 16:40	Reporting of Technical Session-IV	Session Coordinator
16:40 – 16:45	Reporting of Technical Session-V	Session Coordinator
16:45 – 16:50	Reporting of Technical Session-VI	Session Coordinator
16:55 – 17:00	Reporting of Technical Session-VII	Facilitator
17:10 – 17:20	Remarks	S Ayyappan
17:20 – 17:30	Guest of Honour Remarks	A Gulati
17:30 – 17:40	Remarks	RB Singh
17:40 – 17:50	Vote of Thanks	HS Gupta


EXIT
R.S.Parodia


National Workshop on
FORESIGHT AND FUTURE PATHWAYS OF AGRICULTURAL RESEARCH THROUGH INVOLVEMENT OF YOUTH IN INDIA


APAARI


APAARI
National Workshop on
FORESIGHT AND FUTURE PATHWAYS OF AGRICULTURAL RESEARCH THROUGH INVOLVEMENT OF YOUTH IN INDIA
March 1-2, 2012
NASC Complex, New Delhi


APAARI


Manish Mahawar
K. N. Vishwas
Sherly Tomy


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SALIDA
YPARD
Young Professionals' Platform for Agricultural Research for Development
OPPORTUNITIES IN AGRICULTURE


National Workshop on
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NASC Complex, New Delhi