

Regional Consultation on Improving Wheat Productivity in Asia

Bangkok, Thailand
26-27 April, 2012

PROCEEDINGS AND RECOMMENDATIONS



Organized by :

Food and Agriculture Organization of the United Nations-Regional Office for Asia and the Pacific (FAO RAP)
Asia-Pacific Association of Agricultural Research Institutions (APAARI)

in collaboration with
CIMMYT, ICARDA and JIRCAS

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Editors

**Raj Paroda, S. Dasgupta, Bhag Mal, S.S. Singh,
M.L. Jat and Gyanendra Singh**



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Citation : Raj Paroda, S. Dasgupta, Bhag Mal, S.S. Singh, M.L. Jat and Gyanendra Singh. 2012. *Proceedings of the Regional Consultation on Improving Wheat Productivity in Asia*, Bangkok, Thailand; 26-27 April, 2012. 48 p.

Errata

Page # Para/Line	Replacement
Foreword: Para 2, Line 1	“850” with “1090”
Executive Summary: Para 1, Line 1	“FAO” with “Recent”
Para 1, Line 2	“850” with “1090”
Page 1, Para 2, Line 8	“302” with “>400”
Page 2, Para 1, Line 4	Read as: “...germplasm resources though exploited but the yield gains were less due to low investment. Hence ...”
Page 4, Para 1, line 2	“850” with “1090”; “2030” with “2050”
Page 4, Para 1, line 3	“2.0” with “1.6”
Page 20, Bullet 2, Last sentence	Read as: “Ethiopia is also now releasing only rust resistant varieties”.
Page 29, Para 4, Line 3	“850” with “1090”

The Organizers

APAARI (Asia-Pacific Association of Agricultural Research Institutions) is a regional association that aims to promote the development of National Agricultural Research Systems (NARS) in the Asia-Pacific region through inter-regional and inter-institutional cooperation. The overall objectives of the Association are to foster the development of agricultural research in the Asia-Pacific region so as to promote the 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 Committee 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

FAO (Food and Agriculture Organization of the United Nations) is an intergovernmental organization located in Rome, has 191 member nations and is present in over 130 countries. FAO comprises four main areas, namely, i) putting information within reach, ii) sharing policy expertise, iii) providing a meeting place for nations, and iv) bringing knowledge to the field. The FAO serves as a knowledge network and utilizes the expertise of agronomists, foresters, fisheries and livestock specialists, nutritionists, social scientists, economists, statisticians and other professionals to collect, analyse and disseminate data that aid development. The FAO publishes hundreds of newsletters, reports and books, distributes several magazines, creates numerous CD-ROMS and hosts dozens of electronic fora. FAO lends its years of experience to member countries in devising agricultural policy, supporting planning, drafting effective legislation and creating national strategies to achieve rural development and hunger alleviation goals. FAO mobilizes and manages millions of dollars provided by industrialized countries, development banks and other sources to make sure the projects achieve their goals. As FAO is primarily a knowledge based organization, investing in human resources is a top priority. Capacity building including a leadership programme, employee rotation and a new junior professional programme has been established. Individual performance management, an ethics officer and an independent office of evaluation are designed to improve performance through learning and strengthened oversight. For details, please visit: www.fao.org

CIMMYT (International Maize and Wheat Improvement Center) is an international, not-for-profit organization that conducts research and training related to maize and wheat improvement and system research in more than 100 countries across the world. The center develops and applies new science to increase food security, improves the productivity and profitability of maize and wheat farming systems while sustaining natural resources. The center employs a large number of internationally recruited professional staff located at headquarters in Mexico and other 18 locations around the world. Genetic improvement of maize and wheat is CIMMYT's core business; CIMMYT-derived varieties of maize and wheat are grown in developing countries on more than 20 million hectares and 60 million hectares, respectively. The impact of CIMMYT's work

with maize and wheat germplasm improvement and cropping system management especially conservation agriculture has been profound and the center continues to be highly relevant for developing country farmers, including South Asian smallholders. CIMMYT's research strategy is primarily implemented through new CGIAR Research Programmes (CRPs) on maize and wheat led by CIMMYT and implemented in collaboration with more than 500 research and development partners worldwide (over 200 in South Asia alone). For details, please visit: www.cimmyt.org

ICARDA (International Center for Agricultural Research in the Dry Areas) having its headquarter at Aleppo, Syria is the ideal site of the world's non-tropical dry areas and ICARDA's primary mandate area. It also lies in the heart of the Fertile Crescent, where agriculture began 10,000 years ago, and where many of the world's most important crops originated or were first domesticated. Plant genetic diversity in the region is almost unique – and this diversity allows scientists to uncover new genes that control vital traits such as drought tolerance, disease resistance or grain quality. ICARDA's research portfolio spans the entire research-development continuum, ensuring that research outputs translate into tangible benefits at farm level. There are four integrated, multi-disciplinary programmes. Each programme has a major capacity building component. The research agenda in each programme is built on themes and sub-themes, designed to produce, through integrated research and training efforts, targeted outputs that contribute to its objectives. The integrated research and training activities include those carried out at headquarters and/or in collaboration with NARS. Its mission is to contribute to the improvement of livelihoods of the resource-poor in dry areas by enhancing food security and alleviating poverty through research and partnerships to achieve sustainable increases in agricultural productivity and income, while ensuring the efficient and more equitable use and conservation of natural resources. For details, please visit: www.icarda.org

JIRCAS (The Japan International Research Center for Agricultural Sciences), an incorporated administrative agency under the Ministry of Agriculture, Forestry and Fisheries, plays a core role in international collaborations in the field of agriculture, forestry and fisheries research in Japan. JIRCAS has four main research programmes, viz., i) international collaborative research, ii) dispatch and invitation of researchers, iii) research planning and evaluation, iv) cooperation with developing regions. Starting from April 2011, its five year third medium-term plan has commenced with the three main objectives, i) undertakes comprehensive experimental research for technological advancement of agriculture, forestry, fisheries and related industries in tropical and subtropical zones of developing regions, ii) collects, analyzes and publishes information of domestic and international research which are relevant to agriculture, forestry and fisheries as well as farming systems in these developing areas, iii) through the above, JIRCAS seeks to contribute solutions to global food and environmental problems as well as to the stable supply of agriculture, forestry and fisheries resources. For details, please visit: www.jircas.affrc.go.jp

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Foreword

In Asia, rice and wheat are the two major staple foods ensuring the food security of almost 57 per cent of world's population and livelihood of 80 per cent of small holder farmers of the world. Recent concerns about food security and food price volatility have highlighted the critical role of cereals for both food and nutrition security of the poor and vulnerable. In Asia, attention has remained focused predominantly on rice as the region produces almost 80 percent of global rice. However, the importance of wheat in Asia - which supports the livelihoods and provides assured income to a large number of poor, small-scale farmers - has largely been overlooked.

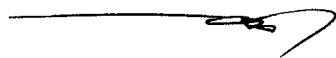
World will need around 1090 million tons of wheat by 2050 to meet the growing needs from its current production level of 680 million tons. To meet this demand, developing countries should increase their wheat production substantially and more than 80 per cent of production increase in developing countries should come from vertical expansion. The production target has to be achieved especially when productivity growth in wheat has slowed down and the average productivity of Asia is even lower than global average.

To address above concerns, a regional consultation on “Improving Wheat Productivity in Asia” was jointly organized in Bangkok, Thailand on 26-27 April, 2012 by the Food and Agriculture Organization of the United Nations (FAO) and the Asia-Pacific Association of Agricultural Research Institutions (APAARI), in collaboration with the International Maize and Wheat Improvement Center (CIMMYT), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Japan International Research Center for Agricultural Sciences (JIRCAS). The consultation was attended by 53 participants representing national agricultural research systems (NARS), CGIAR Centers, FAO, APAARI, non-governmental organizations, farmer organizations and the private sector. It provided a platform to all the stakeholders to share their knowledge and experiences, learn from lessons, assess future trends and prepare a road map to accelerate the overall production and productivity of wheat, taking into consideration the impacts of climate change and (he declining natural resource base.

The consultation covered five technical sessions: i) strategy for increasing wheat productivity, ii) national/regional wheat scenario, iii) managing wheat diseases, iv) stakeholder dialogue, and v) addressing emerging challenges. In addition, two Working Groups on: a) research priorities and need assessment, and b) development initiative for inclusive growth were held to identify policy, research and development needs. The in-depth discussions helped in bringing out key recommendations to overcome (he challenges and enhance wheat production and productivity in the region.

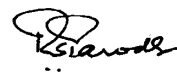
We welcome the decision of the consultation to have a Regional Wheat Alliance (RWC) established to promote wheat production in the region through an integrated manner, ensuring required policy framework and e-networking. We firmly believe that this initiative will help in strengthening wheat research and development activities and their effective linkages in the region.

This publication summarizes the proceedings of the expert consultation. We appreciate the valuable contributions of various participants in making this event a success. It is expected that the investment in wheat research and development will receive high priority in future food security agenda at the national, regional and global levels. We hope that the recommendations of this important and rather timely regional consultation will draw attention of policy-makers, administrators, researchers, farmers and other stakeholders alike in implementing them to increase both wheat production and productivity in Asia.



Hiroyuki Konuma

FAO Assistant Director-General and
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Raj Paroda

Executive Secretary
APAARI

Acronyms and Abbreviations

ACIAR	Australian Center for International Agricultural Research
APAARI	Asia-Pacific Association of Agricultural Research Institutions
APR	Adult Plant Resistance
APRC	Asia-Pacific Research Committee
APSA	Asia and Pacific Seed Association
ARIA	Agricultural Research Institute of Afghanistan
ARI	Agricultural Research Institution
AR4D	Agricultural Research for Development
ASEAN	Association of Southeast Asian Nations
AUDPC	Area Under Disease Progression Curve
AVRDC	The World Vegetable Center
BADC	Bangladesh Agricultural Development Cooperation
BARC	Bangladesh Agricultural Research Council
BARI	Bangladesh Agricultural Research Institute
BGRI	Borlaug Global Rust Initiative
BISA	Borlaug Institute for South Asia
BMGF	Bill & Melinda Gates Foundation
<i>BpLB</i>	<i>Bipolaris</i> Leaf Blight
CA	Conservation Agriculture
CAAS	Chinese Academy of Agricultural Sciences
CCSHAU	Chaudhary Charan Singh Haryana Agricultural University
CEO	Chief Executive Officer
CGIAR	Consultative Group on International Agricultural Research
CHA	Chemical Hybridizing Agent

CIP	International Potato Center
CIMMYT	International Maize and Wheat Improvement Center
CMS	Cytoplasmic Male Sterility
CRI	Crown Root Initiation
CRP	CGIAR Research Programme
CSISA	Cereal System Initiative in South Asia
CTD	Canopy Temperature Depression
CWANA	Central and West Asia and North Africa
DDG	Deputy Director General
DFID	Department For International Development
DG	Director General
DOA	Department of Agriculture
DNA	Deoxyribonucleic Acid
DRRW	Durable Rust Resistance in Wheat
DSSAT	Decision Support System for Agrotechnology Transfer
DWR	Directorate of Wheat Research
EGP	Eastern Gangetic Plains
EGPSN	Eastern Gangetic Plains Screening Nursery
EGPYT	Eastern Gangetic Plains Yield Trial
EIAR	Ethiopian Institute of Agricultural Research
FAO	Food and Agriculture Organization of the United Nations
FAT	Farmer's Acceptance Test
FFT	Farmer Field Trial
FHB	Foliar Head Blight
FIRB	Furrow Irrigated Raised Bed
FLD	Front Line Demonstration
GAP	Good Agricultural Practices

GCARD	Global Conference on Agricultural Research for Development
GCC	Global Climate Change
GCISC	Global Change Impact Study Center
GCP	Generation Challenge Programme
GDP	Gross Domestic Product
GFD	Grain Filling Duration
GFR	Grain Filling Rate
GIBS	Genomic and Integrated Breeding Service
GIS	Geographic Information System
GM	Genetically Modified
GSP	Grain Softness Protein
GWAS	Genome Wide Association Study
GWP	Global Wheat Programme
HI	Harvest Index
HMW	High Molecular Weight
HMWGS	High Molecular Weight Glutenin Subunit
HSI	Heat Sensitivity Index
HYV	High Yielding Varieties
IARC	International Agricultural Research Center
IARI	Indian Agricultural Research Institute
ICAR	Indian Council of Agricultural Research
ICARDA	International Center for Agricultural Research in the Dry Areas
ICM	Integrated Crop Management
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFPRI	International Food Policy Research Institute
IGP	Indo-Gangetic Plains
INHERE	Institute of Himalayan Environmental Research and Education

ILRI	International Livestock Research Institute
INRA	National Institute of Agronomic Research
IPCC	Inter-Governmental Panel on Climate Change
IPR	Intellectual Property Rights
IRRI	International Rice Research Institute
ITPGFRA	International Treaty on Plant Genetic Resources for Food and Agriculture
IWIN	International Wheat Improvement Network
IWMI	International Water Management Institute
IWWIP	International Winter Wheat Improvement Programme
JIRCAS	Japan International Research Center for Agriculture Sciences
KARI	Kenya Agriculture Research Institute
KBRL	Karnal Bunt Resistant Line
LBRL	Leaf Blight Resistant Line
LDC	Less Developed Countries
LMW	Low Molecular Weight
MAIL	Ministry of Agriculture, Irrigation and Livestock
MAS	Marker Assisted Selection
MasAgro	Sustainable Modernization of Traditional Agriculture
ME	Mega Environments
MHA	Million Hectare
MAHYCO	Maharashtra Hybrid Seed Company
MOA	Ministry of Agriculture
MT	Million Ton
MTS	Membrane Thermo Stability
NARC	Nepal Agricultural Research Council
NARS	National Agricultural Research System
NBPGR	National Bureau of Plant Genetic Resources

NCAP	National Center for Agricultural Economics and Policy
NEPZ	North Eastern Plains Zone
NGO	Non-Government Organization
NIASM	National Institute for Abiotic Stress Management
NPT	New Plant Type
NSC	National Seed Cooperation
NUE	Nitrogen Use Efficiency
NUWYT	National Uniform Wheat Yield Trials
NWPZ	North West Plains Zone
NWRP	National Wheat Research Programme
OPV	Open Pollinated Variety
PARC	Pakistan Agricultural Research Council
PD	Project Director
PGR	Plant Genetic Resources
PPB	Participatory Plant Breeding
PPP	Public Private Partnership
PPVFRA	Protection of Plant Varieties and Farmers' Rights Authority
PSU	Public Sector Undertakings
PTOS	Power Tiller Operated Seeder
PVS	Participatory Varietal Selection
QTL	Quantitative Trait Loci
R&D	Research and Development
RCT	Resource Conservation Technology
RIL	Recombinant Inbred Line
RNF	Rural Non Fund Sector
RWC	Rice Wheat Consortium
R4D	Research for Development

SAARC	South Asian Association for Regional Cooperation
SACAN	South Asian Conservation Agriculture Network
SAU	State Agricultural University
SCPI	Sustainable Crop Production Intensification
SI	Strategic Initiative
SMTA	Standard Material Transfer Agreement
SRM	Stem Reserve Mobilization
SSR	Seed Replacement Rate
SRR	Simple Sequence Repeat
THT	Terminal Heat Tolerance
TLS	Truthfully Labelled Seeds
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
WFS	World Food Summit
WPEP	Wheat Productivity Enhancement Project
WRC	Wheat Research Center
WUE	Water Use Efficiency
ZT	Zero Tillage

Executive Summary

Wheat is the second largest food security crop in Asia. Recent estimates indicate that world will need around 1090 million tons of wheat by 2050 from its current production level of 680 million tons. To meet this demand, developing countries should increase their wheat production by 77 per cent and more than 80 per cent of demand should come from vertical expansion.

Taking the above facts in view, FAO and APAARI in collaboration with CIMMYT, ICARDA and JIRCAS organized a “Regional Consultation on Improving Wheat Productivity in Asia” on 26-27 April, 2012 in Bangkok, Thailand to apprise the member countries on the current status of wheat research and development, share experiences, and develop strategies to enhance wheat production to meet the projected demand by 2050. The countries that participated in the expert consultation included Afghanistan, Australia, Bangladesh, China, DPR Korea, India, Iran, Mongolia, Nepal, Pakistan, Thailand and Uzbekistan. A total of 53 participants including the representatives of CIMMYT, ICARDA, JIRCAS, APAARI, FAO, regional NARS, NGOs, CSOs, farmers and the private sector attended. The two day consultation was divided into inaugural session, five technical sessions, two working group discussions and a plenary session.

A total of 26 scientific papers were presented which pertained to five thematic areas: i) strategy for increasing wheat productivity, ii) national and regional wheat scenario, iii) managing wheat diseases, iv) stakeholders dialogue on CRP3.1 (Wheat), and v) addressing emerging challenges. Besides, two working groups were formed to discuss both research and development related issues.

The presentations on strategy for increasing wheat productivity addressed the major research efforts made for breaking yield barriers through germplasm sharing, pre-breeding, conventional breeding, collaborative/ regional testing, and use of new tools and techniques like precision phenotyping, biotechnology, etc. In order to address the emerging climate change scenario, greater focus was stressed on developing biotic and abiotic stress tolerant varieties and resilient management practices for wheat production system. The need to explore new opportunities of GM and hybrid wheat with more than 30 per cent heterosis was also highlighted.

The technical session on national/regional wheat scenario mostly covered the importance of exchange of germplasm with specific traits (biotic, abiotic stress tolerance) and their collective evaluation and sharing of results. For this, a need was felt to establish a regional platform/ alliance for advancement and sharing of new knowledge, germplasm, tools, techniques and practices, for example, stress tolerant germplasm, conservation agriculture based practices, use of small farm machinery, and capacity building, etc.

The disease management strategies were also discussed elaborately. It was highlighted that diseases are not confined within the borders of a particular country and hence, it was considered important to take collective and coordinated action at the regional level for survey, surveillance and early warning. It was also cautioned that emerging diseases are a concern which require institutions like FAO to take lead in terms of awareness that can mobilize resources to tackle the problem.

The session on stakeholders dialogue on CGIAR Research Programme on CRP 3.1 (Wheat) which was officially launched in January 2012, was led by CIMMYT. It was pointed out that through the new CRP, an opportunity for collaboration and sharing research strategies and knowledge has emerged. As 50 per cent of wheat is grown in Asia-Pacific region, major support from this programme should come to this region. A strong partnership around this programme was recommended in order to reap the maximum benefits through involvement of all stakeholders.

In the last session on addressing emerging challenges, the resource persons advocated promotion of conservation agriculture (CA) and highlighted major issues under the conventional tillage based production systems and how CA can help in addressing these issues. Also, issues of adaptation and mitigation to climate change were discussed in detail.

The key highlights of regional consultation on wheat were summarized in the concluding session. Three major areas highlighted for focussed attention included policy, research and development for enhancing productivity of wheat in Asia. It was emphasized that there is a need to develop and popularize wheat cultivars that can withstand the adversaries of weather and soil. The global, regional and country specific research needs would require higher investments, close regional collaboration and mutual understanding to address future threats and constraints in order to ensure food security. Long-term research and development needs must also be kept in view. It was emphasized that food and nutritional security for the people of Asian region could be addressed through increased production of wheat and rice. There is also a need for enhanced focus on the use of alien species, hybrid technology and biotechnology. Environmentally sustainable small farm mechanization requiring support from all the stakeholders also needs to be given due attention. Therefore, regional cooperation among FAO, APAARI, CG Centers like CIMMYT and ICARDA, ASEAN and SAARC is extremely necessary to exchange experiences and learn from each other.

Various action points and recommendations pertaining to the establishment of a Regional Alliance on Wheat (RAW) through facilitation by FAO, APAARI and CIMMYT and to develop a Road Map for future directions for research, development and policy issues emerged. These proceedings cover the details of various deliberations and recommendations emanating from the regional consultation on wheat.

Regional Consultation on Improving Wheat Productivity in Asia

Introduction

Wheat is the second important source of food calories (21%) after rice and the largest source of protein (20%) to 4.5 billion population of the developing countries (Braun *et al.*, 2010). By 2050, the demand for wheat in the developing world will be 60 per cent higher over current level (CIMMYT, 2011). In the Asia-Pacific region, it is the second staple food grain after rice and grown under diverse production systems and ecological settings. Though, wheat has been a key food security crop in the region, its role for food as well as nutritional security has been steadily increasing. During the past half a century, excellent strides have been made in global wheat production but during the past decade or so, the growth in wheat productivity gains has steadily been declining across major wheat production ecologies, posing challenges for the food and nutritional security of the region. Moreover, the instability and vulnerability in aggregate production and productivity of wheat further exacerbates the challenges.

The global wheat harvest during 2010-11 was about 682 million tons from 227 million hectare land with an average productivity of 3.0 t ha⁻¹. However, the productivity in Asian countries which occupied 45 per cent of acreage remained much below (2.23 t ha⁻¹) the global average and contributed only 33 per cent in global wheat production (FAO, 2010-11). The global population is projected to be 9 billion by 2050 of which the Asian countries alone will be inhabiting more than 55 per cent. Therefore, to meet the food demand of ever growing population, the food production in developing countries has to be increased by 77 per cent by 2050 essentially from the same or even less land and water resources. The Asian countries have to produce > 400 million tons of wheat by 2050. As there is no further scope for horizontal growth, most of the production gain (> 80%) has to come essentially through productivity enhancement and sustainable intensification. However, there is a wide variation in the productivity amongst the wheat growing countries of the world. For example, the productivity in Central Asia and Caucasus is 1.4 tons per hectare, while in the European Union, it is around 5.3 tons/ha. In Asia, wheat productivity is 2.3 tons per hectare which indeed is very low as compared to the world productivity of 3.02 tons per hectare and bridging this gap alone can produce 80 million tons of additional wheat in the region that is expected to meet 2050 demand scenario. However, most Asian countries are experiencing yield plateau due to compound effects of low genetic enhancement, natural resource depletion, emerging biotic and abiotic stresses, volatile input costs and climate change effects. This emphasizes on the need to produce more from less favourable environments, on less and inferior quality land, and with less water and energy resources.

This warrants new thinking, direction and strategy for innovations in agricultural research for development (AR4D). For attaining major productivity gains while addressing the emerging challenges to keep pace with population growth, the “Three Pillar Strategy” that includes genetic enhancement, agronomic management and enabling policies, will have to play a critical role.

The genetic variability is the very basis of any crop improvement programme and the wild relatives, landraces and genetic stocks are the important sources for new genetic diversity. However, with the use of conventional breeding tools and approaches, the genetic potential of available germplasm resources though exploited but the yield gains were less due to low investment. Hence, there has not been any quantum yield gain in the new varieties. Moreover, the current efforts on research for developing wheat hybrids are rather limited and without much success. This warrants reorientation of the wheat improvement strategies with greater emphasis on developing high yielding, stable, superior grain quality and more resilient genotypes through integrating conventional breeding and biotechnological tools. Hybrid technology has paid dividends in several crops including self-pollinated crops like rice which has led to rice revolution in many parts of the world. Hence, hybrid technology is one potential option for breaking the yield barriers in wheat. With the projected climate change effects on biotic stresses and new crop management scenarios, genetically modified (GM) wheat may play important role in future productivity gains and needs attention of researchers and policy makers for developing effective strategy for research on GM wheat.

To cope with emerging challenges of natural resource degradation, escalating input costs and declining farm profits while improving the productivity, the new agronomic management practices based on the elements of conservation agriculture and precision farming have shown promise under different production systems in diverse ecologies and farming situations . However, there has been significant genotype \times management interaction which many times limits potential gains of either of components (genotype and management), if they are not compatible. Therefore, tailoring genotypes for different crop management scenario and production systems should also find place while reorienting breeding strategies to capture genotype \times management interactions. Though seed is a basic and critical resource for crop production but despite the major efforts on developing new genotypes/cultivars, the efficient and region-specific seed systems of these genotypes are lacking in most of the developing countries of the region. Hence, farmers do not have timely access to quality seed. Therefore, a suitable mechanism for region-specific seed systems needs to be in place to ensure good seed replacement rates and avoid any pest/disease out-break due to use of age-old and susceptible genotypes.

Several region specific technologies and innovations are in advance stages of experimentation but the lack of a regional common platform for sharing these technological advancements and information and lack of trained human resources at different levels and scales are the major deterrent in accelerating the pace of adoption of new technologies for their impact on enhancing wheat productivity in the region. Hence, greater partnerships for regional learnings, information and technology sharing (for example, CRP 3.1 on Wheat) are a must for harnessing potential benefits of the technologies in the homologous ecologies/regions. Also, there is need for a complete shift in our approach from R&D to R4D as there exists large gaps between research and development and hence we need to effectively translate research into appropriate technology packages that are adaptable to local situations and production systems. Technology development *per se* will not be able to make transformations if a mechanism is not in place for enabling policy environment, effective communication, extension and capacity building for greater uptake and farm level impact of these technologies. Information Communication Technologies (ICTs), for example, cell phone based SMS services with quality and farmer friendly information can help in real time access to information by the large number of farmers. Innovation systems and pathways for participatory adaptation of technologies should

form the integral part of technology development and delivery process to develop consensus among different stakeholders and define recommendation domains of the technologies. Also, enabling policies for resilient practices and environmental services to farmers should find a place in new AR4D agenda.

Against this background, a "Regional Consultation on Improving Wheat Productivity in Asia" was jointly organized by the Food and Agriculture Organization of the United Nations (FAO) and the Asia-Pacific Association of Research Institutions (APAARI), in collaboration with the International Maize and Wheat Improvement Center (CIMMYT), the International Center for Agricultural Research in the Dry Areas (ICARDA) and the Japan International Research Center for Agricultural Sciences (JIRCAS) at Bangkok, Thailand on 26-27 April, 2012. The consultation was attended by 53 participants representing national agricultural research systems (NARS) from Afghanistan, Australia, Bangladesh, DPR Korea, India, Iran, Mongolia, Nepal, Pakistan, Thailand and Uzbekistan, CGIAR Centers, FAO, APAARI, non-governmental organizations, farmer organizations and the private sector. The consultation provided a platform for all the stakeholders to share knowledge and experiences, learn from lessons, assess future trends and prepare a road map to accelerate the overall production and productivity of wheat, taking into consideration the impacts of climate change and the already limited natural resource base.

The consultation was organized into five technical sessions: i) strategy for increasing wheat productivity, ii) national/regional wheat scenario, iii) managing wheat diseases, iv) stakeholder dialogue, and v) addressing emerging challenges. In addition, two Working Group sessions: 1) research priorities and need assessment, and 2) development initiative for inclusive growth were held to identify policy, research and development needs. The in-depth discussions were held in different sessions and the outcomes of the discussions were summarized in the plenary session.

Objectives

The specific objectives of the regional consultation were as follows:

- To provide a regional platform to share experiences and assess national/regional priorities for enhancing wheat production in the region
- To develop a common strategy to address emerging problems in the region
- To develop mechanisms to facilitate the exchange of knowledge and products and to learn from each other's successes and failures
- To develop a 'Road Map' for enhancing wheat productivity and production in Asia for improved livelihood of resource poor smallholder farmers

Inaugural Session

The regional consultation commenced with the welcome address by Dr Raj Paroda, Executive Secretary, Asia-Pacific Association of Agricultural Research Institutions (APAARI). In his welcome address, Dr. Paroda highlighted that wheat in Asia is not only a staple food but also important for nutritional security of the region. He mentioned that it is a matter of pride to be associated with wheat programmes at global level that brought laurels to the world population particularly in Asia with several countries becoming self sufficient in terms of wheat production. However, the decelerating productivity growth rate of wheat which has come down to less

than 1 per cent is not matching with the population growth of 1.8 per cent. For attaining the projected global demand of 1090 million tons of wheat by 2050, the annual production growth has to be 1.6 per cent which essentially has to come from productivity enhancement as there is no further scope for horizontal expansion. Therefore, the three pillar strategy of genetic enhancement, agronomic management and enabling policy has to play critical role to meet the growing demand on a sustainable basis. This calls upon the prioritization of research and development agenda for enhancing productivity while addressing the emerging challenges of wide management yield gaps, deteriorating natural resources, complexities of biotic and abiotic stresses and changing climates.

Dr. Paroda mentioned that there are number of options available for breaking the yield barriers in wheat provided that the issues of narrow genetic base and major biotic stresses such as stripe and stem rust diseases are dealt with integrating conventional breeding with molecular tools and with greater synergy among the stakeholders. He further emphasized the need of optimization of production systems and resource endowments to harness enhanced productivity with efficiency while addressing the impact of projected climate change. New strategies including integrating molecular tools with conventional breeding for quality improvement and value addition in wheat for enhanced nutritional security should also be given thrust under the changing scenario of food habits and globalization of agriculture.

Dr. Paroda further emphasized that agronomic management practices not only for wheat but in a systems perspective have to play key role under the emerging natural resource constraints and changing patterns of demand and supply balances of inputs (water, nutrient, labour, energy, etc.) that have direct bearing on the farm profitability. The conservation agriculture (CA) based management practices have paid dividends in wheat systems of Asia and are getting attention of farmers and policy makers and planners. But, the breeding strategies are still commodity focused and under conventional tillage based practices due to which the full potential of these technologies is not realized. The breeding strategies, therefore, need to be reoriented to capture genotype \times management interactions. The CA based technologies which are currently being adopted on nearly 2 million hectares can be adopted on atleast 12 million hectares to address the challenges of deteriorating soil health, declining water tables, labour and energy shortages. However, local adaptation through participatory approaches, innovation networks, capacity building and knowledge sharing mechanism needs to be in place for accelerated adoption of these knowledge intensive technologies by the smallholder farmers. Therefore, to meet the growing wheat demand for the ever increasing population on a sustainable basis in the region while adapting to climate change effects, not only the technology development but also efforts on convergence, partnerships and enabling policy environments are critical.

Dr. Masa Iwanaga, President, Japan International Research Center for Agricultural Sciences (JIRCAS), Japan, in his special address mentioned that wheat is a widely grown crop covering diverse climates, soil types, and production conditions and is an integral part of food chain in Asia due to its history and product use. He further emphasized that wheat crop is sensitive to climate change and is also vulnerable to diseases like rusts, etc. The stagnating yields, regional yield gaps, and shrinking profitability that exist even in the developed countries are the cause of concern to all of us. He also highlighted that fertilizer use efficiency and value chain components in wheat systems are to be addressed adequately to meet future food demand in the region.

Dr. Thomas Lumpkin, Director General, International Maize and Wheat Improvement Center (CIMMYT) in his chairman's remarks presented the scenario of wheat crop in India, pattern of cereal consumption in Asia and China vis-à-vis per capita consumption in both developing and developed countries. He highlighted that wheat trade by 2050 will be primarily controlled by US, Canada, Australia, Black Sea region, China and Argentina. The global changes would require researchers to look at water, energy, climate change, food demand, diversity and nutrient efficiency in a holistic manner. Dr. Lumpkin said that large yield gaps in wheat in Eastern Gangetic Plains of South Asia need special attention to produce additional wheat with available technological options. He concluded his remarks by the statement that the biodiversity, tolerance to abiotic and biotic stresses, photosynthetic efficiency, decision support tools, small farm mechanization and precision farming, and supply of good quality seed at right time and place will give solutions to many of the present day constraints. Dr. Lumpkin further added that the Borlaug Institute for South Asia (BISA) has been jointly established by Indian Council of Agricultural Research (ICAR) and CIMMYT and this institute will have research focus on these issues.

Mr. Hiroyuki Konuma, FAO Assistant Director General and Regional Representative for Asia and the Pacific, in his inaugural address, highlighted that wheat and rice are the staple food crops and main source of energy globally particularly for vegetarian population. He emphasized that growing concerns for production and productivity gain in major wheat growing countries are to be addressed locally as well as regionally, since many of the problems are common across countries. The enhanced production has to come from less water, less lands and less chemicals by promoting ecologically sustainable approaches for different production systems. There are many challenges due to climate change, soil degradation, fertilizer cost, heat and drought, productivity stagnation and emerging new biological threats. There is a slow down in productivity growth in whole Asia except China. Against this backdrop, this regional consultation is very important and timely. Dr. Konuma was of the opinion that there exists a vast potential of achieving the target production of wheat, provided that the research and developmental efforts are carried forward in right direction.

Dr. Konuma showed a concern that increasing temperature is a major threat and hence, breeding strategies will have to be reoriented to develop wheat varieties which are tolerant to temperature fluctuations and have resistance to new virulent diseases and pests. Therefore, concerted efforts on the part of researchers, extension workers, farmers and policy makers are needed to improve soil health, input use efficiency and the yield potential of wheat crop in the region.

He concluded that we have a good opportunity during the next two days to review and discuss major issues for increasing productivity and production in different countries in Asia with emphasis on managing biotic and abiotic stresses in view of changing climatic scenario. The task of fulfilling the increasing demand for food in general and for wheat in particular is very challenging under the current scenario of climate change, productivity stagnation and emergence of new diseases and insect-pests. Mitigating these challenges requires understanding of the reasons associated, options available and designing an effective strategy with new technologies, enabling policies and establishment of new networks and collaborations. In view of this, it is necessary to put more concerted efforts for the improvement of wheat production and productivity and thus calls for an urgent action to review the current scenario of wheat production and to develop strategies to enhance productivity for sustained food and nutritional security. Dr. Konuma further emphasized that close partnership, regional efforts, FAO's priority for Asia's food production

and representation of various wheat growing countries in this consultation will be very helpful in ensuring the food and nutritional security of Asia.

Subash Dasgupta, Senior Plant Production Officer, FAO Regional Office for Asia and the Pacific delivered the vote of thanks.

Technical Sessions

Technical Session I. Strategy for Increasing Wheat Productivity

Chair: *Dr. S. Nagarajan*

Co-Chair: *Mr. Mirdad Panjsheri*

Rapporteur: *Dr. Gyanendra singh*

In this session, five presentations covering the global and regional perspectives on strategies for increasing wheat productivity were made by the representatives from Consultative Group on International Agricultural Research (CGIAR), National Agricultural Research Systems (NARS) and private sector organizations. Brief summary of the presentations and major highlights of the session are given below:

Dr. Hans J. Braun, Director, Global Wheat Programme, CIMMYT while making his presentation on regional scenario of wheat in Asia, highlighted that Asia is the largest producer of wheat (280 m t) but has highly variable national yields ranging from 1.4 tons per hectare in Kazakhstan to 5.6 tons per hectare in Saudi Arabia. He further mentioned that major Asian wheat producing countries that were involved in the green revolution are today self-sufficient in wheat production with a few exceptions. But, meeting the projected 60 per cent higher wheat demand by 2050 in the developing world (mostly in Asia), where yield growths during 1995-2006 remained around 1 per cent, is a major challenge as this will lead to short fall in the needed 25 per cent increase to keep prices at the current level. He further emphasized that the climate-change-induced heat and water stresses and natural resource degradation are estimated to reduce wheat production in developing countries where 60 per cent wheat is produced. In this regard, he highlighted the need for new studies on consumption patterns, forecasting production statistics and also demand supply issues. Dr. Braun talked about the stagnating yields and developing strategies to enhance yield gains through germplasm enhancement and sharing, international testing, parental characterization, conventional breeding, exploitation of distant gene pools, double haploids, genomic selections, synthetics, application of physiology, developing hybrid wheat, improved agronomy, disease resistance and enabling policies. He also emphasized the challenges in wheat quality improvement and value addition under the global climate change scenarios. He highlighted that future productivity gains will come through systems approach and it is high time to develop and provide a good gene package of high yield, stability, wide adaptation, disease resistance and quality. He stressed that high yield potential and drought tolerance for improved water use efficiency need more attention. There is a need to have network of phenotypic platforms to generate reliable and repeatable data, and better understanding of heat and drought tolerance. While concluding his presentation, Dr. Braun emphasized on higher investments by both private and public sectors on wheat research and development.

Dr. R.C. Sharma, International Center for Agricultural Research in the Dry Areas (ICARDA), on behalf of Dr. S. Rajaram, presented the strategy for increasing wheat productivity highlighting

the projections of wheat for Central and West Asia and North Africa (CWANA) and South Asia in the light of global production. While highlighting the importance of wheat in the developing countries, he stressed that small shortage in wheat supply can cause big price shocks particularly in developing countries and make market highly volatile. He further mentioned that genetic gain in wheat during the last thirty years has been about 1.5 per cent per year. However, to meet the growing demand, this needs to be raised to at least 2.0 per cent per annum. The major challenge of yield barriers is to be tackled through hybrid wheat, exploitation of alien gene pool, improved water use efficiency, enhanced heat and drought tolerance, application of genomics, transgenics, and developing new wheat genotypes using new tools and advanced technologies.

Dr. K.C. Bansal, Director, National Bureau of Plant Genetic Resources (NBPGR), ICAR, India made a presentation on germplasm conservation through use and role of biotechnology in wheat improvement and covered various issues to make better use of available and new germplasm. He expressed that it is time to initiate pre-breeding activities across institutions to address the constraints for wheat productivity. Dr. Bansal said that a paradigm shift in the functional model, genome wide selection studies, trait-based reference collections, variability assessment for specific traits and providing value added germplasm to breeders are some of the options that are to be adopted using an integrated and holistic approach.

Dr. Usha Zehr Barwale, MAHYCO, India presented the progress of work on hybrid wheat and herbicide tolerance at MAHYCO and shared the status of hybrid wheat research, constraints, challenges, opportunities and options to make use of hybrid wheat technology for increasing productivity. Dr. Barwale informed that MAHYCO is currently marketing one hybrid in Central and Peninsular India and many more are in the pipeline. She further mentioned that for commercial cultivation of hybrid wheat, there is a need of economically viable level of heterosis. Though, there are many challenges for the hybrid wheat production but it appears to be economically viable for small scale farmers. It was highlighted that herbicide resistance against some weeds is reported and a team of scientists is working on introducing glyphosate tolerance in wheat using both GM and non-GM approaches. It was pointed out that for such studies, several cycles of testing are required before the product is ready for commercialization.

Dr. A.K. Joshi, CIMMYT, Nepal presented the status of regional collaboration for wheat research in Asia. He pointed out that for livelihood security, wheat in Asia is very crucial as each 1.0 per cent growth in wheat can reduce poverty by 0.5-1.0 per cent. However, for attaining this growth in wheat while addressing the serious issues of resurgence of super races and germplasm exchange, regional collaborations are critical. Citing the example of Mexico-Kenya shuttle breeding programme for managing stem rust problem, he stressed on the need for creating such networks at regional level through regional and international collaboration. He further, highlighted that in view of emerging challenges (climate change, new pathotypes, post-harvest losses, socioeconomic issues) and opportunities (hybrid wheat, biotechnology, conservation agriculture, etc.), the regional collaboration is very critical not only for sharing germplasm but also for knowledge and capacity enhancement.

Key highlights

- For enhancing wheat productivity, major research efforts need to be made on breaking yield barriers through pre-breeding, conventional breeding, germplasm sharing, collaborative regional testing, and new tools and techniques like phenotyping, biotechnology, etc.

- To address the emerging climate change effects, greater focus should be on developing biotic and abiotic stress tolerant varieties and resilient management practices for wheat systems.
- There is a need to explore new opportunities for developing and using GM and hybrid wheat with more than 30 per cent heterosis through collaborative and a mission mode approach to address the major challenges of hybrid wheat, for example, greater genome size (17GB), non-availability of diverse cytoplasm sources, assembling favourable genes from diverse genetic resources, high seed rate and production cost, etc.
- The available germplasm need to be characterized and used to contribute genes for specific traits related to stress tolerance and high yields.
- Reorientation of breeding strategies is extremely necessary to capture genotype × management interactions.
- Integrated approach of agronomic, genetic and physiological interventions need to be deployed for future productivity gains.
- There is a need to develop appropriate mechanism for regional surveys and surveillance for the occurrence of new races of pathogens and pests and to develop location-specific management practices with special reference to conservation agriculture adapted to smallholder farmers.
- Inter-regional cooperation needs to be established/strengthened for exchange of germplasm, production technology and information. Also, there is a need for regional collaboration for enhancing investment in research and development.
- There is a strong need to strengthen capacity building in frontier areas to develop core competence and socioeconomic studies for assessing regional demand-supply scenario to design right policies for increasing profitability.

Technical Session II. National/Regional Wheat Scenario

Chair: *Dr. Thomas Lumpkin*

Co-Chair: *Dr. Shahid Masood*

Rapporteur: *Dr. S.S. Singh*

In this session, the regional and national wheat research and development scenario were presented by wheat research leaders from regional NARS from the Asian countries. The brief summary of each presentation and major highlights of the discussion during the session are presented below:

Dr. M.J. Uddin, while presenting the wheat scenario in Bangladesh mentioned that agriculture sector is the back bone of country's economy contributing 21.7 per cent to gross domestic product (GDP) and engaging 48 per cent of labour force in agriculture and agro-based industries. Bangladesh is facing problem of rapid population increase and reduction in agricultural land area and there is very little scope to bring more area under cultivation. Wheat area decreased by 50 per cent from 0.773 million hectares in 2000-01 to 0.374 million hectares in 2010-11. Similarly, wheat production has also gone down from 1.67 million tons in 2000-01 to 0.972 million tons in 2010-11. However, in case of productivity, there is increase from 2.16 tons per

hectare in 2000-01 to 2.60 tons per hectare in 2010-11. The Wheat Research Center under Bangladesh Agricultural Research Institute (BARI) is responsible for conducting research on wheat crop and in the past 50 years, it has released 28 varieties of which the recently released varieties are high yielding with tolerance/resistance to biotic and abiotic stresses. Emphasis is now being laid on industrial quality and two varieties, BARI Gom22 and BARI Gom24, possessing high gluten content were released in 2005. BARI Gom27 was found to have adult plant resistance to Ug99. Resistance to leaf rust in high yielding varieties is governed by seven major genes including adult plant resistance gene *Lr34*. The good level of tolerance to spot blotch has been observed in new varieties. Dr. Uddin also informed that good research work is in progress in soil and crop management including optimization of fertilizer requirement and its placement options. Acid soils are being amended through application of dolomite lime and other aspects of soil management such as nitrogen use efficiency (NUE), straw and soil fertility have also been taken care of. Conservation agriculture is becoming a reality due to adoption of machines by farmers such as power tiller operated seeder, power tiller operated bed planter and zero till drill which save time, energy, water and seed and reduce the production cost.

Dr. Uddin mentioned that there exists a huge gap in yield mainly due to late planting of wheat in rice-wheat cropping system, sterility due to micronutrient deficiency and depletion of organic matter, etc. Leaf blight is the major disease of wheat in Bangladesh followed by leaf rust, head blight and black point. Rodents and birds are the other major biotic constraints in wheat production. Among the abiotic stresses, high temperature at the time of grain filling is the most damaging as 50 per cent wheat area is planted late due to late harvesting of rice in rice-wheat crop rotation. There is a great loss in production due to less water availability at critical crop growth stages and also water logging due to rains at seedling stage causing stunted growth. Spike sterility due to boron deficiency and soil acidity in north-western part of Bangladesh are also responsible for significant yield losses. In southern region, high salinity at sowing time is causing problem in the expansion of wheat area.

To address the challenges including climate change, Dr. Uddin suggested for developing high yielding varieties with tolerance to abiotic stresses, resistance to biotic stresses and possessing high input use efficiency. There is a need for maintaining continuity for survey and monitoring of new diseases and new pathotypes. He emphasized on strengthening conventional breeding programmes through the use of molecular tools, ensuring crop management for enhancing productivity, conservation agriculture, participatory varietal selection and quality seed production and its horizontal spread to farmers' fields for enhancing wheat productivity. He informed that productivity of wheat crop in Bangladesh can be enhanced in future through vertical increase in yield by developing new varieties, quality seed, timely seeding, recommended doses of fertilizers and irrigation, and use of improved management technologies.

Dr. Uddin further mentioned that in order to sustain and increase wheat production in Bangladesh, more efforts should be made to expand wheat area where annual precipitation is reducing due to global climate change. Simultaneously, artificial recharge of ground water table should be done. There is scope for increasing 0.3-0.4 million hectare area in southern region. Further, strengthening collaborative research programmes with international organizations especially in the fields of breeding for abiotic and biotic stresses including biotechnological research needs to be taken up vigorously. More emphasis is needed on participatory adaptive research and rapid dissemination of new varieties and technologies to the farmers.

Dr. Alain P. Bonjean, on behalf of Dr. Zhong-hu He, Chinese Academy of Agricultural Sciences, presented the status report on wheat production and technology improvement in China. He informed that China is leading in production as well as consumption of wheat in the world. The country is self-sufficient with production of 118 million tons of wheat from 24 million hectare area under 10 agro-climatic zones of the country. The average productivity was 4.7 tons per hectare during 2011 with increasing trend every year. The area covered under wheat crop has come down from 30 million hectares to 24 million hectares due to priority given to other crops for the purpose of increasing diversity. The major constraint in wheat production is the shortage and quality of water. He informed that the major diseases of wheat are sharp eye spot and take-all and there is not a single variety under cultivation which is resistant to these diseases. The other constraints in wheat production are small holdings, competition between cash and grain crops, global warming, lodging due to increase in seed rate under zero tillage, labour shortage, etc. Top priority in breeding high yielding varieties has been given to the use of world germplasm, increasing grain weight, plant height and high harvest index. Emphasis has also been given on developing synthetics and hybrid wheat but with less success. Efforts have also been made for promotion of conservation agriculture including water saving technologies and developing good quality wheat varieties suitable for noodles and other end use products.

Dr. Bonjean mentioned that the efforts are being made to develop genetically modified wheat with resistance to biotic and abiotic stresses, high yield potential and good end use quality. The government is quite positive in providing support in various ways such as increase in price, funding for research and extension, mechanization and quality seed availability. Future strategies suggested are to increase yield potential under less inputs, improvement in processing quality, promotion of mechanization, public-private-partnership in seed industry, developing two line wheat hybrids, marker assisted selection and genetic transformation to achieve target of producing 120-130 million tons of wheat by 2030.

Dr. Indu Sharma presented the status report of wheat improvement in India. She mentioned that the country had record production with 85.93 million tons of wheat from 29.5 million hectare area during 2010-11. India is cultivating three species of wheat, namely, *Triticum aestivum*, *T. durum* and *T. dicoccum* which contribute 95 per cent, 4 per cent and 1 per cent, respectively towards total wheat production. The area under wheat cultivation is divided into six agroclimatic zones. The short duration and high temperature tolerant wheat varieties are being cultivated in central and southern peninsular region. The strength of the country's wheat improvement is the All India Coordinated Wheat and Barley Improvement Project (AICW&BIP) which conducts multi-location and multi-disciplinary trials in all the six zones of the country and has so far released 382 varieties of wheat (377) and triticale (5) for commercial cultivation. There are many constraints in increasing the yield gain which includes narrow genetic base of the available germplasm, increase in ambient temperature due to climate change, water availability at critical stages in some area, changing pest dynamics, high cropping intensity resulting in delayed planting of wheat crop, etc. However, the efforts are being made to enhance productivity through hybrid wheat research, changing plant architecture for high biomass with greater physiological efficiency and stabilizing production through incorporation of genes and their combinations for resistance to diseases especially rusts in newly developed varieties. Molecular markers are being used in breeding programmes at some cooperating centers in the country. The perfection of conservation technology in wheat production has resulted in wide utilization of zero-tillage, furrow irrigated raised bed technology, rotavator, happy seeder and laser land leveller by the farmers, thereby achieving record production continuously for the last three years. The concerted efforts are also

being made to develop varieties rich in micronutrients such as beta carotene, zinc, iron, etc., and better grain quality for end use products. The quality seed availability to farmers is a major task to harness genetic potential of new varieties and also to narrow down the yield gaps in different agro-climatic zones of the country.

Dr. Abdolali Ghaffari presented the status report on wheat in Iran and mentioned that the area covered under wheat crop in 2011 was 6.7 million hectares of which 2.7 million hectares is irrigated and 4.0 million hectares is rainfed with total production of 13.5 million tons in 2011. Iran is generally known for arid and semi-arid climate. Three types of wheat, viz., winter, facultative and spring are being grown in both irrigated and rainfed situations under different agroclimatic zones. There are 28 agroclimatic zones of which 50 per cent receive less than 250 mm rainfall every year, while drought and intense cold are always a limiting factor in wheat production. Stripe rust and Sunn pest are major diseases and pests, respectively. Russian wheat aphid is becoming a problem in cold areas, while common aphid has become a problem in temperate and warmer areas. Other diseases like *Fusarium* head blight and *Septoria* are also gaining importance. The stem rust race Ug99 was reported in 2007 from Broujerd and Hamadan. However, several newly released wheat varieties are found to be resistant to Ug99. The conservation agriculture has not been given due importance in Iran. However, zero-till drills which are less in number are being used as minimum tillage options. Priorities for increasing wheat production are conservation agriculture, early maturing varieties, disease and pest resistant varieties particularly Sunn pest resistant, use of marker aided selection in breeding programmes and dissemination of new technologies to the farmers. The major emphasis is needed in developing good agronomic practices.

Dr. Dhurba Bahadur Thapa, presented an insight into the wheat scenario of Nepal on behalf of Dr. Dil Bahadur Gurung. He indicated that Nepal has wide diversity in landscape, altitude, topography and temperature. Temperature and rainfall are the main factors affecting agriculture. Wheat ranks third after rice and maize in area and production in the country. The average productivity of wheat is 2.30 tons per hectare. Its contribution to national food security is about 25 per cent and consumption rate has increased at a rate of 2 per cent per annum since 1972. The major factors for increasing wheat production are development of high yielding varieties with resistance to biotic and abiotic stresses along with availability of quality seeds. During 2010-11, Nepal produced 1.75 million tons of wheat from an area of 0.76 million hectares. Dr. Thapa further mentioned that 33 varieties have been released since 1962 including 13 varieties introduced from India and Mexico. Due to climate change, the major constraints in enhancement of productivity are water and fertilizer application, temperature during grain filling and disease incidence. To cope up with the emerging challenges, wheat research programme has been strengthened with the objective to breed varieties resistant to biotic and abiotic stresses in addition to higher yield in collaboration with regional and global institutions. Also, emphasis has been laid on developing suitable conservation and crop management technologies, use of molecular tools and public-private-partnership (PPP) in technology generation and dissemination.

Dr. M. Shahid Masood, in his presentation on country report of Pakistan mentioned that among cereals, wheat was grown on the largest area of 8.90 million hectares with production of 25 million tons and productivity of 28 tons per hectare during 2010-11. About 70 per cent area is irrigated and 76 per cent of the total wheat production comes from Punjab province. The wheat research was strengthened by the Pakistan Agricultural Research Council (PARC) through effective linkages among 26 national and 3 international centers. He mentioned that major priorities of

wheat research are breeding varieties with tolerance to abiotic stresses such as drought, heat and salt, tolerance to biotic stresses (rusts and powdery mildew), earliness and good grain quality. The zero-tillage is becoming common in rice-wheat system, while relay cropping is being undertaken in cotton-wheat cropping system. There is also increased use of biotechnology in wheat research in order to reduce time frame in developing varieties, genetic transformation for drought and salt tolerance using simple sequence repeat (SSR) markers and deoxyribonucleic acid (DNA) finger printing of traditional and improved cultivars. He informed that public, private and informal seed sectors are involved in seed production and its distribution. Several collaborative projects with international organizations are also in place for wheat research and development of which Pak-China Phase II Project is focussing on development of hybrid wheat.

Ms. Tuul Dooshin presented the country report of Mongolia on behalf of Dr. Baryartulga L. Khagvasuren. She highlighted the impact of climate in Mongolia which is continental in nature with an average rainfall between 200-400 mm and average temperature ranging from -30°C to +30°C. Therefore, the growing season is short with low irrigation and high evaporation rate. During 2011, wheat production was 0.45 million tons from an area of 0.30 million hectares with average productivity of 1.53 tons per hectare. Focus of Mongolian Government is on production and supply of high quality seeds of high yielding varieties adapted to arid climate. The concept of new varieties and seed policy is always a significant issue for the crop sector development and its efficiency. During the past 50 years, 81 wheat varieties including 9 of durum wheat have been released of which 6 varieties covered 72 per cent area during 2011. The major challenges faced by the country are climate hazards causing low productivity, financial problems and land locked nature resulting in high cost of transportation of agricultural products and introduction of innovative technologies. She informed that in future, Mongolia is planning to import farm implements, fertilizers, agro-chemicals and also to upgrade and develop irrigation systems in order to increase domestic agricultural production.

Dr. Mirdad Panjsheri presented agricultural production scenario in general and wheat in particular in Afghanistan. He mentioned that out of 4 million hectares total cultivable land area, 45 per cent (1.8 m ha) is irrigated and 55 per cent is rainfed. The total population of the country is 27 million out of which 85 per cent is dependent on agriculture. Wheat is the staple food and therefore, food security and employment generation depends on this crop. As a result of continuous disturbances over the last 30 years, the economy of Afghanistan has shattered due to lack of infrastructure, farm machineries and competent human resource in agricultural research. The significance of wheat crop may be judged from its requirement of 5.18 million tons out of total cereal requirement of 6.30 million tons. However, the production during 2011 was 3.39 million tons with deficit of 1.79 million tons. Wheat acreage is 2.23 million hectares with productivity of 1.52 tons per hectare. The efforts are being made to modernize irrigation systems through construction of 30 new medium and large dams and 2,000 small water reservoirs. Agricultural Research Institute of Afghanistan (ARIA) has 12 departments of which crop improvement department is engaged in introduction of technologies especially wheat varieties from international organizations. The challenges are enormous which include lack of competent man power, farm machineries and agricultural equipments, investment, credit systems for farmers and market. ARIA has challenge to come up in agricultural research and developmental activities using modern technologies with the support of international organizations for food security of the country. At the end of his presentation, Dr. Panjsheri made a request on behalf the Afghanistan Government to all the international institutions for their generous support in agricultural research and development programmes of the country.

Dr. R.C. Sharma while presenting report on the status of wheat improvement in Central Asia mentioned that the Central Asia comprises five countries, viz., Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan with total area of 400 million hectares where wheat, barley, rice and maize are major cereal crops with production of 25.5 million tons. Kazakhstan and Uzbekistan are self sufficient in wheat production, while other countries are also giving high priority to increase wheat production to become self-sufficient. Wheat was produced on 16.13 million hectares with the production of 21.04 million tons and productivity of 1.3 tons per hectare compared to whole Asia which was 2.88 tons per hectare during 2010. Winter wheat occupies larger area than spring wheat. Since independence in 1991, Uzbekistan is leading in wheat productivity with 4.74 tons per hectare due to its national commitment and strong linkages with ICARDA and CIMMYT towards enhancement of productivity and production. Dr. Sharma informed that the major constraints to wheat productivity enhancement in Central Asia are biotic stresses (stripe rust, leaf rust, Sunn pest and cereal leaf beetle), abiotic stresses (drought, heat, salinity and frost) and socioeconomic constraints like funding, infrastructure, manpower, seed, technology adoption and policy. Stripe rust is main threat in winter wheat production causing up to 30 per cent yield reduction and the region has faced 5 stripe rust epidemics in the years 1999, 2003, 2005, 2009 and 2010. The winter wheat varieties, Hazrati Bashir, Gozgon and Elomon released in 2010 in Uzbekistan are resistant to stripe rust. Soil salinity is increasing due to availability of less water required for leaching of salts. Sunn pest resistance is missing in all the popular varieties and hence is a major challenge in wheat productivity enhancement. There is an urgent need for increasing area under stripe rust resistant varieties, improving input use efficiency, narrowing yield gaps, crop diversification by inclusion of legumes in the cropping system, enhancing wheat research investment and increasing the number of competent young researchers.

Key highlights

- The major thrust needs to be given on sharing germplasm with specific traits (biotic, abiotic stress tolerance) and their collective evaluation and sharing of results.
- Stripe rust has emerged as one of the major diseases in the region and hence there is an urgent need to put a mechanism in place for preventive measures through organizing joint survey and surveillance activities and deployment of resistant varieties.
- Collaborative evaluation of advanced lines of wheat from all the wheat growing countries in Asia needs to be undertaken.
- There is a need to develop regional platforms/networks for advancement and sharing of new tools, techniques and practices, for example, stress tolerant germplasm, conservation agriculture based practices and machinery, capacity building, etc.
- The nutritional quality issues need to be addressed through biofortification using appropriate strategies including, use of novel germplasm, breeding, molecular tools and management practices.
- Augmentation of research on genetically modified wheat should be given greater focus for enhancing tolerance to heat, drought and salinity stresses to address the climate change mediated yield losses.
- There is a need to develop region-specific effective seed systems to enable the farmers to have easy access to quality seed of potential and locally recommended varieties in time.
- There is a need to develop innovation systems and networks involving public and private

sector organizations, NGOs, farmer organizations and service windows for local adaptation, participatory learning and large scale delivery of improved technologies.

- There is a need for higher investment with convergence by public and public sector undertakings (PSUs) on research and development in wheat at the national, regional and global level.
- Strong collaboration with national and international organizations needs to be established for achieving food security.

Technical Session III. Managing Wheat Diseases

Chair: *Dr. Ronnie Coffman*

Co-Chair: *Dr. Robert Park*

Rapporteur: *Dr. Etienne Duveiller*

Six presentations covering primarily the disease scenario and their management in Asia were presented in this session. The brief summary and key highlights of the discussions during the session are given as under:

Dr. Ronnie Coffman made a presentation on 'Borlaug Global Rust Initiative (BGRI) for Managing Wheat Rusts' which involves more than 20 centers world-wide. Rust surveillance had been very effective since 2008 and gene discovery including from wild relatives has led to the identification of 32 new resistance genes. Marker assisted techniques progressed in recent years and marker assisted selection (MAS) is increasingly used by breeders. Breeding efforts based on minor genes had been very effective under the leadership of CIMMYT. The seed multiplication and delivery needs to be given priority attention as the old and obsolete varieties need to be replaced with the new high yielding varieties. Therefore, donors also should come forward to make sure that quality seed reaches the farmers. The 'Durable Wheat Rust Research' community shares information through the BGRI website which may be consulted for more details.

Dr. K. Vijayaraghavan supplemented the information and presented the progress of work in South Asia. He talked about gene pyramiding and deployment and illustrated the efficiency of screening in early generations in aggressive hot spots in Kenya and Ethiopia. Data are very fragmented and needs to be analyzed. It serves as a toolbox for rust monitoring.

Dr. S. Nagarajan made a presentation on wheat diseases and climate change in Asia and emphasized the role of Central Asia on rust survival and distribution after the shift in crops, namely, the reduction of area grown under cotton and the increase in spring wheat which is more efficient in water use. Climate change is affecting the disease scenarios through changes in crop sequences. He also showed that some genes may lead to increased severity with higher temperatures whereas other genes will be affected by lower temperatures.

Dr. Robert Park, in his presentation on managing wheat rusts by using minor genes highlighted that the genes tend to be durable and there is a need for more detailed studies to understand how minor genes operate. Dr. Park underlined that past durability does not guarantee durability forever. Thus, pre-breeding efforts need to continue. Gene pyramiding is very important and needs greater thrust. There are also exceptions and some genes i.e. *Sr.12* behaves like minor genes, which should be kept in view.

Dr. E. Duveiller presented a paper on management of wheat diseases in Asia and highlighted the revised priorities for wheat disease resistance and control in the Asian context. The three rusts

are global diseases that need to be addressed on priority but foliar blight is the most difficult disease to be resolved in South Asia. *Fusarium* head blight is important in China where the awareness for food safety (less mycotoxin) needs to be enhanced. Wheat blast recently reported only in South America is an emerging disease. However, risk awareness and attention should be given in other continents due to lack of resistance. It does not come from rice. The disease epidemiology needs further understanding and the source of resistance must be identified. He also stressed on breeding for disease and pest resistance and highlighted the need for characterization of source germplasm and breeding for wide adaptation.

Dr. F. Dusuncelli shared the experiences from FAO in the integrated management of rust diseases. He emphasized on the need for farmer field schools, training of plant protection officers and creating awareness of stakeholders through relevant meetings bringing people together. There is a need for more information on fungicide availability, efficacy and registration. He also stressed on the need for greater collaboration at regional and global level.

Key highlights

- Diseases are not confined within the borders of a particular country and hence it is important that collective and coordinated actions are taken at regional level for survey, surveillance and early warning.
- Emerging diseases are a concern which requires institutions like FAO to take lead in terms of awareness that can mobilize resources to tackle the problem. Addressing wheat blast should receive greater attention.
- Using fungicides is not a reasonable option but more information on fungicide in less developed countries is needed. Legislation and compound registration differ significantly between countries. There is a need for a centralized database including what is registered and is available in each country. This is a real need and challenge. FAO should coordinate the development and maintenance of this database.
- There is a need for capacity building on marker assisted selection in NARS to increase the application of molecular markers in breeding programmes for disease resistance in Asia.
- National Agricultural Research Systems (NARS) should join hands for regional coordination for research and development (R&D) in wheat diseases especially in Central Asia.
- An international wheat pathologist should be based in Central Asia to train scientists and the language barrier should be overcome.
- Regional meetings should be organized to exchange experiences between Central Asia and South Asia on regular basis.

Technical Session IV. Stakeholders Dialogue on CRP 3.1 (Wheat)

Chair: *Dr. Raj Paroda*

Co-Chair: *Dr. Hans Braun*

Rapporteur: *Dr. A.K. Joshi*

This special session was organized for stakeholders consultation on CGIAR Research Programme (CRP 3.1 on Wheat) led by CIMMYT. Dr. Hans J. Braun, Director, Global Wheat Programme

(GWP), CIMMYT gave an overview of the CGIAR Research Programme (CRP) to set a platform for discussion and feedback of the stakeholders.

The Session Chair, Dr. Raj Paroda while setting the context highlighted that as a result the launch of CRPs due to part of CGIAR change management process, there are more opportunities for collaboration and sharing new research strategies and knowledge. The feedback of stakeholders that involves participants from public, private, NGOs, farmers, CGIAR, and Agricultural Research Institutes (ARIs) will be immensely helpful not only in developing the work plan for AR4D but also in convergence of investments and resources among the wheat community, Dr. Paroda expressed satisfaction that many countries and institutions were represented in the meeting including farmers and NGOs from South Asia.

Dr. Hans Braun spoke on objectives, strategies and stakeholders involvement in CRP 3.1 (Wheat). He informed that CRP 3.1 was officially launched in January 2012 in a meeting at Mexico in which around 300 stakeholders from all over the world participated. He explained the objectives and expectations from this programme and informed that in the next few weeks, the partners and stakeholders in different countries will be contacted for getting their feedback on priorities and collaboration interest. He further informed that through this programme, CIMMYT is looking for greater impact on poverty reduction. There is a big challenge to boost farm level productivity and hence, we need to act urgently. Therefore, there is a need for much better coordination and avoiding duplication by ensuring that all partners complement each-other. It is important to know where wheat is grown in developing countries and where wheat is really consumed. This will complement middle to high income country investments in national wheat research. There are 2.5 billion poor wheat consumers and 1.2 billion wheat dependent consumers in the world that are to be targeted.

Dr. Braun also explained that the document on 'CRP 3.1 on Wheat' was developed in a transparent way, the feedback was received from 340 institutions and there were consultations with major wheat producing countries. He informed that there are 10 strategic initiatives (SIs) to be taken-up in this programme. SI 1 is technology targeting for impact. This will target to increase the effectiveness and impact of wheat research on food security, poverty reduction and gender equity. The approach and outputs include gender audit of wheat strategy, strategic analysis and targeting of new wheat specific technologies, institutional innovations and policy focus on the poor. Other important issues are special tools like rust mapper and wheat atlas. Future of wheat in Sub-Saharan Africa will also be attended since wheat consumption in this region is going up but wheat production is not increasing. SI 2 is on sustainable wheat based system. It will ensure transfer of technology, and address the yield gaps. This initiative involves the hub concept – innovation network, benchmark site for research on the impacts of conservation agriculture (CA) and focal point for regional capacity building. The structure to work together has to be based with farmers. Hubs will be used to test the best-bet technology, demonstration platform, trainings/demonstrations, platform for relevant research, to integrate the production chain around a common objective and will work as feedback loop to researchers. It will engage in strategic research – value chain analysis, productivity, soil quality, water use efficiency, carbon and nitrogen cycling, trace gas emissions, crop growth and development, phytopathology – soil born diseases, tan spot and *Septoria*. There are 7 hubs in rice – wheat and 2 in cotton-wheat areas. New multi-utility and multi-crop CA planters will be developed and tested for rice-wheat and cotton-wheat systems. Dual purpose wheat, genotype × system × tillage and system based innovative seed systems will also be addressed. The Cereal System Initiative for South Asia (CSISA) hubs are expected to impact 4 million farmers. Likewise,

MasAgro has been launched in Mexico by Mexican Government so that technologies are transferred to the farmers. The target of MasAgro is to increase the yield of maize by 80 per cent and that of wheat by 20 per cent in next 10 years. ICT is also a high priority.

SI 3 is for increasing the use efficiency of vital inputs such as nitrogen, phosphorus and water. Value proposition is to enable 15 million smallholders in irrigated areas to produce wheat with less fertilizer and water. SI 4 is for high yielding wheat varieties. The proposition is to maintain a 0.9 per cent per annum growth rate through genetics. The other 0.9 per cent gain will come from better agronomy and protection from diseases. CIMMYT and ICARDA will not be able to do it alone and hence, cooperation of national partners is important. Hot spot regions for screening will be deployed much more than before. The outputs expected by 2016 include developing elite lines capable of maintaining productivity in South Asia and other heat stressed regions, enhanced drought tolerance, durable resistance, 20 per cent higher Zn and Fe and 5 per cent gain in grain protein. This SI will also work on developing parental stocks for salinity and salt tolerance, develop population for specific traits and regions, enhance participation of NARS partners in International Wheat Improvement Network (IWIN), molecular marker and genotyping platform continually optimize and validated for increased application efficiency. In SI 5, a durable disease and pest resistance in wheat and enhanced host resistance will be targeted for diseases (mainly rusts) that cause economic loss on 5-50 million hectares and to pests and viruses that affect 2-10 million hectares each. Also, it is not only about breeding for resistance but also for finding agronomic solutions like crop rotation. SI 6 pertains to stable yields in the face of climate change, induced heat and drought stress. It has been established that impact of climate change is already equal to -5.5 per cent for wheat. This SI will work to restore wheat productivity in areas vulnerable to climate change – South and Central Asia. BISA will play major role for heat tolerance and wheat lines with 15-30 per cent higher yields will be developed. Drought is possibly the most important abiotic stress. However, even in irrigated conditions, wheat has to have drought tolerance due to competition of water with high value crops. Synthetic derived lines extract more water from deeper soil profile and hence they are important. Physiology and breeding efforts will need greater collaboration. Airborne tools which can cover several hundred plots will also be used for remote sensing.

In SI 7 on breaking the yield barrier, new ways of achieving the targets will be applied. A "Wheat Yield Consortium" has been established to work on enhancing photosynthetic efficiency, extra biomass translated to grains, physiology and molecular breeding. This initiative will look for effective public-private partnership. There is a need for a holistic approach to bring all leading groups and partners together. It also includes sustainable seed systems to accelerate impacts on high priority basis. SI 8 on seeds of discovery is for tackling the black box of genetic resources. Very few world collections have been utilized so far. Mexican Government is extending support of 5 million dollars annually for global food security. Mexico wants to publish what is in store in germplasm so that it can be used for public good. All available accessions with CIMMYT will be sequenced and after careful analysis will look for more variation. Priority traits are heat drought, wheat blast, tan spot, spot blotch, stripe rust, stem rust, Karnal bunt, Sunn pest, etc. SI 9 is for strengthening the capacity of developing world – wheat institutions and specialists. The time has come when the perception about agriculture and wheat needs to be changed. There is a need for advocacy to make it attractive. Agriculture is not the problem, but it is solution. A new generation of wheat professionals and farmers will be created. In SI 10, wheat will focus on high quality partners – research and development - having common values. The presentation was followed by in-depth discussion.

Dr. Raj Paroda briefly summarized the highlights of presentation and opened the floor for discussion. He invited all stakeholders and farmers for participation in the discussion. Dr. Mahboob Hossain, Chief Executive Officer (CEO) of BRAC, Bangladesh, one of the largest NGO in the world, informed about his organization and its programmes and activities. He informed that BRAC has 9 Programmes in Bangladesh including agriculture, climate change and food security. This NGO also collaborates with CGIAR and other International Centers, namely, International Rice Research Institute (IRRI), International Potato Center (CIP), WorldFish and The World Vegetable Center (AVRDC) and has informal relationship with CIMMYT mostly for maize Programme. BRAC has a large seed system and covers about 30 per cent hybrid market of maize. Unless wheat productivity is increased, chance of increasing its area in Bangladesh is very less. A comparative advantage study indicated that import is cheaper than increasing production. If wheat yield is increased upto 3.5-4.0 tons per hectare, then wheat can compete with other crops. He highlighted the role of BRAC in seed system, farmer participatory work and also women involvement. Also, the CRP 3.1 (Wheat) must address climate change effects. Dr. Paroda suggested that BRAC can help in testing new varieties, and their seed production and assessment.

Ms. Sonali Bisht, heading an NGO called Institute of Himalayan Environmental Research and Education (INHERE) working in the Himalayas (Uttarakhand, India), informed that their focus is on livelihood and food security, seed production, processing of produce, capacity building and other human resource development programmes. They had been trying to engage communities with field trials, climate change adaptation trials and seed production. She wanted to know the kind of NGOs selected and their role in CRP. Dr. Hans Braun informed that the role of NGOs will vary according to countries and activities in different countries. CIMMYT works in Afghanistan for seed production. CIMMYT is very open and will be interested in working with any NGO.

Mr. Manoj Munjal, a farmer from Haryana, India informed that most of the area in Karnal district of Haryana State is under rice-wheat system. The farmers need training programme and new improved seeds. They also want solution of stripe rust, which is the main problem now. In view of rise in average temperature, heat tolerant varieties are also required. He also shared his experience on conservation agriculture in wheat systems that helped them not only in increasing productivity and reducing cost of production but also in adapting to climate change effects (terminal heat in wheat) and for this, good farm machinery will also be of great help to farmers.

Mr. Ram Ji, a farmer from Nepal informed that wheat planting is often late in Terai of Nepal. So the farmers need varieties that can give high grain yield even if planted late. Participatory variety selection (PVS) approach has proved very helpful and this approach needs greater emphasis.

Mr. Hasraf Sarker, a farmer from Bangladesh informed that 30 per cent of wheat in the country is grown in Rajshahi. He further informed that he gets wheat yields up to 5 tons per hectare, produces seed and has been practicing conservation agriculture which can be a model to other farmers of the region. Dr. Paroda suggested that outscaling of conservation agriculture (CA) is needed which is evident from the impressive yield obtained by a farmer in Bangladesh. In addition, there is a need to look for good niche areas and exchange visits of farmers between the countries for sharing their experiences.

Mr. Usman, a farmer from Pakistan mentioned that farmers in Pakistan have lot of talent but they get very little support from the Government. Inputs are costly or not available and electricity is very costly. Water is scarce and running tube wells is not easy. Subsidy has also been stopped by the Government. So, in addition to input availability, the farmers need capacity building and knowledge sharing. Dr. Paroda commented that a policy issue has emerged which is part of SI 1. Dr. Mirdad Panjsheri from Afghanistan informed that in his country, drought is the major problem. In addition, farmers need machinery, subsidy for seed industry development and other technical assistance as being given by FAO. They also need seed certification training for better quality control of seed. Dr. Paroda mentioned that there is great potential for increasing wheat production through regional collaboration. CIMMYT can help through the development of new varieties and pre-breeding programmes. Duplication of efforts needs to be avoided since FAO is also doing a lot in seed sector. International Center for Agricultural Research in the Dry Areas (ICARDA) is also working in some countries. Therefore, there is a need to have a holistic approach in a complimentary mode. Dr. Hans Braun informed that CIMMYT has a good collaboration with FAO and ICARDA.

Dr. Rafiqul Islam Mondal, Director General, Bangladesh Agricultural Research Institute (BARI) informed that scope of expansion of wheat in Bangladesh is limited due to strong competition with other crops. There is some scope of expansion in coastal areas and other vacant lands having high pH. Also, the Government is discouraging boro rice in north-west Bangladesh due to declining water table and this area can be put under wheat cultivation. Seed production is another important issue since, compared to rice, wheat needs higher quantity of seed. Farmers face the shortage of seed availability at the time of planting. There is a need to strengthen seed production and capacity building of farmers and other stakeholders so that they can produce and save good quality seed. High yielding wheat varieties with heat tolerance are crucial to sustain wheat production. Bangladesh has strong linkages with CIMMYT for wheat research but the collaboration needs to be strengthened with other centers for other crops. Dr. Jaim, Director of Research, BRAC, Bangladesh, informed that in CRP 3.1 (Wheat), the main focus is on improving food security but not improving livelihood of farmers which needs to be given greater attention. He stressed that livelihood of small farmers must be attended urgently. Seed problem is a serious issue and women's involvement in seed storage also needs attention. Linking farmers to market is important and should be appropriately addressed. Dissemination of knowledge and market intelligence needs to be given due attention. There is also a need to catalyze the policy makers.

Ms. Sonali Bisht from Institute of Himalayan Environment Research and Education (INHERE) suggested that besides linkage with market, the backward linkage is also important which relates to affordability and accessibility of inputs to farmers. There is need to have foresight for supply-demand scenario which has implications for tomorrow. Dr. Paroda informed that Malaysia is a good example to demonstrate that importing food grains is not a good strategy. They shifted from grain production to the production of rubber and date palm but now shifted back to food grain production.

Dr. R.R. Hanchinal, highlighted that seed system needs strong attention since availability of seed at right price, time and place is very important. He informed about the good model of participatory seed production developed at the University of Agricultural Sciences, Dharwad, India and suggested that seed village programme was highly successful. Certification is sometimes a problem and so truthfully labelled seed (TLS) can be used. Use of ICTs in seed production systems and proper seed storage were also considered important issues. Dr. Masa Iwanaga,

President, JIRCAS, wanted to know the procedure for joining one or more initiatives of wheat programme. Dr. Hans Braun clarified that survey is going on to analyze the priorities which will be reviewed by a committee and the procedure will be known very soon. Dr. M.L. Jat, CIMMYT suggested that system research is important keeping in view the needs of farmers. Also, there is a need to bring out 'Wheat Systems Atlas' as the research on wheat crop alone will not be able to provide complete solution.

Dr. Raj Paroda informed that in Northern India, growing wheat after December in sugarcane systems is not paying more and we have better options available, for example, spring maize that gives up to 7 tons grain yield per hectare.

Dr. NCD Barma from Bangladesh informed that incidence of wheat rust was quite high in the crop season during 2011-12 and stripe rust was seen for the first time in Bangladesh. They need help from CIMMYT and BGRI for rust screening in India and to reorganize their hybridization programme. Seed system is being strengthened in Bangladesh and they are giving preference to farmers' seed production as truthfully labelled seed. Dr. Paroda suggested that FAO can support seed programme through their technical programme which is also linked with CRP. Mr Fazil from FAO agreed to extend FAO's full support for wheat research programmes.

Dr. Hans Braun summarized the major issues as follows:

- Seed production of suitable varieties needs urgent attention. Dissemination of Ug99 resistant varieties through United States Agency for International Development (USAID) project is a good example. Seed replacement takes time and therefore, pre-release seed multiplication is important. Policy makers were convinced about the pre-release seed multiplication. The project got real cooperation in six countries to allow pre-release multiplication. Many countries were not doing it before as seed multiplication was used to be done after the varieties are released. This is costly exercise as there could be drop outs, but was highly successful.
- For wheat rusts, there is a need for organizing one more meeting. A good monitoring system exists but policy makers are difficult to be convinced to stop multiplying susceptible varieties. Syria was hit by wheat rust for two years in a row due to cultivation of susceptible varieties. Now susceptible varieties are being stopped. Likewise, Ethiopia is also now releasing only rust resistant varieties.
- Bangladesh has areas where rice-rice cropping system is followed with 90 days gap. For such areas, there is need for super early wheat varieties.
- In Afghanistan, the seed sector is now being increasingly addressed and a few new projects are under consideration.
- One of the most important objectives is to address the issues of resource poor farmers. There is impact targeting and value chain analysis; Hubs will also play significant role in their own way.

The Chair, Dr. Raj Paroda concluded that this is a good opportunity for all of us to build strong partnership. Asia-Pacific region grows 50 per cent of wheat and, therefore, major share of funds from CRP 3.1 should come to this region. The initiatives that are already there must get partnership in the programme so that there is greater synergy for outputs. Policy issue is important for future of wheat in some countries. For resource poor farmers, supply-demand scenario has to be kept in view and institutional support in the region should be available e.g.

National Center for Agricultural Economics and Policy (NCAP) in India and IFPRI. APAARI has earlier endorsed this programme. Partnership for research in wheat should also be developed with advanced research centers like JIRCAS and Sydney University where there is good leadership. Breaking the yield barrier will be a challenge and seed has to be given a high priority.

Capacity building is equally important and partners have to be involved effectively. Addressing the concern of climate change must find high priority. The stakeholders should come forward to be partners who help in many ways but there is a need to identify right partners. There is good scope of deploying participatory approach in many countries. There are important policy issues such as - investments to support wheat research in different countries so that we know how much is being spent in wheat research and development in different countries. This data can make the case for countries that are spending less on wheat compared to others. Dr. Paroda further suggested that effective partners are important and hoped that there will be good representation from Asia-Pacific region on the management committee of this CRP.

Key highlights

- Seed systems need to be strengthened in almost all developing countries.
- Capacity building of farmers, scientists and other stakeholders including women needs to be strengthened.
- There is a great need to adopt farmer participatory approaches in implementing the activities under CRP 3.1 (Wheat).
- Greater thrust needs to be given on the development of varieties possessing resistance to diseases, particularly durable resistance, heat tolerance, short duration, water-use efficiency, and other traits that can address adaptation to climate change.
- Policy aspects need to be given greater thrust particularly with respect to linking farmers to market and providing them market intelligence and other vital inputs.
- Cropping system research along with conservation agriculture must be given greater attention.
- Building strong partnership with advanced research institutes in the region and also among national research institutions and with farmers and other stakeholders be given due emphasis

Technical Session V. Addressing Emerging Challenges

Chair: *Dr. Masa Iwanaga*

Co-Chair: *Dr. R.R. Hanchinal*

Rapporteur: *Dr. M.L. Jat*

Six presentations addressing the major challenges were made in this session. The brief summary of each presentation and the key highlights of the discussions during the session are summarized below:

Dr. M.L. Jat, made a presentation on promoting conservation agriculture (CA) and highlighted major issues under the conventional tillage based production systems and how CA can help in addressing these issues. He cited the example of delayed planting of wheat in eastern Gangetic

Plains of South Asia that leads to large yield losses. Optimizing cropping systems through targeting appropriate crop varieties of both rice and wheat with conservation agriculture based management practices plays a key role in advancing planting of either crop, escapes terminal heat and attains higher yields. He mentioned that adoption of conservation agriculture based management practices and their component technology for local adaptation is a must. There is a need to develop regional and sub-regional networks for 'basic-strategic-applied research-capacity building-knowledge sharing-delivery continuum' to serve as learning centers. The herbicide resistant wheat has to play important role under changing management scenario and has to find place in the breeding programmes of the national systems as well as CGIAR and ARIs. Special focus should be laid on capacity building at different levels (researchers, extension agents, service providers, farmers, etc.) and scales (local, regional, international level). For accelerated adoption of CA based management practices, the emphasis should be on creating full time and value chain service window to serve the twin purpose of providing real time services and facilitate technology led small-scale rural business. Laser land levelling in India is one successful example of such kind which provides employment to rural youth to the tune of 3.5 million person days/year at current number of laser units (more than 10,000 in India). Public-private partnerships should be strengthened through pooling resources for common goals of reaching farmers with better understanding and synergy on technologies, prioritization of investments and linking different programmes for greater impact. Systematic database-management, curation, access, sharing mechanism and use should form integral part of R&D. He concluded that an effective mechanism should be developed for common regional platforms, knowledge sharing and consultations.

Dr. Mustaq Ahmad Gill made a presentation on enhancing wheat production and productivity through resource conservation technologies in Pakistan and emphasized that major technical and socioeconomic challenge is adoption of conservation agriculture techniques. He said that socioeconomic factors are significant barriers being faced by smallholder farmers to increase wheat production and productivity. Pakistan has rice-wheat rotation in sizable area where average wheat yield is between 2.2-4.0 tons per hectare depending on holding size. The large number of wheat growing farmers in Pakistan practice rice-wheat crop rotation and are smallholders having huge potential that remain untapped to enhance wheat productivity. The major wheat productivity limiting factors include lack of improved agronomic practices, non-availability of quality seeds, limited access to conservation tillage and farm machinery, uncertain crop support price, and lack of effective research and technology backup to majority of farmers in the country. The feedback information from the case studies suggests that the wide variation in wheat production and productivity amongst farmers particularly smallholders and large farms can be bridged through amelioration of socioeconomic constraints. In conclusion, he highlighted that there is need to develop suitable farm policies and strategies for large scale adoption of resource conservation techniques and to provide a road map that can enhance wheat productivity and farmers' livelihood in rice-wheat areas of Pakistan.

Dr. S. Naresh Kumar addressed the issues of adaptation and mitigation to climate change. Under the business as usual scenario, the projected increase in temperatures due to climate change effects is likely to affect the crop production by 10-40 per cent by the end of current century in the Indian sub-continent. The projected impact of climate change on wheat indicates that if suitable adaptation measures are not taken, with every rise of 1°C temperature throughout the growing period, a loss of production in India alone will be to the tune of 4-5 million tons per year. The losses could be as high as 19.0 and 27.5 million tons with respective increase in temperatures by 3°C and 5°C. The post-anthesis temperature is crucial factor for the maximum

kernel weight in wheat and each 1°C rise in temperature above the optimum can cause a 3-5 per cent reduction in grain weight which ultimately translates in yield and quality losses. The terminal heat/ high temperature stress leads to reduction in grain growth duration which is the major cause of loss in productivity. The decline in the rate of grain growth is mostly due to a decrease in the rate of starch accumulation. In addition, rapid leaf senescence is one of the major causes of yield reduction as it impedes supply of photosynthates for grain development. He mentioned that tolerance to heat stress is a difficult trait due to genetically and physiologically complex traits which are highly influenced by the various environmental factors during growth and development of grains. He also emphasized on understanding the target environments which is vital for designing wheat for high temperature environment as adaptation of genotypes is often location specific. Genotype \times management interaction has to play key role in thermal tolerance. Taking into consideration the underlying complexities in mechanisms of tolerance to high temperatures and individual contribution of several traits so far reported, an appropriate strategy should be developed to identify the genes and stack them in suitable genetic background that matches with the target environment and resource management practices. There is a need to intensify food production systems through establishing and strengthening technology and input delivery systems and linking farmers with market. Also, there is a need to promote conservation agriculture based crop management technologies for improved land and water management, improved resource use efficiency and adaptation to climatic extremes. He was of the opinion that the time has come to develop suitable policies to provide incentives to farmers for resource conservation and use efficiency, pricing of resources, and giving credit for transition to adaptation technologies.

Dr. J. Rane in his presentation on developing terminal heat tolerant wheat highlighted various areas that can have possible influence on wheat yields under changing climate. Dr. Rane highlighted the precision phenotyping and its importance with particular reference to physiological interventions. He was of the opinion that persistent efforts through genetic, physiological and breeding approaches need to be made so as to develop wheat genotypes tolerant to high temperatures. For this purpose, several traits associated with thermal stress tolerance, their influence on grain yield and combining quantitative trait loci (QTLs) through combination of conventional breeding approaches and molecular tools are needed. He emphasized on understanding the complex mechanism, and developing appropriate strategy and suitable resource management practices to enhance yield potential of future wheat genotypes to mitigate possible impacts of climate change.

Dr. R.K. Gupta, made a presentation on improving quality traits and informed that with the diversified uses of wheat for industrial purposes, systematic efforts should be made for breeding wheat cultivars for quality traits by selecting parents and advancement of generations and target them in different regions in accordance with product specific quality requirements of that region. The projected climate change will have effects on the quality of wheat. For example, gluten strength has less influence by the elevated CO₂ but protein content for flour decreases significantly with increased CO₂ concentration. Also in general, there is some increase in protein content at high temperature, but there is change in the glutenin/gliadin ratio and thus adversely affects quality. Therefore, new breeding strategies should have these considerations in view in addition to climate resilience and yield.

Dr. H.S. Gupta, made a presentation on current status and future strategies for seed production in Asia. He stressed on the need to encourage seed enhancement mechanism and technologies for

more viability of seed and also develop regional cooperation in quality seed supply, for example, APSA (1994) and SAARC Seed Forum (2010). He further mentioned that there is a need to develop a common variety list and harmonized quality assurance system for SAARC countries for seed supply. In self-pollinated crops, small farmers tend to produce and use farm- saved seed to the tune of 60-70 per cent, except in warm and humid areas where the vigour and viability of seed decline rapidly. In the global scenario of climate change, farmers are frequently facing newer challenges of abiotic and biotic stresses. Thus, there is a greater need to replace old varieties with new improved ones. Hence, adoption of new varieties can be achieved only by increasing the seed replacement rate (SRR). In conclusion, he proposed the following strategies for increasing seed production: (i) maintenance of seed chain: breeder-foundation-certified, (ii) involvement of public sector agencies-self-pollinated and high volume crops, (iii) encouragement to private sector, (iv) farmers' participatory seed production, (v) better and fast institutional mechanism for seed certification, and (vi) developing efficient seed distribution network.

Key highlights

- Large management yield gaps in wheat exist particularly in Eastern Gangetic Plains of South Asia and the major factors contributing this are poor crop establishment and delayed planting. Conservation agriculture based technologies and appropriate cultivar choices in wheat systems have helped in bridging the yield gaps and hence needs strategies for accelerated adoption.
- Conservation agriculture practices provide opportunities for resilience in production systems, sustainable intensification through optimization of cropping systems and conservation of natural resources.
- The basic elements of CA remains the same, however, for realizing potential benefits, the recommendation domains of the component technologies (water, nutrient, weed, cultivar choices, seed rate, depth etc.) need to be defined through participatory adaptation to meet local needs.
- Significant genotype \times management interactions have been observed and hence the breeding strategies need to be reoriented in order to capture G \times M interactions and define the domains of the genotypes and realize potential yields.
- As immediate strategy to cope with climate change effects, the farmers should be assisted with establishment of weather services, agro-advisories, insurance and community banks for seed and fodder.
- Research programmes need to be strengthened for enhancing adaptive capacity on climate change monitoring and warning systems.
- Intensive efforts are required for developing nutritionally superior wheat varieties enriched with iron and zinc using molecular tools as well as agronomic manipulations.
- Breeding strategies should be reoriented to develop micronutrient enhanced wheat cultivars without compromising tolerance to abiotic/biotic stress, crop productivity, and acceptable end-use quality.
- Greater thrust needs to be given on developing value chain for wheat products and linking farmers to market.

- There is a great need to increase seed replacement rate (SRR) through developing robust seed systems. To attain this, there is a need to encourage public-private-partnership and implement seed village/valley concept in farmer participatory mode for local seed systems.
- Investments in modern technologies e.g. conservation agriculture, precision agriculture, sensor based polymer coats, flash treatments (electronic magnetic/heat/electron, etc.) are very high and hence partnerships with technology providers and seed growers need to be adequately strengthened.

Working Group Discussions

Focussed discussion to identify research priorities and need assessment on research and development initiatives for inclusive growth were organized involving key resource persons in related fields and were moderated by an eminent expert. The key issues and recommendations emerged from the two working group discussions are summarized below:

Working Group 1. Research Priorities and Need Assessment

Facilitator: *Dr. H.S. Gupta*

The first group involving 28 participants from Asian countries, CIMMYT, ICARDA, APAARI and FAO had in-depth discussion on prioritization and need assessment for future wheat research in Asia. The key issues/recommendations emerged are summarized below:

Augmenting genetic capacity for enhancing productivity and adaptation

- ❖ Increasing biomass and harvest index (HI) for improved grain yield
- ❖ Development of terminal heat tolerant varieties with high revival capacity
- ❖ Strengthening biofortification of wheat
- ❖ Developing and strengthening research programme on hybrid wheat
- ❖ Development of synthetic wheat varieties
- ❖ Developing transgenic (multiple stress tolerant) varieties
- ❖ Initiating efforts for converting wheat from C_3 to C_4 crop
- ❖ Developing twin strategy (genotype \times management) for increasing input use efficiency of water and nutrients
- ❖ Enhancing system productivity through developing sustainable intensification strategies with focus on conservation agriculture and precision farming
- ❖ Promoting mechanization for timeliness of operations
- ❖ Greater thrust on developing effective seed production systems

Leveraging policy options to enhance productivity

- ❖ Strengthening inter-institutional and regional (inter-country) cooperation for information/knowledge/technology sharing in Asian region.
- ❖ Promoting the exchange of varieties with simplicity of IPR guidelines
- ❖ Developing strategies for bridging inter- regional yield gaps

Informatics and computational biology with focus on phenotyping

- ❖ Establishing mechanism for developing, managing and sharing database for wheat systems
- ❖ Developing knowledge system on wheat through portal development
- ❖ Enhancing use of information communication technology (ICT) for effective dissemination of technology to the end user

Human resource development

- ❖ Strengthening capacity building at different levels (students, researchers, extension agents, farmers, policy planners) and scales (field to international) in frontier areas of research and development with special reference to Central Asian countries and Mongolia
- ❖ Promoting exchange visits of scientists, students, farmers and policy planners

Working Group 2. Development Initiative for Inclusive Growth

Facilitator: *Dr. S. Dasgupta*

The second group comprising 25 participants met to discuss and finalize issues and recommendations related to development initiative for inclusive growth. The group identified various policy issues, input supply system related needs, investment for a small farm mechanization, efficient management of natural resources, strengthening extension system and capacity building. The key issues/recommendations emerged are summarized below:

Policy

- ❖ Making wheat development an integral part of national policy and ensuring strong political commitment from the government to implement the policy
- ❖ Promoting conservation agriculture for sustainable intensification of wheat systems
- ❖ Promoting scientific land use planning
- ❖ Providing incentives for new niches for the expansion of wheat areas
- ❖ Focusing attention on climate resilient agriculture
- ❖ Strengthening conservation of plant genetic resources through use
- ❖ Focusing on research and enhancing investment in research and development

- ❖ Putting special emphasis on needs of smallholder and resource poor farmers and women while developing technologies

Seed supply system

- ❖ Focusing on quality seed production at farmers level through contract farming
- ❖ Providing equal priority to both formal and informal seed sectors
- ❖ Establishing community/village level seed banks
- ❖ Strengthening partnership programme with informal sector to produce quality seeds
- ❖ Increasing seed replacement rate
- ❖ Promoting small scale mechanization
- ❖ Enhancing funding in wheat sector from national sources

Small farm mechanization

- ❖ Ensuring availability of adaptable technologies suitable for smallholder farming conditions
- ❖ Developing entrepreneurship to produce technologies at local level
- ❖ Developing indigenous and location-specific technologies

Natural resource management systems

- ❖ Increasing use efficiency of inputs mainly water and nutrients
- ❖ Developing mechanism for carbon credits and incentives for environmental services
- ❖ Integrated management practices for agro-chemicals and natural/indigenous resources

Strengthening extension systems

- ❖ Developing innovation systems and networks through active participation of all stakeholders at all levels of technology development, adaptation and scaling out strategies
- ❖ Strengthening public extension systems
- ❖ Developing private extension systems
- ❖ Enhancing the role of CSOs, NGOs and farmers in extension systems
- ❖ Strengthening knowledge sharing mechanisms among different change agents through developing regional knowledge banks
- ❖ Linking farmers to markets

- ❖ Developing infrastructure and institutions to promote technology transfer
- ❖ Establishing South-South linkage and cooperation at regional level
- ❖ Establishing farmers' network at regional level

Capacity development

- ❖ Organizing informal vocational trainings for the farmers
- ❖ Strengthening education and learning process at grass root levels
- ❖ Linking women and youth with small enterprises

Plenary Session

Chair: *Mr. Hiroyuki Konuma*

Co-Chairs: *Dr. Thomas Lumpkin,*
Dr. Raj Paroda

Rapporteur: *Dr. Bhag Mal*

The key highlights of different Technical Sessions and the Working Groups were presented by the Rapporteurs/Moderators. The reflections and remarks by the Chair and Co-Chairs and the key recommendations relating to research, development and policy emerged are given below:

Mr. Hiroyuki Konuma, Assistant Director General and FAO Regional Representative for Asia and the Pacific in his concluding remarks emphasized on three major areas, viz. policy, research and development, for enhancing productivity of wheat as wheat is one of the two most important staple foods in Asia. This region is facing problems of shortage of arable land and water due to increasing population pressure and on top of it, there is increasing threat from climate change affecting the wheat production through biotic and abiotic stresses vis-à-vis food security of the region. He emphasized on wheat improvement through conventional and molecular approaches in order to develop new high yielding wheat varieties in shorter time frame having resistance/tolerance to biotic and abiotic stresses that adversely and significantly affect the wheat productivity. There is increasing need to develop wheat varieties suited to zero till condition and have increased water and nutrient use efficiency due to continuous dwindling of natural resources in Asia. Dr. Konuma indicated that rice-wheat system is the most popular covering larger acreage and thereby affecting soil health and ground water adversely. Hence, diversification of cropping systems is essential. There is an urgent need for adoption of resource conservation technologies and farm mechanization. He stressed on effective linkages between wheat research and extension for faster dissemination of modern technologies benefiting resource poor farmers through increased income and also livelihood security. In order to enhance wheat productivity in Asia where fluctuation in temperature and rainfall is a regular phenomenon in changing climatic situations, there is need to develop medium and long-term forecasting model for sustainable production.

Dr. Thomas Lumpkin, Director General, CIMMYT, Mexico highlighted that the favourable climate for higher production may not be a regular feature and therefore, there is a need to

develop and popularize wheat cultivars that can withstand the adversaries of weather. The global, regional and country specific research requires more investment in wheat, close collaboration and mutual understanding to address future threats and constraints to ensure food security. He also stressed on developing strategies for outscaling of conservation agriculture producing more from less area and lesser inputs for which good agronomy needs to be continued. He also mentioned that long-term research and development needs must also be kept in view.

Dr Raj Paroda, Executive Secretary, APAARI in his concluding remarks was emphatic on food security and nutritional security for the people of Asian region. He stressed on the possibility to increase wheat productivity by 1 ton per hectare in 75 million hectare area in Asia (except China). In order to achieve this target, there is need for adoption of aggressive approach for genetic enhancement through use of modern technologies and natural resource management. He also emphasized on the need for enhanced use of alien species, hybrid technology and biotechnology. Major efforts are needed in outscaling resource conservation technologies to produce more at less costs, improving soil health, and reducing environmental pollution in order to enhance productivity and production of wheat crop. He mentioned that environmentally sustainable small farm mechanization requires support from all the stakeholders. Therefore, regional cooperation among FAO, APAARI, ASEAN and SAARC for close interactions is extremely necessary to exchange experiences and learn from each other. Involvement of private sector and youth is also very important. Also, South-South and North-South partnership is needed for greater collaboration. International organizations like CIMMYT should provide facilitation role towards strengthening wheat improvement activities in these countries. Public-private-partnership in Asia needs promotion aggressively in quality seed production, greater investment in conservation of natural resources and farm mechanization. He emphasized on strengthening extension services for faster dissemination of technologies where NGOs can also play significant role. He gave a call for building up a "Regional Alliance on Wheat (RAW)" for catalysing policy makers through FAO.

Dr. Bhag Mal, Consultant, APAARI extended vote of thanks to the organizers, co-sponsors and the participants attending the regional consultation.

Recommendations

The wheat growing countries of Asia, especially China, India and Pakistan have played critical role in ensuring food security in Asia. In this context, the Green Revolution in South Asia had been a great success story. The world would need around 1090 million tons of wheat by 2050 from its current production level of 680 million tons. This production target has to be achieved especially when productivity growth rate in wheat has declined and the same is even lower than global average in Asia. Hence, improving productivity of wheat is of immediate concern for the Asian wheat growing countries. In this context, there exists large untapped potential for doubling wheat productivity in the region. However, it is also clear that business as usual will not work. The first revolution in wheat was primarily through germplasm enhancement (single pillar). For second revolution, we shall need a 'three pillar' strategy, involving germplasm enhancement, agronomic management and enabling policies.

The major recommendations related to wheat research, development and enabling policies, as emerged during the discussions in the regional consultation, are given below:

A. Research related recommendations

- The reversal of slowdown in genetic gains (breaking yield barriers) needs concerted efforts through effective use of germplasm. Germplasm enhancement/pre-breeding through the use of trait-specific germplasm from genebanks (seeds of discovery) need to be strengthened for developing new plant architecture and advancement of generations using conventional breeding supplemented with biotechnological tools and collaborative regional testing. CGIAR Centers such as CIMMYT and ICARDA should facilitate as well as accelerate the pre-breeding initiatives.
- The breeding programmes in wheat need to be strengthened adopting conventional breeding, biotechnology and marker assisted selection. Research on development of synthetic wheat, use of double haploids, hybrid wheat and GM wheat (herbicide tolerant, water and nutrient use efficient) needs a focused and mission mode approach involving all active stakeholders and the CG Centers. There is also a need to establish hybrid wheat consortium at the regional level in order to accelerate the pace of research in this direction.
- Greater thrust needs to be given to breed varieties with multiple/durable resistance against major biotic and abiotic stresses using novel germplasm and molecular tools. Pyramiding genes for resistance to rusts must be given a high priority attention. Minor genes based multiple resistance also needs to be given preference.
- As a long-term strategy to address the vulnerability of wheat to changing climates and projected shrink in favourable wheat mega environments, photosynthetic efficiency of wheat plant needs to be enhanced. Hence, concerted long-term strategy for conversion of C_3 wheat to C_4 should be in place. Advanced international institutions, viz., CIMMYT, ICARDA and JIRCAS, in collaboration with regional institutions such as Borlaug Institute for South Asia (BISA), and the stronger NARS should play important role in this basic research area.
- There is a greater need in the present context to develop resilient plant types with better root architecture having improved efficiency in the uptake of nutrients and water, better nutrient partitioning and higher nutrient density grains.
- Special efforts need to be made on bioinformatics and research programmes to understand/explore physiological basis of stress tolerance (drought, terminal heat, etc.) and nutritional quality.
- Trans-boundary diseases and pests surveillance regional research networks need to be established to address possible outbreaks of new races of diseases having potential threats, especially in case of stripe rust, leaf rust, foliar blight, stem rust (UG 99), etc. for their effective management.
- Greater thrust needs to be given to regional approach on the development of varieties possessing resistance to diseases, particularly durable resistance, heat tolerance, short duration, water use efficiency, nutrient use efficiency, high nutritional and end-use quality (biofortification). Institution like BISA should have major mandate for this.
- The shuttle breeding programmes need to be accelerated for which facilitation role of international centers will be highly critical.

- Renewed efforts need to be made for research on developing and defining resilient wheat production systems having greater synergy with resource endowments particularly to meet the needs of small holder farmers under varied ecologies to harness enhanced productivity with efficiency, while addressing the issues of natural resource degradation and projected impact of climate change. For climate change resilient varieties, new types of genes are required to be incorporated into the varieties. Conservation agriculture based crop management technologies should also form the integral part of this strategy.
- Concerted efforts need to be made for research on dual purpose wheat varieties, crop residue cover needs and crop-livestock interactions in relation to conservation agriculture under irrigated and rainfed ecologies. Such wheat varieties will enable farmers to address their concerns for lack of good quality fodder for their milch animals.
- There is an urgent need for enhancing farming system based productivity through promoting agronomic (water, nutrient, weed management), genetic and physiological interventions and also to introduce resource conservation technologies at small farm level.
- There is an urgent need for basic and strategic research on integrated use of crop modelling, sensors, geographic information system (GIS), remote sensing, decision support systems and ICTs for climate change monitoring, in-season estimates of crop performance (input application), advance forecasting (pest, disease, weather, yield) and early warning at different scales (local, national and regional level).
- There is a need to address also the issue of quality seed production, storage and supply, through greater public-private-partnership. Also, the seed village concept in farmers participatory mode and establishment of the seed banks in different wheat growing regions will help in achieving higher wheat productivity.

B. *Development related recommendations*

- Thrust needs to be given to assessment of field level attainable yields using best practices in different agro-ecologies, production systems and farmer typology and define the recommendation domains of the potential technologies for bridging the yield gaps. There is an urgent need to outscale available technologies adopting eco-region specific approach/strategies.
- Greater thrust needs to be given now on 'resilient agriculture innovation systems' through developing best-bet 'seed-to-seed' technology modules (new seeds, mechanization/CA, improved input management, etc.). Such best practices are to be outscaled under diversified situations using most effective input delivery systems.
- Concerted efforts are needed to develop databases and knowledge and service banks to facilitate women and youth entrepreneurship for effective dissemination of improved technologies including small farm machinery, new seeds, tools, techniques and custom hire services at farmers' door-step.
- Focused attention is needed on capacity building at different levels (research scholars, researchers, extension agents, service providers, farmers, women and farm youth) and scales (local, regional, international level) through informal vocational trainings and capacity building. Special efforts are needed for enhancing capacity of stakeholders especially

from Central Asian countries and Mongolia in the areas of breeding, seed production, conservation agriculture, survey, surveillance and monitoring of diseases and pests, etc. A regional mechanism needs to be in place to facilitate the exchange visits of farmers, scientists and policy makers for knowledge sharing. Leadership of FAO in this regard will be highly appreciated.

- Under the projected climate change scenario, the uncertainties and risks of abiotic and biotic stresses are likely to be intensified. Therefore, there is a strong need to develop a suitable mechanism for adoption of resilient varieties targeting high variety replacement rate (VRR) through increased seed replacement rate (SRR) using effective seed chain by ensuring greater public-private-partnership (PPP).
- There is an urgent need to develop infrastructure on post-harvest management, storage, value chain for wheat products, and market infrastructure for linking farmers to market through developing long-term export strategy in order to provide remunerative prices to the farmers and enhance their income.
- Many farmers of the region are harvesting very high yield levels of wheat. The best practices adopted by such farmers have to be understood and synthesized to know the factors contributing to such high yields and devise appropriate strategies to disseminate the same to other farmers in the region.
- Suitable mechanism needs to be developed to minimize technology dissemination losses and time lag through the non-traditional extension system. Custom hire services need to be encouraged through creation of technology agents (private, entrepreneurs, NGOs, farmers, etc.) to complement the traditional extension that have become relatively less efficient.
- There is an urgent need to define the successful models of public-private partnerships and develop 'technology led business models' for yet greater synergy, outputs and long-term sustainability.

C. Policy related recommendations

- There is an urgent need to establish a "Regional Platform/Alliance on Wheat" in order to share knowledge, germplasm and technologies. Such a platform will help in capacity building in core competence areas and for organizing periodic consultations and review. For this, required support from FAO, CG Centers (CIMMYT, ICARDA) and, APAARI will be necessary.
- The "Regional Alliance on Wheat (RAW)" is much needed for the collaboration in research, development and extension. There is also a need to build the North-South and South-South partnership for required technological breakthrough. The RAW should will facilitate these two processes. There is a need to facilitate the exchange of useful germplasm between countries within the region in order to strengthen their respective breeding programmes. Such initiative might be established under the umbrella of RAW. The germplasm can be transferred between countries through the standard material transfer agreement (SMTA) adopted by the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). This can be facilitated by the Borlaug Institute for South Asia (BISA), through adoption of suitable policies and procedures.

- The CGIAR Research Programme on Wheat (CRP 3.1) should help in building RAW for intensifying wheat research and development in the wheat producing countries in Asia.
- In Asia, there is a need to have a clear policy framework and regulatory mechanism in place to undertake research on developing hybrid wheat, genetically modified (GM) wheat and varieties with specific traits not used before in breeding programmes.
- Appropriate policy support should be in place to encourage higher investments for agricultural research for development (AR4D). Suitable policy actions in line with GCARD Road Map and Bangkok Declaration need to be taken to double the investments on wheat research and development in Asia. Also, there is a need for greater synergy and convergence of research and development schemes and funds for greater impact and increased wheat production.
- Eco-regional niches will have to be defined for both horizontal and vertical growth in wheat production through strategic decisions on investments/incentives considering resource endowments, consumption forecasts, regional food demand and supply chain and possible implications of changes in diet patterns linked to economic development.
- In view of new threats due to changing climate, concerted efforts are required to create awareness and mobilize resources to tackle future problems. Enabling policies need to be put in place for linking farmers to markets by empowering them with required market intelligence and region-specific input/output delivery system, knowledge networks, agro-advisories, weather services, insurance and community banks for seed and fodder. Also policies are needed for compensating smallholder farmers for their environmental services like promotion of conservation agriculture.
- For the use of fungicides, more information is needed about the legislation and compounds' registration in place in different countries. There is a need for centralized database including what is registered and available in each country. FAO could be approached for the development and maintenance of such database.
- There is an urgency to encourage investments in modern technologies/innovation systems e.g. conservation agriculture, precision agriculture, farmer cooperatives, single-window input services, community based/region-specific seed systems, incentives to farmers for carbon credits, environmental services, improved grain quality, etc.
- The institutional mechanism and required infrastructures in some of the Asian countries are not adequate e.g. Afghanistan, Mongolia, Bhutan, etc. This needs urgent attention of the national, regional and international community to establish and strengthen institutional capacity to support wheat research in such countries in the region.
- There is over production of wheat in some countries, while others are deficient in the production resulting in import from other countries. It is, therefore, extremely necessary that a suitable regional policy is in place to balance the import-export of wheat for long-term food security in Asia. In this context, RAW would help in needed policy advocacy.
- There is an urgent need for greater involvement of private sector through provision of enabling policies especially in areas such as upstream research e.g. GM wheat, hybrid wheat, small farm mechanization and cost-effective input delivery system for which appropriate models need to be identified and promoted on priority.

- A holistic and coordinated approach for research and development on wheat needs to be adopted and duplication of efforts are to be avoided to economize on scarce resources. Also, more focused policy issues should be in place to address the needs of farmers, traders and consumers in the context of supply/demand scenario.
- Quality seed is extremely important input and hence the seed health aspects need to be given high priority. Policy makers in wheat growing countries need to be convinced such that continuous growing of wheat varieties, susceptible to diseases, is discouraged. Also, there is a great need for regional cooperation in supply of quality seed for which an appropriate mechanism/strategy needs to be developed. FAO could facilitate having a regional programme on seed development and training in countries such as Afghanistan, Nepal, Bhutan and Mongolia.

Conclusion and Future Road Map

Wheat in Asia-Pacific region is the second largest staple food crop grown widely in different ecological conditions. Despite, significant achievements in improving wheat production by different countries, the productivity level is still far behind the required target to feed the growing population and have improved livelihood security in Asia. There is yield stagnation leading to instability and vulnerability in aggregate production and productivity. Even the productivity level is below the global average productivity. Hence, there is an urgent need to intensify current efforts and develop suitable strategies for research, development and policy to enhance both production and productivity of wheat for sustained food and nutrition security in Asia. Against this background, a regional consultation on improving wheat productivity was organized in Bangkok which was attended by the representatives from Asian NARS, CIMMYT, ICARDA, JIRCAS, APAARI, NGOs, farmers and the private sector. There were intense discussions in different sessions and working groups on enhancing productivity of wheat that enabled the development of a Road Map for enhancing wheat productivity by the smallholder farmers in Asia. Decision was also taken to establish "Regional Alliance on Wheat (RAW)" for greater collaboration for research, development and extension. It was strongly felt that there is great need for developing North-South and South-South partnership for effective collaboration. Various action points pertaining to the Road Map, future directions for research, development and policy issues and the recommendations emerged for enhancing productivity, profitability, food and nutritional security and sustainable livelihood in the region.

Inaugural Address

Hiroyuki Konuma

Assistant Director General and Regional Representative for Asia and the Pacific

Bangkok, Thailand

Dear Dr Thomas Lumpkin, Dr Raj Paroda, Dr Masa Iwanaga, distinguished participants, ladies and gentlemen!

It is a great pleasure for me to inaugurate this extremely important regional consultation on “Improving Wheat Productivity in Asia” jointly organized by FAO and APAARI in collaboration with CIMMYT, ICARDA and JIRCAS. I warmly welcome all of you to this consultation. I express my deepest thanks to CIMMYT, ICARDA and JIRCAS to be with FAO and APAARI in organizing this event jointly.

While we are approaching 2015, it is becoming more and more clear that not all the countries in this region will achieve MDG target 1, in spite of their tireless efforts. As you all know, FAO has been assisting member countries for taking appropriate measures on food security in a comprehensive and integrated manner since 1996 when FAO organized World Food Summit (WFS) and the latest follow-up meeting held in 2009 in FAO Headquarters, Rome where FAO reminded all member countries that we have to work harder to achieve MDG target 1. The world population is expected to reach 9.2 billion in 2050. To meet the growing demand, according to new estimates released by FAO recently, the world food production has to be increased by 60 per cent in 2050 from the level of 2005/07 and in case of developing countries, it has to be increased by 77 per cent during the same period.

Food security of this region largely depends on the availability of rice and wheat-two major food security crops of the Asian people. Two major rice and wheat producing countries (China and India) are located in this region. These two countries rank first and second in the world in terms of population too. FAO-IRRI organized a similar regional consultation on “Increasing rice productivity in underexploited areas of South Asian countries” on 10-11 March, 2010. As an outcome of this consultation, a project proposal has been developed which is under consideration of some donors for possible funding. It indicates FAO’s focused attention to these two important crops that are vital for food security in Asian countries. It is also worth mentioning that the Asian region is the net importer of wheat and productivity growth of this crop has been slowing down. In this backdrop, we are meeting today here to discuss how to increase productivity of wheat in Asian countries by reversing trends in current productivity growth. The other important purpose of this consultation is to inform member countries about the development status of wheat so that they can take appropriate decision for improvement in time. The challenges ahead of us are enormous. In the past, in this sector we had made considerable success but at the cost of substantial damage to the environment. Future productivity growth should come in an environmentally sustainable manner. In view of that, FAO has been

advocating sustainable crop production intensification (SCPI) and diversification with ecosystem approach which has been clearly described in a recently published book “Save and Grow”. I am also pleased to inform you that in recently completed APRC held in Vietnam on 12-16 March 2012, this new approach has been highly appreciated and the Director General, FAO mentioned that sustainable food production and consumption will remain FAO’s main priority area of intervention.

The bottom line is that we have to increase both productivity and production of wheat in an environmentally sustainable way and make wheat production system more stable and less risky and vulnerable. By increasing productivity and making wheat production system sustainable, we can release land from this crop for the use of other crops. Importance of this crop has been increasing due to less water requirement of wheat compared to rice which is becoming scarcer. Our understanding is that to achieve success in this sector, we have to target improvement both in “breeding” and “agronomy” simultaneously. Past experience showed that emphasis in one sector bypassing other sector and scientific thinking in isolation is one of the main obstacles to increasing productivity of this crop. Availability of plant genetic resources and creation of greater genetic diversity; use of molecular genetics and biotechnological tools and techniques in combination with conventional breeding systems to develop better varieties; and modern crop management technologies will play vital role in achieving productivity gains in wheat.

We are firmly confident that all these issues, among others, will be discussed in this forum in detail in next two days and the consultation will come up with implementable recommendations for further actions in collaboration with development partners with ultimate goal to reduce poverty and hunger in this region. FAO attaches utmost priority to this consultation to know more about the problems of productivity gains in wheat and their possible solutions. Our expectation from this forum is extremely high and that is why we have tried our best to ensure participation of best scientists of the region in this consultation. We have also tried to bring together large number of country representatives, development partners and international institutions so that a lively scientific and development oriented discussion can be held for the betterment of our people.

In view of that FAO and APAARI have put lot of efforts to make this meeting successful. We also hope that we will work together in future too, to implement the recommendations that emerged from this meeting.

I would like to thank all our development partners for accepting our invitation and thanks again to APAARI for its excellent cooperation. We are very grateful to CIMMYT, ICARDA and JIRCAS to agree to our request to support this consultation and also for their participation. We in FAO look forward to the deliberations and outcomes of this important consultation and will be happy to work further with our partner agencies and member countries for improving the food security of the poor people through wheat productivity gain in this region.

I wish you fruitful deliberations and a pleasant stay in Bangkok, Thailand.

Welcome Address

Dr Raj Paroda

Executive Secretary, Asian-Pacific Association of Agricultural Research Institutions (APAARI)
Bangkok, Thailand

Dr Hiroyuki Konuma, Dr Thomas Lumpkin, Dr Masa Iwanaga, Dr Ronnie Coffman, Dr Subash Dasgupta, distinguished participants, ladies and gentlemen !

At the outset, I would like to extend a very warm welcome to you all to this important "Regional Consultation on Improving wheat productivity in Asia", being jointly organized by Food and Agriculture Organization - Regional Office for Asia and the Pacific (FAO RAP), Asia-Pacific Association of Research Institutions (APAARI), in collaboration with International Maize and Wheat Improvement Center (CIMMYT), International Center for Agricultural Research in the Dry Areas (ICARDA) and Japan International Research Center for Agricultural Sciences (JIRCAS).

As you all know, the growth rate in wheat productivity has come down to less than one per cent in comparison to much higher growth rate of 1.8 per cent in human population. For achieving the projected global demand of 650 million metric tons of wheat by 2030, there is need to accelerate the overall wheat production annually by at least 2.0 per cent. Since, there is little scope for expansion in area under wheat, the only alternative left is the vertical improvement by enhancing the genetic potential of wheat varieties.

Also, the new challenges are emerging on account of the global climatic change, new threats of diseases and pests, new weed flora, herbicide resistance, depleting soil health and stagnating productivity levels. There are number of options available for breaking the yield barriers in wheat which include new breeding initiatives for developing wheat hybrids through CMS approach, widening the genetic base of varieties through the use of winter \times spring variety hybridization, synthetic wheat varieties and wild species for increasing resistance/tolerance against various biotic and abiotic stresses that adversely and significantly affect the wheat productivity. Since both winter and spring wheat are grown in different ecological conditions and both the gene pools have evolved in isolation, there is likelihood of introgression of diverse genetic factors. Winter wheat is expected to bring improvement in spring wheat varieties with respect to effective tillers per unit area and grains per spike, besides contributing genes for drought tolerance, bread making quality, powdery mildew resistance and resistance/tolerance to cold/frost. These breeding strategies need to be augmented in ongoing research programmes of participating countries to further enhance the yield potential and genetic diversity.

Besides, the narrow genetic base, biotic stresses such as yellow and stem rust diseases need special attention to fulfill the demand of the new varieties and matching production technology for different production conditions. Synergy between conventional and new molecular tools

to develop new technologies for enhanced productivity and input use efficiency is extremely important.

The Indian wheat programme including the All India Coordinated Wheat Improvement Project has made breakthrough in the wheat production starting from green revolution era to the second highest producer of wheat in the world. This has been possible mainly due to well designed, multi-dimensional, multi-locational and a model programme that enabled the country to harvest the record wheat production of 85.97 million tons from 29 million ha area during 2010-11 and a record production of 90 million tons is expected this year from an area of 29 plus million hectares. Although, the wheat production in India has been continuously increasing from the last five years (75.8 mt in 2007, 78.6 mt in 2008, 80.6 mt in 2009, 80.7 mt in 2010 and 85.97 mt in 2011), the productivity has been stagnating at 2.7-2.8 tons per hectare. This calls for intensified efforts to change the plant ideotype in order to enhance productivity potential, early vigour and faster crop establishment.

This consultation is very timely and provides opportunity to discuss during the next two days the major thematic areas such as breeding strategies, applications of molecular breeding for biotic and abiotic stresses, resource optimization for enhanced productivity, management of new races of rusts and other emerging diseases, enhancing value addition and quality improvement and managing impact of climate change on sustainable production of wheat in Asia. The scientists engaged in wheat research should focus not only on improving productivity but also product quality parameters. It is high time that we pay adequate attention to conservation agriculture, improving soil health, input use efficiency, mechanization and diversification of cropping system.

A new race of yellow rust known as 78 S 84 has come to stay in Indian wheat fields and it has knocked down the most popular variety of wheat PBW 343 which is covering more than 7 million hectares of area in Indo-Gangetic Plains. Also, new stem rust race Ug99 posed a serious threat to wheat cultivation across the globe and starting from Uganda, it has already reached Iran. However, to pre-empt the threat posed by new races, the anticipatory resistance breeding work have been initiated by screening wheat materials from wheat growing countries at hot spot locations where high disease pressure exists under natural field conditions. Besides, a regional network for survey and surveillance of new races by the participating countries needs to be established and strengthened to keep watch on the disease scenario under changing climate.

Another crucial factor is terminal heat which is becoming the main hindrance in recent times for achieving new heights in wheat production. With each degree rise in ambient temperature beyond 30°C during anthesis, wheat yield is reduced by 3-4 per cent. Similarly, each degree rise in minimum temperature beyond 15°C at the time of grain filling leads to about 290 kg/ha loss in grain yield. More than hundred years ago, Howard made a statement that wheat production in India is a gamble due to temperature and this is true in present times as well. With climate change shrinking in winter spell coupled with rise in temperature in February-March has become a usual phenomenon in the wheat granary of Indo-Gangetic Plains of India. Several heat tolerant genotypes of wheat have been identified using physiological techniques like canopy temperature depression (CTD), cell membrane stability, stem reserve mobilization (SRM), heat sensitive index (HSI), etc.

Besides, there is great need to focus on tagging resistant genes, and use of marker assisted selection for gene pyramiding to breed genotypes with durable resistance. It is necessary to establish marker assisted selection laboratory facilities in each country. Adoption of transgenic approach to improve the quality and to impart resistance to important diseases needs attention. Survey and surveillance activity needs to cover more area so that the monitoring of diseases and insect-pests can be done more effectively and emergence of new races/virulence can be known within a short time through such programme at regional level.

In view of changing climatic conditions and introduction of new resource conservation technologies (RCTs), it is imperative to study the effect of climatic change on the spectrum and dynamics of different diseases, insects and pests with respect to wheat crop. There is need to breed varieties suited to zero tillage condition in particular and also to make efficient use of limited supply of water and essential nutrients. The double cropping pattern (rice-wheat) over about 12 million ha in South Asia has adversely affected the soil health and ground water. Rice-wheat system should, therefore, be diversified by incorporating crops like mungbean, urdbean, soybean, pigeon pea, etc. to improve the soil health. The efforts already initiated in this direction should be further strengthened. Furrow irrigated raised bed (FIRB) technology plays an important role in diversification of rice-wheat system by providing alternative for raising crops like pigeonpea, soybean, maize, vegetable peas and wheat for enhancing productivity and profitability. Hence, popularization of this system is needed to gain the maximum profit. Use of laser land levelling which is proving as a precursor for the adoption of new RCTs, needs to be popularized with a view to increase the area under cultivation, economize on the use of water and nutrients. Combined use of inorganic fertilizers with organic manures and biofertilizer, crop residue management, crop diversification, intensification of rice-wheat system by introducing vegetable pea in between rice and wheat and a cultivation of summer mung/ sesbania, etc. also need to be popularized. In addition, efforts are needed for popularizing farm machines like rotary disc drill, happy seeder, rotavator, etc. for cost effective higher productivity.

I would like to emphasize that the grain quality aspects have not been paid adequate attention and hence, there is an urgent need to initiate regional programmes for breeding for quality traits and to restructure our research agenda focusing on quality aspects without compromising on the high yield, adaptation and rust resistance. It is essential to create facilities for screening material to identify high molecular weight (HMW) banding pattern, sedimentation value and atomic absorption to estimate levels of micronutrients. More and more emphasis need to be placed on the development of product specific varieties suitable for making good quality noodles, biscuits, pastas, breads, chapattis, etc. The quality improvement work should be based on genetic information and molecular markers available for use in breeding programme.

You all will agree that we have to be prepared for new challenges as population in Asia is increasing at a faster rate and a demand for additional production of wheat is estimated to be around 230 million tons by the year 2030. This will call for the integration of classical breeding approach and new cutting edge molecular tools involving different disciplines. The issue of narrow genetic variability, recombinant DNA technology and hybrid wheat are to be addressed in time bound manner for bringing a paradigm shift in varietal development to make desirable progress.

I would like to emphasize that we need to devise and follow innovative ways in developing technologies. We should try to bring about novel changes in wheat plant. Can it be possible to

transform C_3 wheat plant into a C_4 system which is physiologically more efficient system than C_3 ? Such a change may prove to be a boon to wheat plant under changing climatic conditions. Will it be a reality in this age of biotechnology to infuse 'Nif' genes into wheat? Under the present situation when the soil health is largely at stake, the self-sustaining system for nitrogen supply to wheat plant is very much needed.

I am sure that the research managers, researchers and other stakeholders representing various disciplines and programmes would deliberate during these two days and come out with the road map to addresses major issues to plan future research strategies so as to overcome the anticipated problems of wheat production in Asia for the years to come.

I wish the regional consultation a great success.

Thank you

Technical Programme

Thursday, April 26, 2012

Registration : 08:30 – 09:00

Inaugural Session

09:00 - 09:15	Welcome and Brief on Consultation	Raj Paroda, APAARI
09:15 - 09:25	Special Remarks	Masa Iwanaga, JIRCAS
09:25 - 09:40	Chairman's Address	Thomas Lumpkin, CIMMYT
09:40 - 10:00	Inaugural Address	Hiroyuki Konuma, FAO
10:00 - 10:05	Vote of Thanks	Subash Dasgupta, FAO
10:05 - 10:30	<i>Tea/Coffee Break and Group Photograph</i>	

Technical Session I: Strategy for Increasing Wheat Productivity

Chair : S. Nagarajan, PPVFRA
Co-Chair : Mirdad Panjsheri, MAIL
Rapporteur : Gyanendra Singh, DWR

10:30 - 11:00	Strategy for wheat improvement in Asia	Hans Braun, CIMMYT
11:00 - 11:20	Strategy for increasing wheat productivity	S. Rajaram, ICARDA
11:20 - 11:40	Germplasm conservation through use and role of biotechnology in wheat improvement	K.C. Bansal, NBPGR
11:40 - 12:00	Hybrid wheat and herbicide tolerance research at MAHYCO	Usha Zehr Barwale, MAHYCO
12:00 - 12:20	Regional collaboration for wheat in Asia	A.K. Joshi, CIMMYT
12:20 - 13:00	Discussion	
13:00 - 14:00	<i>Lunch</i>	

Technical Session II: National/Regional Wheat Scenario

Chair : Thomas Lumpkin, CIMMYT
Co-Chair : Shahid Masood, PARC
Rapporteur : S.S. Singh, National Consultant,
Govt of India

14:00 - 14:15	Country Report : Bangladesh	Jalal Uddin, WRC
14:15 - 14:30	Country Report : China	Alain Bonjean, LIMAGRAIN
14:30 - 14:45	Country Report : India	Indu Sharma, DWR
14:45 - 15:00	Country Report : Iran	Abdolali Ghaffari, IDLARI

15:00 - 15:15	Country Report : Nepal	Dhurba Bahadur Thapa, NARC
15:15 - 15:30	<i>Tea/Coffee Break</i>	
15:30 - 15:45	Country Report : Pakistan	Shahid Masood, PARC
15:45 - 16:00	Country Report : Mongolia	Tuul Dooshin, MFALI
16:00 - 16:15	Country Report : Afghanistan	Mirdad Panjsheri, MAIL
16:15 - 16:30	Report on Central Asia	R.C. Sharma, ICARDA
16:30 - 17:00	Discussion	
17:00 - 18:30	Working Groups	Moderator
	1. Research Priorities and Need Assessment	H.S. Gupta, IARI
	2. Development Initiatives for Inclusive Growth	Subash Dasgupta, FAO
19:00	<i>Reception Dinner</i>	

Friday, April 27, 2012

Technical Session III: Managing Wheat Diseases

	<i>Chair</i>	: Ronnie Coffman, Cornell University
	<i>Co-Chair</i>	: Robert Park, University of Sydney
	<i>Rapporteur</i>	: Etienne Duveiller, CIMMYT
08:30-08:50	Global initiative for managing wheat rusts	Ronnie Coffman, Cornell University
08:50 - 09:10	Wheat diseases and climate change in Asia	S. Nagarajan, PPVFR
09:10 - 09:30	Managing wheat rusts by using minor genes	Robert Park, University of Sydney
09:30 - 09:50	Management of wheat diseases in Asia	Etienne Duveiller, CIMMYT
09:50 - 10:10	Integrated management of wheat rust diseases : approach of FAO	Fazil Dusunceli, FAO
10:10 - 10:30	Discussion	
10:30 - 11:00	<i>Tea/Coffee Break</i>	

Technical Session IV: Stakeholders Dialogue on CRP 3.1 (Wheat)

	<i>Chair</i>	: Raj Paroda, APAARI
	<i>Co-Chair</i>	: Hans Braun, CIMMYT
	<i>Rapporteur</i>	: A.K. Joshi, CIMMYT
11:00 - 11:30	Objectives, strategies and stakeholders' involvement in CRP 3.1 (Wheat)	Hans Braun, CIMMYT
11:30 - 13:00	General Discussion	
1300-1400	<i>Lunch Break</i>	

Technical Session V: Addressing Emerging Challenges

Chair : Masa Iwanaga, JIRCAS

Co-Chair : R.R. Hanchinal, UAS Dharwad

Rapporteur : M.L. Jat, CIMMYT

14:00 - 14:15	Promoting conservation agriculture in Indo-Gangetic Plains	M.L. Jat, CIMMYT
14:15 - 14:30	Conservation agriculture for improved wheat production in Pakistan	Mustaq Ahmad Gill, DOA
14:30 - 14:45	Impact of climate change on wheat productivity	S. Naresh Kumar, CECRA
14:45 - 15:00	Developing terminal heat tolerant wheats	J. Rane, NIASM
15:00 - 15:15	Improving quality traits in wheat	R.K. Gupta, DWR
15:15 - 15:30	Current status and future strategies for seed production in Asia	H.S. Gupta, IARI
15:30 - 15:50	<i>Tea/Coffee Break</i>	
15:50 - 16:20	Discussion	

Plenary Session

Chair : Hiroyuki Konuma, FAO

Co-Chair : Thomas Lumpkin, CIMMYT

Rapporteur : Bhag Mal, APAARI

16:30 - 17:00	Sessions' recommendations	Rapporteurs
17:00 - 17:20	Remarks by Co-Chairs	Thomas Lumpkin, CIMMYT Raj Paroda, APAARI
17:20 - 17:30	Concluding remarks by Chair	Hiroyuki Konuma, FAO
17:30 - 17:35	Vote of thanks	Bhag Mal, APAARI

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