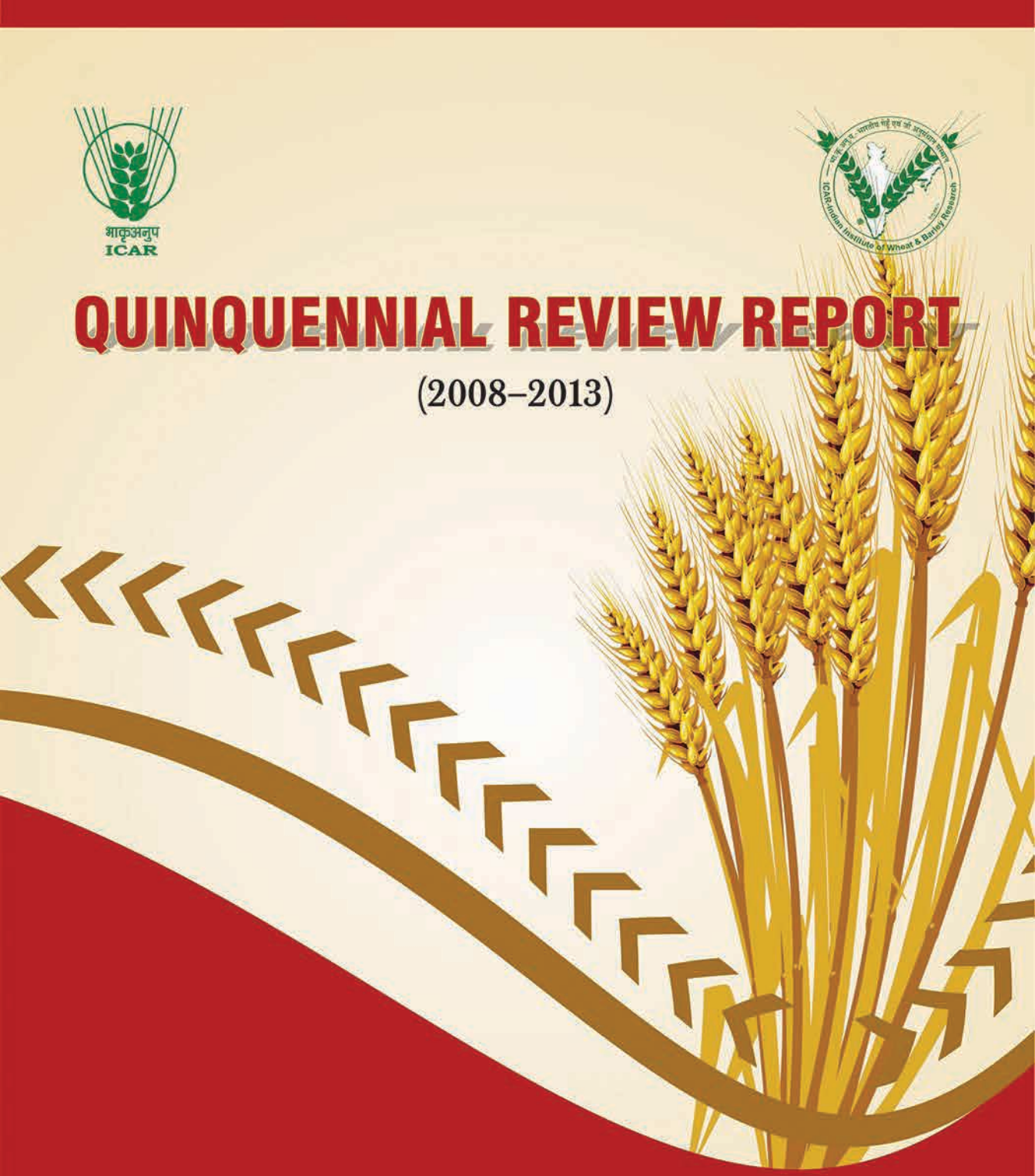
भाकृअनुप
ICAR

QUINQUENNIAL REVIEW REPORT

(2008–2013)



ICAR-Indian Institute of Wheat & Barley Research

Karnal - 132 001


DWR
ICAR
गेहूँ अनुसंधान निदेशालय
DIRECTORATE OF WHEAT RESEARCH
Quinquennial
Review
Team
Meeting

Quinquennial Review Report

2008-2013

July 5, 2013, Karnal

Dr. S Ayyapan
Secretary (DARE) and Director General (ICAR)
Indian Council of Agricultural Research
Krishi Bhavan,
New Delhi 110 001

Sub: Review of DWR & AICW & BIP by Quinquennial Review Team (QRT) ICAR office Order No. 16(7)/2011-IA. IV dated 28-05-2012

Dear Dr. Ayyappan,

We are pleased to inform you that the QRT constituted by ICAR has reviewed the research programme of the Directorate of Wheat Research (DWR) and All India Coordinated Wheat and Barley Improvement Project (AICW&BP) and the report is enclosed herewith for your kind perusal. The QRT had very positive interactions with Incharges of AICW&BIP centres and Principal Investigators of Directorate of Wheat Research. Subsequently the QRT members were able to travel to 9 Centres (IARI, Delhi; PAU, Ludhiana; CCS HAU, Hisar; CSAUT, Kanpur; SKUAST, Jammu; AAU, Shillongani, UBKVV, Coochbehar, BCKV, Kalyani and SKRAU Durgapura) for field visits and interaction with wheat and barley researchers, Heads, Directors and Vice chancellors. Based on these meetings, presentations and visits we are pleased to say that the wheat and barley research has been well executed at the national level.

The record production of 94.88 million tonnes during 2011-12 clearly indicates the strength of systematic and planned wheat research and development in the country. However, challenges ahead are extremely complex and will require different strategies and pathways to achieve the production goal of 120 million metric tons by 2050. Consequently, we have put in our collective wisdom and made recommendations, which we believe, would require your considerations for immediate action.

The QRT is grateful to Dr. SK Datta, DDG (Crop Science), ICAR for his critical advice for reviewing the programme. We are also thankful to Director Dr. (Ms.) Indu Sharma and QRT Member Secretary Dr. Ravish Chatrath as well as all the DWR and AICW&BIP scientists for their contributions towards this important review and their excellent hospitality. The overall organization of the meetings and visits were adequately organized enabling us to complete the task assigned to us.

We are grateful to you for giving this opportunity to serve the Council.

Sincerely yours,

PK Joshi
Member

GS Nanda
Member

PK Gupta
Member

SK Nayar
Member

Yadvinder Singh
Member

SC Gulati
Member

B Mishra
Chairman

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INTRODUCTION

The area, productivity and production of wheat have increased 119%, 247% and 658%, respectively in the year 2012 by taking 1965 as the base year. There was record production during the last 5 years with the highest wheat production of 94.8 mt during 2011-12. The "rate of return analysis" largely explains the success of wheat improvement programme and this is evident from the fact that the investment made in wheat research has been repaid through increased productivity and production. Nevertheless, this progress should not make us complacent as we face a myriad of challenges in the years to come. The population is increasing in a geometric progression leading to an increased demand of wheat but there is no possibility of further increase in area due to growing urbanization, diversification, dwindling water resources, micro-nutrient deficiencies and soil health deterioration. Therefore, to meet the demand of 130 million tons wheat by 2050 there is a need to produce more wheat with fewer resources in a sustainable and cost effective way.

Due to increased industrial demand, the barley crop will be known as cash crop in the coming years. Some industries are adopting contractual farming and giving premium on better malt producing varieties. Besides this, barley is also an important crop for feed and fodder purposes.

Constitution and Composition of QRT

The ICAR constituted the QRT team vide office order F 16-7/11-1A-IV dated 28th May 2012 (Annexure 1) to review the research accomplishments of the DWR, Karnal as well as AICW&BIP for the period 2008-2013. The composition and term of reference of the QRT are as follows:

Composition of QRT

1.	Dr. B Mishra, Former Vice Chancellor, SKUAST, Jammu	Chairman
2.	Dr. PK Joshi, Director (South Asia), IFPRI, New Delhi	Member
3.	Dr. GS Nanda, Former Director Research, PAU, Ludhiana	Member

4.	Dr. PK Gupta, Hon. Emeritus Professor & NASI Sr. Scientist, Meerut University, Meerut	Member
5.	Dr. SK Nayar, Ex-Head, DWR Regional Station, Flowerdale Station, Shimla	Member
6.	Dr. Yadvinder Singh, INSA Sr. Scientist, Department of Soils, PAU, Ludhiana	Member
7.	Dr. SC Gulati, Ex-Principal Scientist, IARI, New Delhi	Member
8.	Dr. Ravish Chatrath, Principal Scientist, DWR, Karnal	Member-Secretary

Terms of Reference

ICAR has given the following terms of reference to the QRT:

A. Institute/ unit

(i) Research Achievements and Impact

- To critically examine and identify research achievements of the Institute, Projects and its Regional Stations and AICRP Centers vis-à-vis sectoral programmes since the previous QRT and critically evaluate them. Commensurate with the objectives, mandates and resources of the organization, the socio economic impact of research on farmers/ beneficiaries and transferability of results to farmers through extension should be critically reviewed.
- The research and its impact should be brought out in quantifiable benchmarks wherever possible.
- To know the value for money, QRT should assess and bring out the physical outputs and outcomes vis-à-vis the budget spent during the period under report. If the likely outcomes are going to take considerable time, the projected outcomes should be indicated.
- The socio-economic impact of research on farmers/ beneficiaries and transferability of results to farmers being an important aspect of

research outcome, the transferability should be mandatory for research projects.

(ii) Research Relevance and Budget Allocation

To examine objectives, scope and relevance of the research programmes and budget of the Institute for the next 5 years in relation to overall state/ regional/ national plans, policies, short- and long term priorities and also the Perspective Plan and Vision 2030 documents.

(iii) Relationship / Collaboration with SAUs and other Stakeholders

To pinpoint whether the research programmes of the past and proposals for future are in harmony with the Vision of the ICAR (Hq) and the programme of related centers of research and agricultural universities, state government, private sector and IARCs.

(iv) Linkages with Clients / End-users

To examine the kinds of linkages established with the clients and end users of the research results, i.e. farmers and the extent of interests displayed in conducting "on-farm research" on farmers fields and in organizing demonstrations/ training courses for the transfer of technology to extension agencies and KVKs of the ICAR. The collaboration with State Agricultural Universities, International Centers of Agriculture and State Departments of Agriculture, Inter-Institutions and Inter- departmental linkages should be examined.

(v) Proposed Changes in Organizations, Programmes and Budget

To examine whether any changes in the organizational set- up are called for manpower and funds allocation. The decentralization in day to day working and the transparency should be highlighted. Further, the Committee may also examine the resource generation efforts and implementation of Project-based Budgeting.

(vi) Constraints

To examine constraints hindering the Institute and AICRP in achieving their objectives and implementation of the programmes and goals and to recommend ways and means of minimizing or eliminating them.

(vii) Looking forward

To look into any other point considered relevant by the Committee or referred to it by the ICAR, the Institute Director or the Management Committee, in respect of future programme development, research prioritization and management changes.

B. All-India Coordinated Research Projects (AICRPs)

(i) To analyze growth of manpower, number of co-operating centers', both in terms of funds as well as staff resources.

(ii) To critically examine and evaluate achievements of the AICRPs in research with reference to (i) focus on national programmes (ii) multi-locational testing (iii) evaluation of pests and diseases (iv) exchange of scientific information (v) inter-institutional and inter-disciplinary linkages (vi) development of strategic plans (vii) linkages with international programmes (viii) information on technology base (ix) encouragement and guidance by the PC (x) off-season nursery facilities (xi) healthy competition in Annual Workshops and professional challenge (xii) quality of recommendations of the Annual Workshops (group meetings) and follow up on those recommendations (xiii) whether research is of routine nature on trodden path or they are breaking new grounds (xiv) whether there is an individual initiative (xv) whether there is too much regimentation/ rigidity and (xvi) whether the resources including manpower are optimally utilized.

Budget

(iii) To examine sufficiency of the Budget of the Coordinating center as a part of the total budget of the SAU's and of the ICAR.

Organization and Management

(iv) Integration of research-whether the work being carried out under the coordinating project derives full support from other related programmes, including basic and strategic researches.

(v) What is the monitoring mechanism of the coordinated project in the cooperating centres to avoid distortions/ duplication/ overlapping in programmes of the AICRP and the SAUs, including those at the regional stations?

(vi) Whether a strategic plan for the respective crop, commodity or natural resource with major emphasis on sustainability of production system has been developed by the coordinating unit in close collaboration with the cooperating centres?

(vii) How much operating funds does each scientist get under coordinated projects? Is it at least Rs 60,000 per scientist per year?

(viii) Whether the PC is located in the ICAR institute or the SAU? Whether institute scientists working on coordinated projects from the cadre strength of the institute, and their work forms the priority work of the institute? Do they get additional funds for the travel for the work of coordinated project?

Annual Workshops (Group Meetings)

(ix) How the Annual Workshop is organized? Is it serving as a focus of generation of new ideas? Do the senior officials from the Departments of Agriculture and Extension attend the workshops? Do scientists from private sector participate?

(x) Is a policy brief prepared after the workshop for use by policy makers and planners? If so, what has been the outcome? Does the coordinating unit maintain an extensive database on the crop/ commodity/ natural resource?

(xi) How is the HRD programme organized for the young scientists working in the project and also other staff working in the project?

QRT meeting

To review the work of the Directorate of Wheat Research and AICW&BIP from 2008 - 2013, the following four meetings were organized:

QRT meeting (October 20-21, 2012)

Quinquennial Review Team (QRT) reviewed the progress of each AICW&BIP funded centres in a meeting held at Directorate of Wheat Research, Karnal on October 20-21, 2012. During the review meeting, Principal Investigators of all the funded centres except Manipur presented the salient achievements, constraints and priority areas. They presented the main production constraints in the state and the region they represented along with salient achievements of their centre for the period under review. They also briefed about the administrative, personnel and technical constraints faced by them along with brief future activity plans. This was followed by discussion and interactions.

QRT meeting (February 10-11, 2013)

Quinquennial Review Team (QRT) reviewed the research programmes of the DWR, Karnal. The Project Director and Principal Investigators of each programmes made presentation and held detailed discussion with the QRT members.

Proceedings of both the meeting are appended as Annexure II and III.

First QRT Meeting held at DWR on October 20 -21, 2012

QRT meeting (May 16-19, 2013)

Draft of final report was prepared.

QRT meeting (June 2-3, 2013)

Recommendations were finalized and circulated to all the members.

Visits of QRT members

As a part of the review process, the QRT members visited some of the good as well as poor performing AICW&BIP centres, farmers' field and hold a meeting with all the associated scientists as well as university officials (Vice Chanellor, Director Research, Dean etc.).

Schedule of visits of QRT members

Member's name	Date	Centre visited
Dr. B Mishra, Dr. SK Nayar	March 3-6, 2013	Niphad and Rahauri
Dr. SK Nayar	March 5, 2013	Mahabaleshwar
Dr. Yadvinder Singh	March 11-12, 2013	Kanpur
Dr. PK Gupta	March 14-17, 2013	Shillongani, Coochbehar and Kalyani
Dr. SC Gulati	March 19-20, 2013	Durgapura
Dr. B Mishra, Dr. Yadvinder Singh	March 21-23, 2013	Delhi, Hisar and Ludhiana
Dr. B Mishra, Dr. Yadvinder Singh, Dr. SK Nayyar and Dr. SC Gulati	March 24, 2013	Gullarpur village, Karnal on occasion of farmers day
Dr. B Mishra, Dr. Yadvinder Singh	March 31, 2013	Jammu

A

B

C

D

Second QRT Meeting at DWR on February 11-12, 2013 (A) and (B) QRT Chairman conducting meeting (C) QRT visiting research farm (D) QRT with DWR staff

QRT visiting farmers' field during farmer day on March 24, 2013

A

B

C

D

E

F

G

H

QRT at (A) IARI (B) Hisar (C) Kalyani (D) Kalyani (E) Kanpur (F) Shillongani (G) Shillongani (H) Ludhiana

INSTITUTE BACKGROUND, OBJECTIVES, MISSION AND ACTIVITIES

The establishment of the All India Coordinated Wheat Improvement Project (AICWIP) in 1965 by the Indian Council of Agricultural Research (ICAR) resulted in the real breakthrough in the productivity of wheat, through the introduction of semi-dwarf Mexican wheat, which led to usher the Green Revolution in the country. The AICWIP was subsequently raised to the status of Directorate of Wheat Research (DWR) in 1978. DWR was later on shifted from IARI, New Delhi to its present location at Karnal in 1990. Wheat and Barley projects were merged and renamed as the All India Coordinated Wheat & Barley Improvement Project (AICW&BIP) in 1997. DWR through AICW&BIP is coordinating multidisciplinary and multilocational testing of varietal, newly developed improved genotypes, crop management and crop protection technologies across the diverse ecosystems for stabilizing and increasing the wheat and barley production. As a nodal agency for wheat and barley research, DWR facilitates planning, exchange of experimental material, monitoring of field trials / nurseries, data compilation and documentation. At present 107 scientists from 31 funded centres and 174 scientists from 123 non-funded co-operating centres are carrying out the planned activities of different production conditions of the six agro-ecological zones. Apart from this, DWR also undertakes the basic, strategic and applied research to enhance productivity of wheat and barley through various inter and intra institutional research projects. Research capabilities and facilities are being strengthened through various network projects to enhance output of competent research centres under AICW&BIP. In addition to the headquarters, DWR also have two regional stations, one at Shimla and another at Dalang Maidan (Lahaul & Spiti), Himachal Pradesh. Recently, 200 acre of land has been alotted to DWR at Hisar for experiment and seed multiplication purposes.

The Directorate has breeding, pathology, physiology, quality and biotechnology laboratories, polyhouses to screen for diseases and pests, glass houses, museum,

seminar hall, 100 acres research farm, canteen, standby electric generator systems etc.

Through coordinated research efforts nearly 403 wheat and 84 barley varieties suited to different agro-ecological conditions and growing situations have been released so far. These genotypes have been very successful in increasing the wheat production from a mere 12.5 million tons in 1964 to around 94.88 million tonnes during 2011-12. Apart from this, 150 wheat genetic stock possessing yield traits, resistance against various diseases, abiotic stresses or quality attributes were registered with NBPGR.

During the period of review, Directorate received prestigious Chaudhary **Devilal outstanding All India Coordinated Research Project Award 2011** for playing key role in enhancing the wheat and barley productivity of the country. Apart from it, number of scientists received awards from international and national organizations. Some of the prestigious awards bagged by the scientists during the review period are Pran Vohra Award, Dr HC Dube Outstanding Young Scientist Award by Ind. Soc. Myco. & Pl. Path., Lal Bahadur Shastri Young Scientist Award, Young Scientist Award of Indian Society of Extension Education.

Objectives

- Organize, coordinate and monitor multi-locational and multidisciplinary research for developing and identifying superior wheat and barley varieties having better quality, tolerant to biotic and abiotic stresses under varied agro-climatic zones.
- Collect, acquire, evaluate, catalogue, maintain and share working germplasm collections of wheat and barley with focused attention on identifying suitable donors for yield components, biotic and abiotic stresses and quality traits.
- Undertake basic and strategic research for a major advance in genetic yield potential, quality, and durable disease resistance through the utilisation of genetic resources and genetic enhancement.

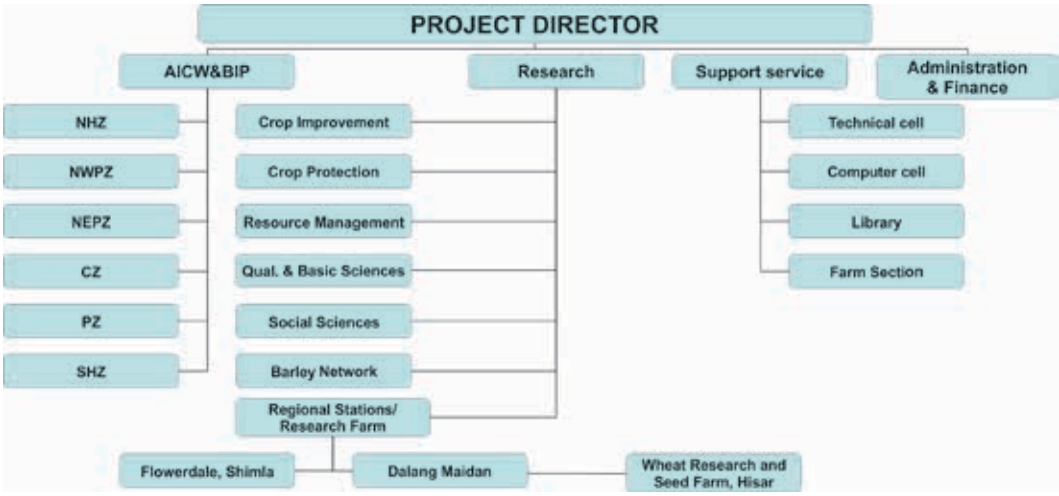
- Mobilise genetic diversity from national and international sources for developing new genetic stocks for distribution to the cooperating centres in different zones.
- Develop strategic research, which will lead into precision farming, enhance input use efficiency, optimal use of renewable resources, and enhance the sustainability of wheat based cropping systems.
- Monitor the obligate parasites e.g. rust pathogen dynamics and develop strategies to mitigate crop losses due to pests and diseases.
- Establish national and international linkages for strengthening wheat and barley improvement programmes.
- Provide off-season nursery facility for rapid generation advancement and seed multiplication.
- Serve as a core facility for data analysis, documentation and information management, so that DWR becomes the national repository for all wheat and barley databases.
- Coordinate and organise nucleus and breeder seed production.
- Impart training/education related to wheat and barley improvement, production, protection, utilisation and trade.

The Mission

Ensuring food security of India by enhancing the productivity and profitability of wheat and barley on an ecologically and economically sustainable basis and making India the world leader in wheat production.

Organisational setup

A chart showing the organizational structure of the DWR is given below.



In addition to the headquarters, DWR has two Regional Research Stations. DWR Regional Research Stations at Flowerdale, Shimla (established in 1930), serves as a national facility for monitoring wheat rust pathotypes, evaluating advanced generation material, postulating probable rust resistance genes in the test lines and act as a repository for maintenance of the wheat rust virulences. The Regional Station at Dalang Maidan is located at an altitude of 10,000 feet with twelve hectares of land, of which six hectares is cultivable. The office cum laboratory and guest-house facilities has been created for the benefit of research workers. Facilities of this station are being utilized for advancing the generation, conservation of germplasm, making crosses during off-season and screening against yellow rust resistance by AICW&BIP centres.

AICW&BIP

In all, a wide network of 31 funded centres under AICW&BIP are located in different state agricultural universities (SAUs), autonomous institutions and central universities for supporting multidisciplinary research on wheat. Besides, 123 centres are coordinated within the project as voluntary centres

to provide help in the evaluation work. In addition, some other testing sites are also provided by non-government organizations and State Agriculture Departments. These locations have been identified in such a way that all the agro-climatic zones of the country are covered.

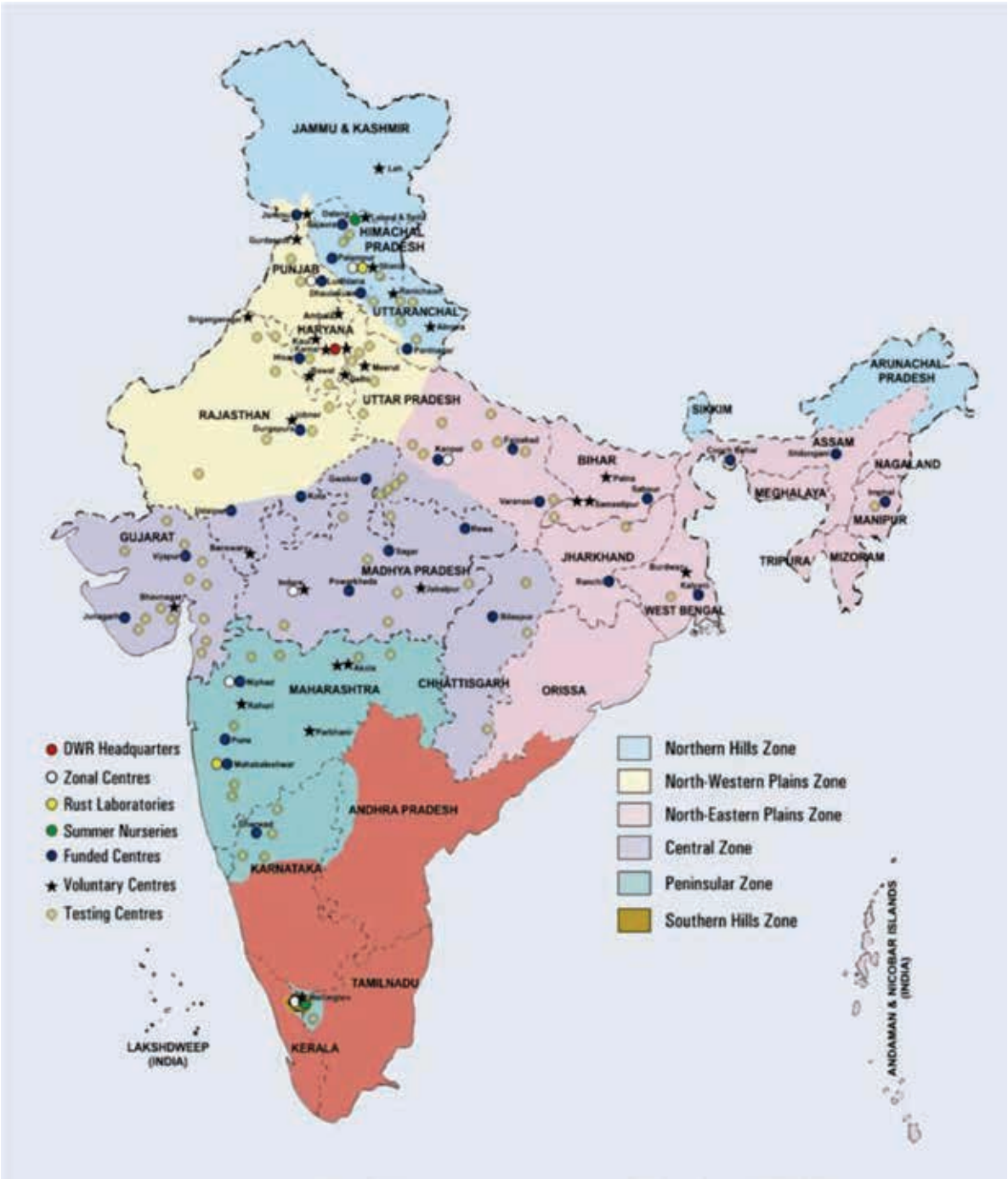
There are six major wheat growing zones under AICW&BIP in the country. In each zone (NWPZ, NEPZ, CZ, PZ, NHZ and SHZ) one Zonal coordinator has been nominated by the DWR and the Zonal Coordinator is helping the Project Director (Wheat) in the constitution, dispatch, conduction and monitoring of advance varietal trials in particular zone.

Zone wise funded Centres under AICW&BIP

Zone	Area covered	Centre
Northern Hills Zone (NHZ)	Western Himalayan regions of J&K (except Jammu and Kathua distt.); H.P. (except Una and Paonta Valley); Uttarakhand (except Tarai area); Sikkim and hills of West Bengal and N.E. States	CSK-HPKV-Palampur, CSK-HPKV-Dhaulakuan CSK-HPKV-Bajaura * DoA Mantripukhri-Manipur
North Western Plains Zone (NWPZ)	Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and Western UP (except Jhansi division), parts of J&K (Jammu and Kathua distt.) and parts of HP (Una dist. And Paonta valley) and Uttarakhand (Tarai region)	PAU-Ludhiana, CCSHAU-Hisar* GBPUAT-Pantnagar RAU-Durgapura* SKUAT-Jammu SVBP- Modipuram
North Eastern Plains Zone (NEPZ)	Eastern UP, Bihar, Jharkhand, Orissa, West Bengal, Assam and plains of NE States.	CSAUAT-Kanpur* NDUAT-Faizabad* BHU- Varanasi* RAU-Sabour BAU-Ranchi BCKV-Kalyani UBKV-Pundibari AAU-Shillongani

Central Zone (CZ)	Madhya Pradesh, Chhattisgarh, Gujarat, Kota and Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh	CoA- Rewa@ ZARS-Powarkheda RARS-Sagar RVSUA&T, Gwalior IGKVV-Bilaspur MPUAT-Udaipur MPUAT-Kota SDAU-Vijapur JAU-Junagarh
Peninsular Zone (PZ)	Maharashtra, Karnataka, Andhra Pradesh, Goa, plains of Tamil Nadu	UAS-Dharwad MPKV-Niphad MPKV-Mahabaleshwar (Pathology) ARI-Pune
Southern Hills Zone (SHZ)	Hilly areas of Tamil Nadu and Kerala comprising the Nilgiri and Palni hills of southern plateau.	

*These centres are working on Barley also, @ Rewa centre is exclusively working on barley



Wheat and Barley Coordinating Centres in India

MANAGEMENT

Annual Workshop

The coordinated research programme is reviewed every year in the annual wheat workers meet and modified as per recommendations of location specific needs. During the period under review, the following five All India Wheat and Barley Research Workers' Meet were organised:

Details of All India wheat and barley research workers meets' from 2008 to 2013

Sl No.	Workshop	Held at	Dates
1.	47th All India Wheat and Barley Research Workers' Meet	CCSHAU, Hisar	August 17-20, 2008
2.	48th All India Wheat and Barley Research Workers' Meet	NASC Complex, New Delhi	August 28-31, 2009
3.	49th All India Wheat and Barley Research Workers' Meet	PAU, Ludhiana	August 27-30, 2010
4.	50th All India Wheat and Barley Research Workers' Meet	NASC Complex, New Delhi	September 1-4, 2011
5.	51st All India Wheat and Barley Research Workers' Meet	Swami Keshwanand Rajasthan Agricultural University, Durgapura, Jaipur	August 24-27, 2012

The meet provides a platform to discuss emerging issues related to wheat and barley production in the country. It is being attended by the wheat and barley researchers from the national and international organizations (CIMMYT, ICARDA etc.), officials of Department of Agriculture and Co-operation, PPV&FRA, different state agricultural department and policy makers.

Zonal Monitoring

Zonal monitoring of AICW&BIP programme by a team of scientists belonging to crop improvement, protection and resource management is regularly done every crop season during February to April in all the zones.

The recommendations made by the zonal monitoring teams help to identify agronomically superior and disease resistant materials, besides improving the genetic purity of test varieties.

Procedure of Testing and Promotion of New Wheat Genotypes in Coordinated trials

Initially the materials were evaluated for yield potential in station trials and disease resistance in IPPSN, promising material then evaluated in NIVT followed by AVT.

Trials		Criteria for promotion/retention
One Year Inter Zonal Test i.e.		
NIVTs:	(NIVT-1A, NIVT-1B, NIVT-2, NIVT-3, NIVT-4, NIVT-5A, NIVT-5B)	Yield potential, disease resistance and quality traits are taken into account for promoting entries into various AVTs at AVT-I stage
Special trials:	Salinity-alkalinity trial, *Dicoccum* trial, *Triticale* trial	-do-
AVT-I (One Year Zonal Test)		Yield potential, diseases resistance and quality traits are taken into account for retaining entries in AVT-II stage
AVT-II (One Year Zonal Test)		Yield potential, disease resistance, quality traits and agronomical investigations are carried out on final year entries

Institute Research Council

Modifications suggested by RAC are taken into consideration in formulating and finalising the annual programme in Institute Research Council (IRC) meetings which is headed by the Project Director.The lead research is reviewed by Institute Research Council (IRC) and it is scrutinised by the Research Advisory Committee (RAC) of the Project Directorate. The modifications suggested by RAC are taken into consideration and the final programme is formulated and communicated to the Crops Division of ICAR Headquarters

for approval. During the period under review, the following five meetings were organised.

IRC meetings held at Directorate of Wheat Research, Karnal during 2008-2013

S.N.	Meetings	Date
1.	XV-IRC meeting	Oct. 18, 20 & 24, 2008
2.	XVI- IRC meeting	Oct. 30-31, 2009
3.	XVII-IRC meeting	Oct. 25-26 & 29 and Nov. 02, 2010
4.	XVIII- IRC meeting	Dec. 12-13, 2011
5.	XIX- IRC meeting	January 21-22, 2013

Research Advisory Committee

The on-going programmes are being evaluated and reviewed annually by Research Advisory Committee (RAC), consisting of experts representing different disciplines and chaired by an eminent scientist. The RAC guides the institute in deciding the thrust areas of research. During the period under review, a total of five RAC meetings were organized.

RAC meetings held at Directorate of Wheat Research, Karnal during 2008-2013

S. No.	RAC Meeting	Dates held	Chairman	Members
1.	13th RAC	March 3, 2009	Dr. H. K. Jain, Former Director, IARI, New Delhi	• Dr. S. N. Shukla, ADG (FFC), ICAR, New Delhi • Dr. R. G. Saini, Former Head, Deptt. of Pl. Breed. & Genetics, PAU, Ludhiana • Dr. R. D. Mishra, Former, Dean (Agriculture), GBPUA&T, Pantnagar • Dr. D. V. Singh, Former Head, Division of Pl. Pathology, IARI, New Delhi • Dr. Ramesh Chand, National Professor, NCAP, New Delhi • Prof. Bijay Singh, National Professor, PAU, Ludhiana • Dr. Jag Shoran, Project Director, DWR, Karnal • Dr. Ravish Chatrath, Principal Scientist, DWR, Karnal. (Member Secy)
2.	14th RAC	April 3, 2010	-do-	Same as above except PD was Dr. SS Singh
3.	15th RAC	March 30, 2011	-do-	-do-

4.	16th RAC	March 5, 2012	Dr. P.L. Gautam, Ex-Chairperson, Protection of Plant Varieties and Farmer's Rights Authority	• Dr. V.S. Rao, Former Director, ARI, Pune • Dr. Raj K. Gupta, Regional Facilitator, Rice Wheat Consortium,CIMMYT -INDIA • Dr. S.M. Bhatnagar, Former In-charge Wheat Programme, RAU,Durgapura • Dr. T. Mohapatra, Director,CRRI,Cuttack (Orissa) • Dr. B.K. Mishra, Former PI, Quality, DWR, Karnal • Shri Ved Pal, Progressive Farmer, Karnal • Dr. Indu Sharma, Project Director, DWR, Karnal • Dr. Sewa Ram, Principal Scientist, DWR, Karnal
5.	17th RAC	March 2, 2013	-do-	-do-

PME Cell

As per the ICAR guidelines, PME cell and PMC have been constituted in DWR, Karnal to prioritize research, monitoring and evaluation. It will help in prioritizing the research areas for managing resources in an efficient way and will enhance accountability of concerned scientists because of efficient monitoring and evaluation system. This will lead to more outcome. Committees of experts have been constituted to evaluate the progress of research projects, to report on technology validation of completed projects and to update database of DWR on half yearly basis.

Publications

A large number of publications in journals of repute by the scientists DWR have played a significant role towards improving scientific exchange, professional competence, awareness and dissemination of improved production technology

to the cultivators. The year wise publication made by DWR are given in following table

	Publications		
Year	**International Journals**	**National Journals**	**Total**
2008	14	52	66
2009	6	16	22
2010	18	20	38
2011	10	18	28
2012	15	40	55
Total	**63**	**186**	**209**

Publications by AICW&B Centres at Karnal

Publication record of majority of centres is very poor (except Ludhiana, Coochbehar, Dharward, Pantnagar), some centres submitted a long list of publications but most of them are in journals with no impact factor. Surprisingly, there are many centres that have no publications during the last 5 years. We strongly recommend that scientists be encouraged to write and publish results of their studies in national and international journals of repute. Many times good piece of work remains in data books and scientists at the other centres will not be able to take the advantage of the information already available.

Infrastructure facilities available at the Headquarters and Regional Stations

Laboratory and Field Equipments at Karnal

The DWR has well equipped laboratories in the disciplines of Crop Improvement, Resource Management, Quality, Biotechnology, Crop Protection and Malt Barley.

Biotechnology: Temperature Control Phenotyping Facility, LICOR- semi automated DNA Sequencer, RT-PCR, Gel-DOC system, Water purification system, Tetrad PCR Thermal cyclers, Centrifuges, Lypholizer, Refrigerator,

Deep freezer (-20°, -80°C), Liquid Nitrogen containers, Vortex shaker, Water bath etc.

Crop improvement: Porometer, Spectrophotometer, Root scanner, XRF micronutrient analyser, Infra red thermometer, Chlorophyll meter, Grain counters, SPAD meter, Canopy analyser, Weather station, Nitrogen analyzer, Falling Number (for □amylase enzyme analysis).

Germplasm conservation facility: Two germplasm modules for storing wheat and barley working germplasm for medium duration. Storage facilities also created at Dalang Maidan for conserving germplasm under natural conditions.

Crop protection: BOD's, Refrigerators, Deep freezer, Thermal cycler, Water purification system, Spectrophotometer, Shaker, Laminar flow, Centrifuges, Microscopes with photographic system, Bio-fermentor, Poly houses and glass house.

Quality: State of art facilities developed for quality testing includes NIR System (for quick and non-destructive analysis of protein content), Semolina mill, Semolina purifier, Pasta making unit, Gel Electrophoreses system, Alveograph, Mixograph, Farinograph, Rapid-Visco Analyzer, Glutomate, SKCS, Refrigerated Centrifuge, Brabander Senior Mill, Cyclotec, Baking units for Bread and biscuit making etc.

Resource management: Atomic absorption spectrophotometer, Nitrogen analyzer, UV Spectrophotometer, Flame photometer, CHNS analyzer, Soil moisture meter, Green seeker, Leaf canopy analyser, Infra red thermometer and recording penetrometer *etc*.

Malt barley: Micro-Malting System for barley (for malting the small size samples of 50 g from early generation breeding programme), Malt friability meter, Grain uniformity tester (Sortimat), Wort Viscosity meter, NIR system for grain & malt analysis, Malt mashing bath, Protein analyser etc.

Field facilities: DWR has a well-developed experimental farm of about 45 acres at main campus. Also, another area of 48 acres of land adjacent to NBAGR has been acquired developed as seed cum research farm. Both the farms have underground irrigation facility, required farm machinery with seed storage facility at main farm.

Flowerdale, Shimla

Various glass and poly-houses mostly with temperature control, field area (about an acre) for multiplying seed along with the Visiting Scientist facility have helped wheat rust workers to utilize this station in a very effective way for identification of resistant sources. A small biotech laboratory is also set-up there to study molecular biology aspects of the rust pathogens. The station has Thermal cycler, Centrifuges, Lypholizer, Spectrophotometer, Refrigerators, Deep freeze(-20°, -80°C), Liquid Nitrogen containers, Vortex, Water bath etc.

Dalang Maidan (Lahaul and Spiti)

The DWR Regional Station located at Dalang Maidan (Himachal Pradesh) acts as a national facility for providing various kinds of support to wheat and barley researchers of the country. This regional station of DWR is situated on the right bank of Chandra river at Dalang Maidan in tribal district of Lahaul-Spiti in Himachal Pradesh. It is located approximately at 32°30'N and 76°59'E at an altitude of about 10,000 feet above sea level. The climatic conditions at the station are very favorable to grow wheat during summer (May to Oct.) as off season nursery.

It serves as a national wheat summer nursery facility for generation advancement, seed multiplication and evaluation of breeding material during offseason. About 6 ha of land is under experimentation with assured irrigation and power supply during the crop season. The climatic conditions in this valley are very conducive for the development of yellow rust and therefore, this station has very significant role in screening of wheat and barley material against yellow rust. In addition, the station serves as one of the national wheat

and barley repository for storing germplasmunder the natural conditions in a cost-effective manner. The creation of doubled haploid facility is now being explored at this centre. At present the station is equipped with farm machinery to carry out field experimentations. However, there is urgent need for the renovation of irrigation facilities at the station. Besides these, fax and internet facilities are being created for efficient communication between Dalang Maidan and DWR, Karnal.

LINKAGES

DWR has a strong and wide network of linkages and collaboration with organizations both in India and abroad.

Linkages with funded coordinated centres and other institutes

Close linkage exists among SAUs and DWR headquarters. DWR has very strong network of 31 funded and voluntary centres under AICW&BIP umbrella which includes four ICAR institutes, 25 SAUs, one Central university (BHU), two state universities, one institution under Department of Science and Technology (ARI) and one NGO (Lok Bharti). All the cooperating scientists meet annually at the Wheat Research Workers Group Meeting organised in August each year. In addition, mid season monitoring trips are organized for meeting and effective interaction and inspection of trials at the sites.

Linkages with other national and international institutions

To create awareness among the farmers about various technologies, linkages are being established with the SAUs, State Departments of Agriculture, Fertilizer Companies, Input Suppliers, Hariyali Kisan Bazar etc. to carry out research. The Directorate of Wheat Research and the AICW&BIP are having active collaborations with following international and national organizations:

International linkages

- International Center for Maize and Wheat Improvement (CIMMYT), Mexico
- International Center for Agricultural Research in Dry Areas (ICARDA), Syria
- International Rice Research Institute (IRRI), Philippines
- United States Department of Agriculture (USDA), USA
- Australian Council of International Agricultural Research (ACIAR), Australia
- Indo-Swiss Collaboration in Biotechnology (ISCB)

- Adelaide University, Adelaide
- DRRW (Durable Rust Resistance in Wheat), Cornell University
- BGRI (Borlaug Global Rust Initiative)

National linkages

- Department of Agriculture and cooperation
- Department of Biotechnology (DBT), Government of India, New Delhi
- Department of Science and Technology (DST), Government of India, New Delhi
- Council of Scientific and Industrial Research (CSIR)
- State Agricultural Universities (SAUs)
- Banaras Hindu University (BHU)
- State Agriculture Departments
- Other ICAR Institutes

Linkages for capacity building

The scientists of DWR also imparts guidance to students from various universities for disserataion work.

Inter institutional collaboration on wheat rust research

The centre is actively extending all the logistics for wheat rust research including hands on training in India. DWR is in close associations with SKAUST Jammu, CSKHPKV Palampur, PAU Ludhiana, GBP University Pantnagar, VPKAS Almora, HAU Hisar, IARI New Delhi/its regional stations, ARI Pune, UAS Dharwad, BHU Varanasi, IGKV Raipur, JNKV Jabalpur and other private institutions.

Linkages with industry

Barley network programme has strong linkages with malt industry.

MANPOWER AND BUDGET

Budget

The consolidated year wise statement of allocation and expenditure under Plan and Non-plan head is given in the follwing tables:

Plan (DWR, Karnal and AICW&BIP)

(Rs. Lakhs)

Plan	Year	DWR		AICW&BIP		Total	
		Allo.	Exp.	Allo.	Exp.	Allo.	Exp.
IX Plan	1997-98	173.00	172.91	200.00	199.42	373.00	372.33
	1998-99	140.00	139.70	291.75	291.59	431.75	431.29
	1999-00	175.00	174.91	328.50	328.38	503.50	503.29
	2000-01	120.00	119.97	371.00	371.00	491.00	491.97
	2001-02	131.00	131.00	404.00	404.00	535.00	535.00
Total		**739.00**	**738.49**	**1595.25**	**1594.39**	**2334.25**	**2332.88**
X Plan	2002-03	80.00	79.82	900.0	899.61	980.00	979.43
	2003-04	90.00	89.68	732.0	732.00	822.00	821.68
	2004-05	180.00	179.98	500.0	500.00	680.00	679.98
	2005-06	96.50	96.49	524.0	524.00	620.50	620.49
	2006-07	76.51	76.51	465.76	465.76	542.27	542.27
Total		**523.01**	**522.48**	**3121.76**	**3121.37**	**3644.77**	**3643.85**
XI Plan	2007-08	124.00	123.99	679.00	679.00	803.00	802.99
	2008-09	200.00	199.65	1674.85	1674.85	1874.85	1874.50
	2009-10	650.85	651.28	1090.00	1090.00	1740.85	1741.28
	2010-11	810.00	793.02	995.00	995.00	1805.00	1788.02
	2011-12	475.00	465.31	1131.00	1131.00	1606.00	1596.31
Total		**2259.85**	**2233.25**	**5569.85**	**5569.85**	**7829.70**	**7803.10**
XII plan	2012-13	530.00	529.58	1840.00	1840.00	2370.00	2369.58

Non-Plan

(Rs. Lakhs)

Plan	Year	Allocation	Expenditure
IX Plan	1997-98	168.00	164.64
	1998-99	246.00	239.10
	1999-00	238.60	238.59
	2000-01	264.94	264.92
	2001-02	295.20	294.78
Total		**1212.74**	**1202.03**
X Plan	2002-03	309.00	308.41
	2003-04	350.00	349.96
	2004-05	384.00	383.98
	2005-06	444.00	441.34
	2006-07	438.00	437.96
Total		**1925.00**	**1921.65**
XI Plan	2007-08	476.0	473.93
	2008-09	733.65	716.57
	2009-10	1012.37	1011.00
	2010-11	1098.85	1063.79
	2011-12	1208.5	1193.95
Total		**4529.37**	**4459.24**
XII plan	2012-13	1231.86	1204.63

Manpower (As on March, 2013)

DWR, Karnal

The Institute had a sanctioned scientific strength of 57 scientists, 48 technicals, 25 administrative and 34 supporting staff during XI Plan. About 8 post of scientists are lying vacant.

S. No.	Manpower	Sanctioned Strength	In Position	DWR, Karnal	DWR R.S. Shimla	DWR R.S. Lahaul Spiti
1	Scientific	56+1*	48+1	44+1	4	
2	Administrative	25	22	19	3	
3	Technical	48	48	42	5	1
4	Supporting	34	23	16	7	-
Grand Total		**163+1***	**141+1**	**121+1**	**19**	**1**

*RMP

Scientific staff strength

AICRP on Wheat and Barely has cadre strength of 107 scientific staff belonging to 14 disciplines. Centre-wise cadre strength is given in Annexure –IV. The discipline-wise cadre strength is given below:

Discipline	Number of centres	Number of posts
AICRIP Wheat		
Plant Breeding	24	29
Agronomy	23	24
Plant Pathology	20	24
Entomology	4	4
Bio-chemistry	5	5
Nematology	3	3
Physiology	3	3
Botanist	1	1
Cereals Analyst	3	3
Geneticist	1	1
Food and Nutrition	1	1
AICRIP Barley		
Barley Breeding	7	7
Barley Agronomy	1	1
Barley Pathology	1	1
Total		**107**

Review of manpower at AICW&BIP

As on date, the project is running at 31 funded centres spread over 17 states. Ten states have one centre each, 2 states have 2 centres each. Himachal Pradesh, Rajasthan and Maharashtra have 3 centres each while Uttar Pradesh and Madhya Pradesh have 4 centres each. Of the 31 centres, 24 centres are exclusively working on wheat, while six centres are working on both wheat and barley, whereas Rewa centre is exclusively working on barley.

The main objective of the project is to plan and organize multi-disciplinary/ multi-location Varietal and Management Technology trials to enhance and stabilize wheat production with resource and input use efficiency.

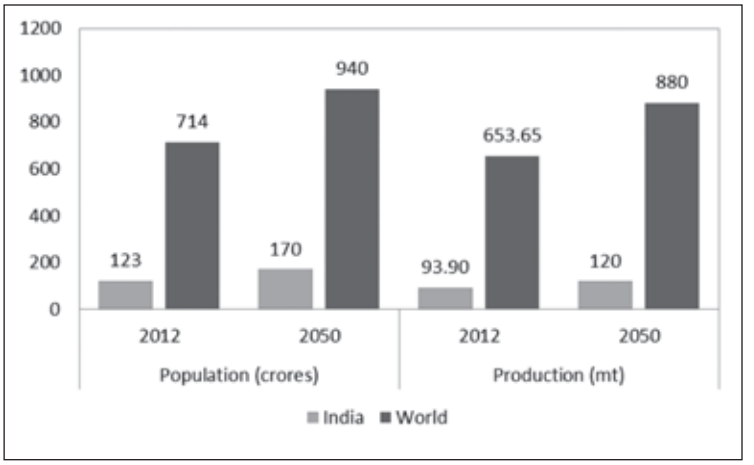
Changes in the staffing pattern

Suggestions of changes in staffing pattern have been given in the recommendations under AICW&BIP.

WHEAT PRODUCTION SCENARIO

Global scenario of wheat

Wheat is an important crop and a principal source of calorie intake for a majority of world population. Global wheat production during 2011-12 was estimated at 667 million tonnes. Among countries, India is the second largest producer of wheat (next to China) followed by USA. It accounts for about 12 per cent of the global wheat production and consumption. Though China and India have a significant share in production, wheat exports arise more from USA, followed by EU-27, Canada, Australia and Russian Federation. The surplus wheat of major wheat producing countries are being imported mainly by Egypt following Brazil, Indonesia, Japan and EU-27. India, however exported 6.5 million tonnes and imported 0.01 million tonnes during 2012. With respect to global productivity in 2012, New Zealand ranks first (8 tonnes/ha) followed by Zambia, Mexico, Switzerland and Chile.

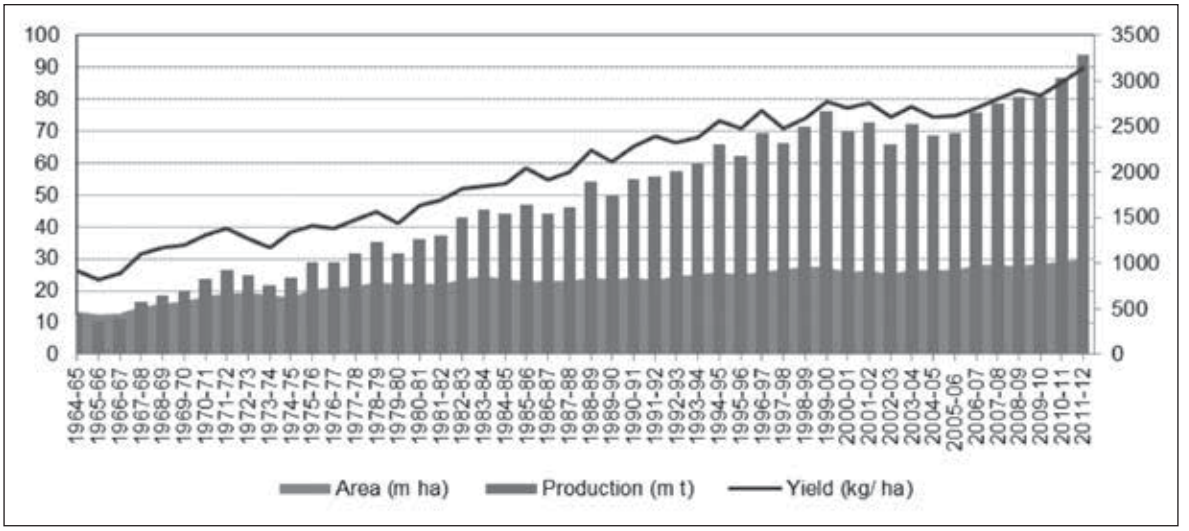


With the rising world population, demand for wheat and wheat based products are increasing globally. Among the countries, China consumes more wheat (123 million tonnes), followed by EU-27, India, USA and Russian Federation. Expecting world population to reach 9.40 billion by 2050, the current wheat production has to reach 880mt by 2050 to feed the population.

Comparison of wheat production by countries (2012)

Indian wheat scenario

India's wheat production exhibited a significant increase since the implementation of AICWIP in 1964-65 and it registered a historic 94.88 million tonnes during 2011-12. The scenario during the past decade has clearly indicated that wheat production has increased to a greater extent despite a marginal increase in crop acreage. For the year 2011-12, the increase in production over its previous year was estimated at 8 million tonnes. This was due to the increase in area by 0.83 million hectares and yield by 152 kg/ha. The increased production in 2011-12 was attributed more to yield increase (9.2%). Yield increase shall be credited to the coordinated research, extension, favourable policies and weather factors. Rise is wheat area has a link with the support price. Under remunerative price (₹12850/ tonne in 2011-12), farmers tend to allocate more area than the usual acreage devoted to a particular crop.



Trends in Area, Production and Yield in Indian Wheat (1964-65 to 2011-12)

Wheat cultivation in India traditionally been dominated by the northern region, wherein states of Punjab and Haryana have been the prolific wheat producers. About 92% of the wheat is produced in six states viz., Uttar Pradesh, Punjab, Haryana, Madhya Pradesh, Rajasthan and Bihar. Among states, Uttar Pradesh leads wheat production (30.29 million tonnes) in 2011-12 followed by Punjab and Haryana. These three states contributed a share of 64 per cent in total wheat production in the country during 2011-12. Uttar Pradesh had the maximum area under wheat (9.73 million hectares) during 2011-12 holding a share of 32.54 per cent to the total area under wheat in India, a factual reason for its high production. Wheat yield in 2011-12 was highest in Haryana (5030 kg/ha) followed by Punjab (4898 kg/ha) and Rajasthan (3175 kg/ha). In case of productivity, the top three states *viz.,* Haryana, Punjab and Rajasthan recorded their historic yield.

Area, Production and Productivity of Wheat in major wheat growing states during last five years

State / Country	Variable	2008	2009	2010	2011	2012
Bihar	A	2163	2158	2193	2104	2170
	P	4450	4410	4571	4098	4787
	Y	2058	2043	2084	1948	2206
Jharkhand	A	86	100	100	96	179
	P	140	154	173	158	335
	Y	1621	1541	1737	1643	1876
Gujarat	A	1274	1091	878	1274	1351
	P	3838	2593	2352	4020	4100
	Y	3013	2377	2679	3155	3035
Haryana	A	2462	2462	2492	2515	2522
	P	10236	10808	10500	11630	12684
	Y	4158	4390	4213	4624	5030
Himachal Pradesh	A	367	360	353	357	357
	P	504	547	327	547	596
	Y	1376	1520	928	1530	1671
Jammu and Kashmir	A	278	279	289	291	289
	P	496	484	290	446	406
	Y	1782	1735	1003	1535	1404
Karnataka	A	276	269	283	255	230
	P	261	247	251	279	194
	Y	946	918	887	1094	843
Madhya Pradesh	A	3742	3785	4276	4341	4889
	P	6033	6522	8410	7627	10580
	Y	1612	1723	1967	1757	2164
Chhattisgarh	A	93	89	112	111	109
	P	99	93	122	127	129
	Y	1059	1040	1086	1144	1186
Maharashtra	A	1253	1022	1081	1307	843
	P	2079	1516	1740	2301	1313
	Y	1659	1483	1610	1761	1558
Punjab	A	3488	3526	3522	3510	3513
	P	15720	15733	15169	16472	17207
	Y	4507	4462	4307	4693	4898
Rajasthan	A	2592	2295	2394	2479	2935
	P	7125	7287	7501	7215	9320
	Y	2749	3175	3133	2910	3175
Uttar Pradesh	A	9115	9513	9668	9637	9731
	P	25679	28554	27518	30001	30293
	Y	2817	3002	2846	3113	3113
Uttarakhand	A	397	398	395	379	369
	P	814	797	845	878	874
	Y	2050	2003	2139	2315	2369
West Bengal	A	353	307	316	317	316
	P	917	765	847	874	884
	Y	2602	2490	2680	2760	2800

Area (A): '000 ha, Production (P): '000 tonnes and Yield (Y): kg/ha

These states productivity coupled with their high area under wheat cultivation helped to achieve the massive output. Further, exceptional and prolonged cool weather throughout the crop season, especially during grain development stage; marginal increase in area; containing yellow rust incidence in north India through active surveillance, issuing timely crop protection advisories and increasing the adoption of rust resistant varieties; organising contingent awareness programme for agricultural department and farmers; and the support and proactive role of state extension machinery under the umbrella of National Food Security Mission (NFSM) have contributed too for the record production of wheat in 2011-12. Despite these factors, only three states in India *viz*., Haryana, Punjab and Rajasthan recorded yield more than the national average (3140.35 kg/ha) during 2011-12 which is a matter of great concern. Haryana surpassed all the states in wheat yield with a historic record yield of 5030 kg/ha which is more than the national average yield by 1889 kg/ha. Karnataka recorded the lowest productivity (843.48 Kg/ha) which is far down from the Indian average by 2297 kg/ha.

Majority of the states have registered increased production during 2011-12 over previous year. It was more in Jharkhand (111.70%), followed by Madhya Pradesh (38.72%), Rajasthan (29.18%) and Bihar (16.83%). Increased area under wheat cultivation attributed more to Jharkhand's wheat production. On the contrary, increased yield (23.17%) contributed more to Madhya Pradesh's wheat production. Wheat production has reduced much in Maharashtra and Karnataka in comparison to 2010-11. Barring Maharashtra, Karnataka, Uttarakhand, Chhattisgarh, J&K, West Bengal and Himachal Pradesh, rest of the states shown an increase in crop area with respect to previous year. Similarly, Maharashtra, Gujarat, Karnataka and J&K registered a decline in wheat yield.

Consumption of wheat in rural India has increased apparently due to the availability of nutritious cereal. The share of wheat in total cereals consumption has increased from 25.43% (3.88 kg/month) in 1972-73 to 37.36% (4.24 kg/month) in 2009-10 (rural India) while a marginal increase from 42.88% (4.82

kg/month) to 43.54% (4.08 kg/month) was observed in urban India. Punjab, Haryana, Madhya Pradesh, Uttar Pradesh and Rajasthan provided maximum wheat to the national grain pool in 2011-12 to feed the growing population through public distribution system, an essential component of food security. These states together constituted more than 90% of the total procurement (38.14 million tonnes in 2012-13 marketing season). The current year procurement was higher by 9.81 million tonnes in comparison with 2011-12 marketing season. Consequent to the surplus production and with a gross consumption of 84.54 million tonnes, India has exported about 6.5 million tonnes of wheat to destinations like Bangladesh, UAE, Pakistan and Afghanistan. However, the country is now grappling with the problem of plenty since already produced wheat and the current stocks gone much higher than the buffer capacity norm.

BARLEY PRODUCTION SCENARIO

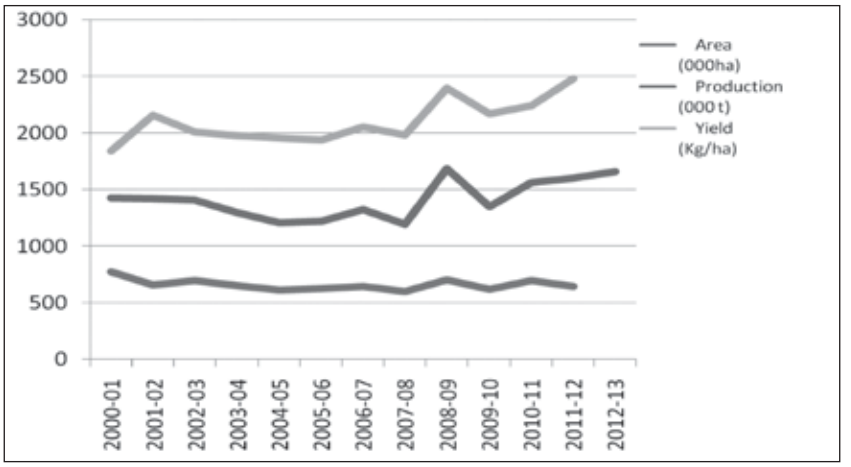
Barley is very adaptable and is a widely grown crop. It is cultivated as a summer crop in temperate areas and as a winter crop in tropical areas. Barley has a short growing season and is also relatively drought tolerant. It has less input requirement as compared to other cereals. However, it is a tender grain and care has to be taken in all stages of its growth and harvest. Barley is used as livestock feed, human food and barley malt. Historically, livestock consumed most of barley produced globally, but this is no more the case, now food and industrial consumption of barley has also become prominent.

Global scenario

The annual global barley production has been in the range of 130-140 million tonnes in the recent years. However, in 2008-09 it is risen sharply around 151 million tonnes. European Union, Russia, Ukraine, Canada, Australia, Turkey and USA are the major producers of barley accounting for around 75% of the total global production, with average production in these regions being around 55, 18, 10, 10, 6, 6, 4-5 million tonnes respectively in the recent years. Following corn, barley is the second largest coarse cereal traded globally. The global trade in barley is reported to be around 17-18 million tonnes, with Ukraine (4-5 million tonnes), Russia (2-3 million tonnes), Australia (2-3) and EU-27 (2-3 million tonnes) being the major exporters. The major importing nations are Saudi Arabia (6-8 million tonnes), China (1-1.5 million tonnes) and Japan (1-1.5 million tonnes. While, Saudi Arabia imports barley mainly for feed, Japan and China import it for both feed and malt production

The global malt production is estimated to be around 22 million tonnes, more than 90% of which is produced from barley. It is estimated that around 94% of global malt production is used for making beer. The EU accounts for approximately 42% of the world's malt production. Consumption is expected to increase by 2% in 2013-14, owing to higher demand for livestock feeding

and from the brewing industry. Stocks in 2013-14 are forecast to rise by 10%, including a 20% rise in export.



Indian scenario

Barley is cultivated as a *rabi* crop in India, with sowing being undertaken from October to December and harvesting from March to May. In Leh and Ladakh and parts of Lahual Spiti area, it is grown in early May to September. India's annual production of Barley was around 1.2-1.5 million tonnes before 2008-09 and increased to 1.54 million tonnes 2008-09 and 1.61 millions tonnes in 2011-12. The estimate of 2012-13 shows the barley production 1.66 million tonnes. The area under cultivation has also stabilized at around 0.6-0.7 million hectares, with a per hectare yield of around 2.4 q. The major producers of barley in the country are Rajasthan (40%), Uttar Pradesh (34%), Madhya Pradesh (8%), Haryana (6%) and Punjab (5%). Some cultivation is also undertaken in Bihar, Himachal Pradesh, and Uttarakhand. In addition, to direct human consumption barley is utilized by the beer industry, food processing industry and feed manufacturing industry in India. Annual demand from beer industry is estimated to be around 3.5-4.0 lakh tonnes.

However, rising demand for beer among India's urban young consumers is leading to increased demand for barley malt from Indian beer manufacturing units. The country's beer consumption in volume terms is projected to grow by

almost 51% percent between 2006 and 2011. During 2001-06, it is estimated to have grown by around 45% to over 907 million litres. India's barley production is projected to increase to around 2 million tonnes in a couple of years to meet the rising demand for barley malt.

The increase in industrial demand of barley as raw material during early nineties resulted in hike in market prices and created a situation of short supply. In fact presently only about 25-30% of the total barley production is used in the manufacture of malt and malt extract, which is further utilized for brewing, distillation, baby foods, cocoa-malt drinks and medicinal syrups. Rest of the production is utilized as cattle feed, cereal food and in preparation of local beverages in the tribal areas. The available six-row barley possessed higher husk and less carbohydrate resulting in poor malting quality. The Government of India has issued license to several new breweries, which created a demand for international quality malt as raw material for the breweries and they are looking for the collaboration/ competition with multinational companies. The same trend is still continues and India is currently having highest growth rate/ increase in demand for beer in the world and several multinational companies have already established their set up in country to cater this demand. Further to promote the cultivation of malting type cultivars, these companies have initiated "Contract Farming" in states like Punjab, Haryana and Rajasthan to ensure continuous supply of the raw material (malt barley grain) to meet the growing demand of malt for brewing and confectionary items. In the era of climate change, where shortage of water and rise in temperature are becoming limitations, barley cultivation can provide a viable alternative to farmers.

SALIENT RESEARCH ACHIEVEMENTS DIRECTORATE OF WHEAT RESEARCH

A. CROP IMPROVEMENT (WHEAT)

Breeding

- In all, 2278 sets of varietal evaluation trials including national initial varietal trials (NIVTs) and advanced varietal trials (AVTs) were proposed, out of which 2155 (94.60% trials) were laid out at more than 120 locations, inclusive of voluntary centers in six mega wheat growing zones of the country. The trial conductance was maximum in NEPZ (97.57%) followed by NWPZ (96.51%) and CZ (95.20%). This three-tier coordinated evaluation process culminated in the release of 43 varieties from 2008 to 2013 for different production conditions. Zonal monitoring of AICW&BIP programme by a team of scientists belonging to crop improvement, protection and resource management was regularly done every crop season during February to April in all the zones. The details of year wise breeding trials coordinated by the DWR are as follow:

Year	2008		2009		2010		2011		2012	
Zone	P	C	P	C	P	C	P	C	P	C
NHZ	54	45	53	48	52	44	46	43	53	51
NWPZ	122	115	127	124	129	126	123	117	130	127
NEPZ	74	71	77	72	73	72	71	71	75	75
CZ	92	88	95	93	96	87	97	89	99	99
PZ	72	70	70	60	72	68	61	58	70	69
SHZ	11	8	12	11	12	12	9	7	11	10
Sp. trials	33	28	28	23	27	24	27	25	25	25
Total	458	425	462	431	461	433	434	410	463	456
% Conducted	92.79		88.74		93.92		94.47		98.48	

- During 2008 to 2013, 43 wheat varieties namely VL892*, HPW251*, PBW550*, WH1021*, HI1544*, HD2932, HI8663(d), DDK1029(dic.), HS490, PBW590, RAJ4120, CBW38, MP1203*, UAS415(d)*, PBW596*, MACS2971(dic)*, VL907, PDW314(d), DBW39, MPO1215(d),

MACS6222, AKAW4627, KRL210, KRL213, HD2985, HD2987, HS507, HI1563, WHD943(d), NIAW1415, DPW621-50, HD2967, WH1080, MP3288, HD3043, UAS428(d), PBW644, TL2969, HD3059, HPW349, HI8713(d), HW5216 and WH 1105 were released through CVRC. Apart from this, 17 wheat varieties were also released through State Varietal Release Committee.

Wheat varieties released through CVRC

Year	Bread wheat	Durum wheat	Dicoccum wheat	Triticale	Total
2008 *	6	1	1		8
2009	6	1	1		8
2010	6	2	0		8
2011	7	1	0		8
2012	4	1	0		5
2013	4	1	-	1	
Total	**33**	**7**	**2**	**1**	**43**

* denotes varieties released during 2007-08.

- So far, 150 germplasm lines of wheat have been developed and registered in NBPGR, New Delhi. Of the thirty-seven namely FLW28*, FLW29*, FLW30*, GW2002-18, GW2002-51, HS424, HS431, LBRL4*, LBRL6*, LBRL1*, VL852, VL876, LBRL11*, LBRL13*, HS492, PHR1011*, PHSL5*, PHSL10*, PHSL11*, HS491, UP2698, AKAW3717, UP2689, WH1063, WH1080, NIAW1342, DDW12*, DBW46*, DBW51*, HTW6*, HTW118*, KBRL76-3, WCF-12-7, WCF-12-19, WCF-12-61, WCF12-208 and DWRL1* germplasm lines registered in NBPGR during the last five years, 18 lines were developed and registered by DWR Karnal. (* denotes line registered by DWR)
- During the said period, 102 applications of bread wheat were submitted by the DWR for registration under PPV&FR Act, 2001, 87 varieties have been registered under extant category.
- DWR has maintained 11,414 wheat accessions in the medium term storage facility (+4^{o}C and RH 30-35%) at Karnal. These include local

collections, identified donors from various national and international nurseries, genetic stocks, released varieties, wild relatives and exotic collection. 8,697 accessions of wheat are also being conserved at Regional station Dalang Maidan under natural cold and dry conditions. During the last five years 3026 wheat accessions were characterized and promising accessions for different agro-morphological traits were identified. During the period under report 125 exotic (USA, Germany Canada etc.) and 522 indigenous wheat accessions from various sources were acquired. Similarly, 5603 and 342 accessions were supplied to various indentors within and outside the country, respectively.

- Under pre-breeding efforts synthetic hexaploids exhibiting resistance to major diseases, heat tolerance, high grain protein, high grain weight and soft texture of grain were identified and utilized in the hybridization programme. This resulted in development and registration of five genetic stocks namely FKW 1, FKW 3 and FKW 3 (resistance to yellow and brown rusts) while FKW 4 (resistance to brown and black rust) and DWRL-1 (lodging resistance with *Rht8* dwarfing and *Lr19* genes). More than 50 cross combinations involving elite released varieties and wild sources *Ae. kotyschii Ae. peregrina, Ae. geniculata, Ae. speltoides, Ae. longissima* and *Agropyron* species are being advanced and backcrossed. The fixed material having yield component traits transferred from *Ae. squarrossa* and synthetic hexaploid wheats are being tested in PYT and DWR station trial. Chinese Spring *Ph1b* wheat genotype was crossed with hexaploid (PBW 502 and DBW 16) and tetraploid (HI 8498) cultivars to transfer the mutant gene into spring wheat background.

- The spring x winter wheat hybridization programme is being carried out at DWR, Karnal in cooperation with VPKAS, Almora. The Spring x Winter Wheat Segregating Stock Nursery (SWSN) comprising crosses in F_2 generation was shared with cooperating centres, namely IARI-New Delhi, GBPUA&T-Pantnagar, NDUAT-Faizabad, BAU-Sabour, JNKVV-Powarkheda, SDAU-Vijapur and JAU-Junagarh. The breeders

at these cooperating centres make selections as per their requirement for yield components, morphological traits, disease resistance and seed characteristics. The 22-100% utilization of the SWSN was reported from different centres. The yield potential of 44 lines produced through spring x winter hybridization programme were tested in the DWR station trials and 13 were promoted to multilocation evaluation in coordinated trials

- Under wheat improvement for northern India, two varieties (CBW 38 and DPW 621-50) were released from this project. Besides, four entries RWP 2006-33, RWP 2006-34, RWP 2006-35 and RWP 2008-23 were confirmed as genetic stock for grains/spike through Short Duration Nursery. A total of 44 entries were contributed and tested in different NIVTs, AVTs. About 25 promising early maturing genotypes identified with high yield in different zones.
- Under wheat improvement for eastern India, a set of 51 lines showing high degree of resistance to HLB was shared with 34 centres across the four zones. 23 entries showed high degree of resistance against HLB disease even at third and final stage of disease recording. Recombinant Inbred Lines (RILS) was developed for spot blotch resistance by involving contrasting parents (HUW 234 /YM # 6, Kanchan/Chirya 1 and Sonalika/ BH 1146). The material was screened under high inoculum load of HLB at DWR, Karnal. In all 104 lines were found resistant, while 287, 223 and 111 were found moderately resistant, moderately susceptible and susceptible, respectively. A set of RILs (728 lines) in F_8 generation was evaluated at seven locations under natural field conditions to select promising and widely adapted model genotypes having HLB resistant.
- In hybrid wheat research, the CMS lines having cytoplasm from *Triticum timopheevi* were developed, maintained through controlled pollination and diversified in new agronomic backgrounds of bread wheat. During the reporting period, more than 280 stable and promising male sterile lines have been developed/ maintained and more than 150

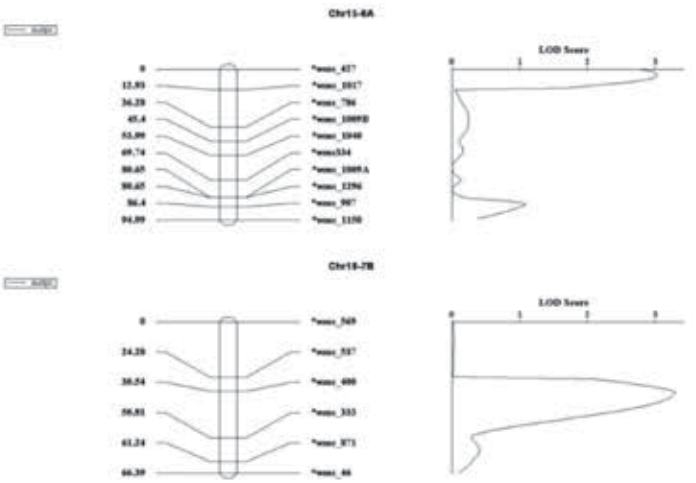
CMS lines in different agronomic backgrounds are in pipeline. Over the years approx. 400 hybrid combinations were made and evaluated but standard heterosis of more than 20% for grain yield was observed only in few combinations. In addition, 156 genotypes were studied for four floral biology traits namely, anther length, stigma length, anther extrusion and openness of the florets and promising genotypes were identified for further utilization in parental diversification programme.

Wheat Physiology

- During the period 2008-2013, 238 genotypes including checks were screened for drought tolerance at 10-12 locations by sowing under irrigated and rainfed conditions. Of these, HI 1564, KLP 787, KO 624, KO 623, AKAW 4630, RS 1002, WSM 1472, RS 1017, RAJ 4083, KLP 1042, K 0624, GW-09-264, HI 1581, AKAW 4705, KLP 1043, GW-09-270, RAJ 4128, AKAW 4730, NWL-9-15, HI 1580, KLP 3077, KYP 0826 and RAJ 4258 had low drought sensitivity index
- Out of 136 genotypes evaluated for heat tolerance by sowing under timely and late sown conditions at 7-11 locations for three years, genotypes RAJ 3765, HW 2004, WH 1022, LOK 54, HW 2045 and RAJ 4101 were found less sensitive to heat stress. Genotypes MP 4106, HI 977, HD 2997, PDW 315, PBW 590, HD 2864, HD 2985, PBW621, HI1563, HI 1571, HI 1563, UAS 320, HD 3040, MP 3304, UAS 428 and LOK 62 were found less sensitive to thermal regimes.

Biotechnology

- Marker assisted selection programme was undertaken to bring the target rust resistance genes particularly leaf rust and stripe rust into the elite background. The combinations of *Lr35 & Lr37, Lr24 & Lr35, Lr24 & Lr37* and *Lr28 & Lr37* genes were made in the background of variety Lok1. Similarly, the gene combinations of *Yr15 & Yr10, Lr35 & Lr37, Yr10 & Lr35* and *Yr10 & Lr37* were made in the background of HUW234.



Linkage map and LOD score for selected chromosomes

Presently, the effective genes are being transferred in several advanced varietal trial entries and some of the lines are under the preliminary yield trial (PYT) stage.

- A QTL map was generated using 204 SSR markers and data on AUDPC for stripe rust resistance in 99 Recombinant Inbred Lines from the cross HI 977 x HD 2329. Two QTLs located on chromosome 6A (4.0 cM, flanked by wms 427 and wms 1017) with a LOD score of 3.03 and phenotypic variance 15.4%, another on 7B (31.cM, flanked by wms 400 and wms 333) having LOD score of 3.3 and phenotypic contribution as 12.7 %.

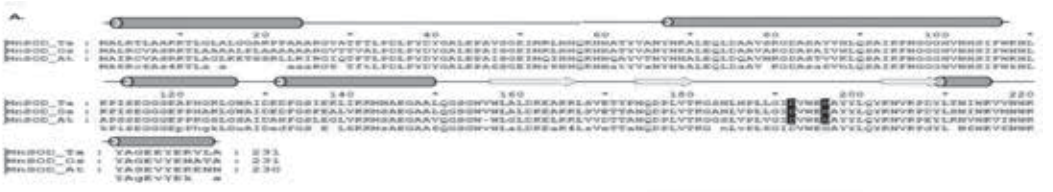
- A mapping population from the cross PBW343 /Capelle Desprez developed for the identification of markers linked to the stripe rust resistance. Both phenotypic and genotypic data were generated. Single marker-trait association provided only limited information, therefore a dense map using SNPs and DArT is being developed for identification of utility QTLs.

- A set of 111 recombinant inbred lines (RILs) derived from Raj4014 (a heat sensitive genotype) and WH730 (heat tolerant cultivar) showed clear-cut segregation pattern for differences in grain filling rate (GFR)

at timely and late sown conditions. 300 SSR (μsatellite) markers out of which 25% were polymorphic in parental line were used to study the association of GFR trait with gene/QTL markers. This study revealed that, PSP3094, one of the markers reported earlier for QTL associated with grain development, could explain genetic variation in dGFR in RILs.

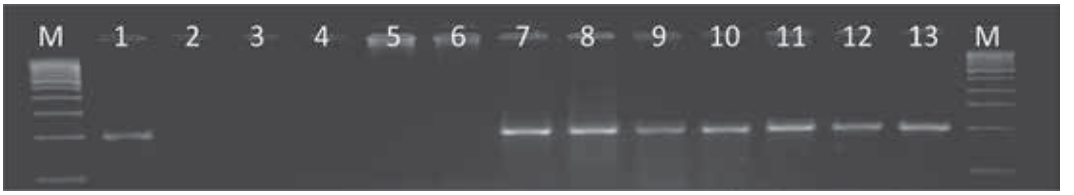
- The expression profile of antioxidant enzymes-Superoxide dismutase (SOD), Catalase (CAT) and Ascorbate peroxidase (APX) was studied using *in silico* approach. Phylogenetic analysis revealed that in SOD, CAT and APX, three major families of signature were found commonly and some unique families were present in particular antioxidant and its isozymes like, AMP_PHOSPHO_SITE in mitochondrial MnSOD and FeSOD, TYR_PHOSPHO_SITE in catalase and CAMP_PHOSPHO_SITE in ascorbate peroxidase having significant function in relation to oxidative stress.

Amino acid sequence alignment of antioxidant protein Mn-SOD in selected plants. Alpha helices and beta strands are represented as rods and arrows. Conserved metal binding residues in plants



are shown by shaded region.

- Attempts were made to identify single nucleotide polymorphism (SNP) and to differentiate the heat tolerant and heat susceptible genotypes of wheat using HSP16.9 as the target gene. DNA fragment covering a partial sequence of *Triticum aestivum* HSP16.9 were amplified from heat

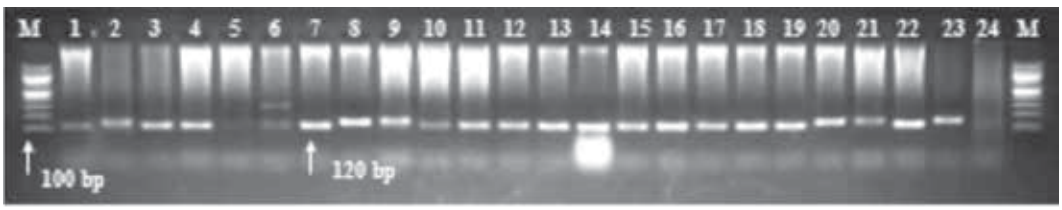


PCR analysis using the SNP marker Lanes: 1- RAJ 4O14, 2- K 7903(Halna), 3- PBW 502, 4- K 9107, 5- HD 2329, 6-K 9465, 7- WH 147, 8- PBW 175, 9-WH 542, 10- HUW 510, 11- HD 2733, 12- HD 2687, 13-VL 616, M. DNA ladder 100bp.

tolerant and heat susceptible genotypes, and subsequently analyzed for the presence of SNP. One SNP was found between the genotypes based on which a PCR primer was designed to develop an allele-specificity at 3¢end. Single-marker analysis explained 29.89% and 24.14% phenotypic variation for grain weight and thousand grain weight respectively.

- The dimeric α-amylase inhibitors isolated and characterized from three Indian bread wheat genotypes NP 715, C 281 and NI 234 having 95% homology with the other dimeric *a*-amylase inhibitor gene sequences available at GenBank database. Sequences were deposited in GenBank (Accessions: JN051659-61).

- The *Sr*2 complex is known for slow rusting and provides partial resistance against stem rust of wheat. With a view to help the breeders in incorporating resistance against stem rust, a set of 135 prominent varieties from northern, central, peninsular and southern hill regions were screened, out of which *Sr*2 was confirmed in 92 varieties. The molecular data was confirmed with the available seedling resistance



Amplification pprofiles of Indian wheat varieties for Sr2 gene with molecular marker GWM533. M: 100b ladder, 1: Hope, 2: DL788-2, 3: GW10, 4: GW89, 5: GW18, 6: GW89, 7: GW190, 8: J24, 9: PBN51 Amplification profiles of Indian wheat varieties for Sr2 gene with molecular marker GWM533. M: 100bp, 10: DWR16, 11: DWR162, 12: HD1925, 13: HD2189, 14: HD2501, 15: K9644, 16: NI747-9, 17: PBN142, 18: Vinita, 19: HW741, 20: HI385, 21: HI617, 22: HI1077, 23: HI1418, 24: HW2004

test (SRT) to evaluate the efficacy of respective molecular marker.

Seed production programme

- During last five years, a total of 164457q breeder seed of around 157 wheat varieties was produced by different centres against a DAC indent of 135907q. For 2012-13, an allocation of DAC indent of 21074.40q

breeder seed of 147 wheat varieties was received. The details of year wise indent and production of breeder seed are presented below:

Year	Variety in seed chain	DAC Indent (q)	Breeder seed production (q)
2008	138	21460.56	26179.23
2009	148	23215.04	29013.96
2010	152	32380.99	35049.11
2011	145	29691.60	38469.44
2012	157	29159.55	35744.93
2013	147	21074.40	-

B. RESOURCE MANAGEMENT

- During 2008 to 2013, a total of 633 trials were conducted on different agronomic aspects (sowing time, restricted irrigation, nitrogen levels, and rainfed conditions). The AVT 2nd year entries (*T. aestivum* and *T. durum*) were tested at different dates of sowing in different zones which indicated that delaying the wheat sowing (normal to late) significantly decreased the yield in different zones for timely sown varieties. For addressing different zone wise issues (Conservation Agriculture practices, weed management, nutrient management, heat stress, water use *etc*.), 277 special coordinated trials on various aspects of production technology were conducted for multilocational evaluation in different zones during last five years under AICW&BIP network.
- In Mn deficient soils, two sprays of 0.5% MnSO4 at 40-45 DAS and 55-60 DAS should be applied for higher productivity.
- It is a must to apply recommended NPK for the higher productivity and sustainability of wheat production, since, on the basis survey, it has been found that farmers are applying 196 kg N/ha, 57 kg P/ha and only 4 kg K/ha, which comes to NPK ratio of 49:14:1 instead of recommended ratio of 4:2:1.

- Organic manuring alone (50% to 125% of equivalent N) recorded 10 to 40% yield reduction in wheat in NWPZ and CZ as compared to recommended inorganic fertilisation.
- In boron deficient soils of NEPZ, application of 10 kg/ha Borax as a basal dose gives better productivity. The recommendation was based on the experiments conducted at three locations in the NEPZ i.e. IARI Pusa, Sabour and Ranchi for two years.
- For enhancing the system productivity, intensify rice-wheat system by including zero till sown short duration summer green gram after wheat or zero till sown short duration vegetable pea after rice.
- For control of complex weed flora in wheat, apply ready-mix sulfosulfiuron 25%+carfentrazone-ethyl 20% 45 WDG at 45 (25+20) g ai/ha with cationic surfactant of 625-750 ml/ha at 30-35 days after sowing.
- For higher profitability and sustainability of the rice-wheat system, direct seeded rice followed by wheat with rice residue incorporation or surface retention and application of 25% additional nitrogen, should be practised.
- Grow summer green gram or cowpea after wheat or vegetable pea after rice followed by late sown wheat in rice-wheat for greater system productivity, profitability and sustainability. For higher productivity of pulse crops, grow green gram, cowpea and vegetable pea under bed planting or zero tillage.
- Surface residue retention of 4 t/ha with four irrigations should be practised for higher wheat productivity and water use efficiency (15-20%) in North Western Plains. This is based on two years data for three locations (Karnal, Ludhiana and Pantnagar).
- In soybean-wheat system of Peninsular India, application of Farm Yard Manure (3.75 t/ha) and vermicompost (1.25 t/ha) in addition

to recommended NPK in wheat and 75% of recommended NPK and any of the organic source (FYM 7.5 t/ha or vermicompost 2.5 t/ha or FYM 3.75 t/ha + vermicompost 1.25 t/ha) in soybean gives higher system productivity. This is based on three years data of two locations (Dharwad and Niphad).

- Dry seeding immediately followed by irrigation cannot be practised in north western and north eastern plains and the present practice of seeding after pre-sowing irrigation under conventional or zero tillage should be followed for higher yield. This is based on two years data of 3 to 4 locations (Karnal, Ludhiana, Pantnagar and Varanasi)

- The optimum sowing period being followed for many years in NEPZ was 47 (19-25 Nov) Julian week. The Resource Management group thought it to be a bit late and conducted special coordinated trial with three periods of sowing i.e. 45 (5-11 Nov), 46 (12-18 Nov) and 47th Julian week at nine locations. Based on two years data the 46th Julian week was found optimum for maximizing wheat productivity.

- The experiment on row to row spacing was conducted in all the wheat growing zones (3-5 locations in NHZ, 7-8 locations in NWPZ, 3-11 locations in NEPZ, 3-9 in CZ and 3-4 locations in PZ). The row spacing treatments were 15, 17.5, 20 and 22.5 cm. Based on two years data the optimum row to row was 17.5 cm in NHZ, 17.5 to 20 cm in NWPZ, 15-17.5 cm in NEPZ and CZ. The narrow spacing also helped to reduce the weed infestation. Therefore the row spacing needs to be reduced for higher productivity.

- For higher wheat productivity in Peninsular Zone, apply two sprays of 2% NPK (19:19:19) mixture or DAP at 55 and 70 days after sowing.

- In cotton-wheat system, the productivity of wheat is low due to delayed sowing. Relay wheat crop by broadcasting in standing cotton at the time of last irrigation to cotton to improve the productivity. This is based on two years data of Ludhiana centre.

- Zero-tillage (ZT) can be adopted for economic wheat production as it produces similar wheat yield to conventional tillage and saves more than 90% diesel and time along with lowest energy requirement. However, it gives significant yield gain when time of late sown wheat is preponed due to adoption of zero tillage. Bulk density was marginally higher in ZT & STD (strip till drill) and lower in rotary and FIRB system of wheat cultivation.
- The Rotary till-drill facilitates direct wheat sowing without prior field preparation as it pulverises the soil with simultaneous seeding of wheat. This technology gave 5-10% higher yield over conventional tillage (CT) system in multilocation evaluation and saves more than 85% diesel and time. Higher yield in rotary tillage was due to initial crop vigour reflected in higher leaf area and root length index compared to other tillage options which made it most profitable.
- Furrow Irrigated Raised Bed-planting System (FIRBS) helped in economising on seed and fertiliser especially nitrogen and also helped in easier (mechanical) weed control. Less *Phalaris* population was observed in this system. This also save irrigation water by about 25-30% compared to flat planting. This technology also showed promise at farmer's field for wheat- sugarcane inter-cropping system. However, it is more conducive for growing pulses and oilseed crops. This technology can be explored for inter cropping of wheat with sugarcane or sugarcane with many other vegetable crops.
- The rice crop growth was affected mainly by the tillage options in rice whereas the tillage in wheat has not much effect. Puddling (Wet tillage) may not be required and dry field preparation followed by ponding of water and transplanting may be a better option, in soils having low infiltration, to avoid the destruction of soil structure by wet tillage for puddling. The wheat crop yield was not affected by tillage in rice but tillage in wheat had marginal differences in yield. The highest yield

was recorded in rotary tillage followed by almost similar yield in zero and conventional tillage.

- The direct seeded rice yield under various residue management options in rice wheat system was 4 to 22 per cent lower than the puddled transplanted condition with lowest yield when residue of both wheat and rice crops was burnt. The yield reduction in residue incorporation treatments was 4 to 9 per cent and that of surface retention was 11 to 15 per cent whereas burning crop residue lead to yield reduction of 12 to 22 per cent.
- The soil organic carbon percentage increased with residue retention and incorporation whereas burning of crop residue resulted in decreased soil organic carbon status of the soil.
- Surface residue retention had favourable effect on wheat productivity with saving of 1 to 2 irrigations. The surface residue retention can help mitigate the moisture stress and may be useful in mitigating the climate change effect by moderating the soil and crop canopy temperature.
- The optimum N use can be made by matching the supply with crop demand. In many field situations, up to 50% of applied N is lost due to the lack of synchrony of plant N demand and N supply. In the past, the timing of fertilizer to best match demand with supply has been based on blanket regional recommendations. However, large spatial (field to field N supply capacity of the soil) and temporal (year to year) variations contributes to the inefficient use of applied nitrogen. Moreover, most of the times, farmers apply fertilizer N much higher than the blanket recommendations to ensure high yields. Efforts were made using leaf colour charts and normalized difference vegetation index (NDVI) sensors to apply need based N to the wheat and rice crops. The agronomic efficiency of applied nitrogen to wheat using LCC and NDVI sensor was much higher (24 to 26 kg grains/kg of applied nitrogen) than the blanket recommendation of 150 kg N/ha

(around 20 kg grains/kg of applied nitrogen). However, hand-held NDVI (GreenSeekerTM optical) sensor offers distinct advantage over leaf colour charts and SPAD meter by being quantitative compared to qualitative evaluation. The experimental results over the past few years showed nitrogen savings of more than 15% in wheat and more than 20% in rice without any yield penalty.

- Nitrogen use efficiency was found more when fertilizer was applied in three splits doses i.e. 1/3rd basal at sowing, 1/3rd at first irrigation (20-25 days after sowing-DAS) and 1/3rd at second irrigation(40-45DAS) in wheat. Urea top dressing just before irrigation was better than its top dressing after irrigation when field comes in condition (8-10 DAS).

- Direct seeded rice grown either in flat or in bed, with and without residue under either basal or split N application was found inferior to transplanted puddled rice. The wheat yield was maximum at 150 kg N application (1/3 + 1/3 +1/3) in residue removal as well as residue retention condition.

- The organic production of rice and wheat indicated at par productivity of basmati rice cultivar PB 1 and wheat cultivar C 306 with application of FYM 30 ton or more/ ha, as compared to inorganic fertilizer indicating that low nutrient requiring cultivars will fit better in organic rice-wheat cropping system. Integration of green manuring or 15 tons of FYM with recommended doses of fertilizers (150:60:40 kg N, P_2O_5 and K_2O/ha) was found the best nutrient management combination followed by sulphur at 7-10 kg (Reap 90 WDG)/ha + micronutrients (Zn, Fe, Mn, Cu and B) as foliar spray (0.1 – 0.5%) with recommended doses of NPK fertilizers, for rice-wheat cropping system in long term field experiment.

- The intensification of rice-wheat system by inclusion of green gram and cowpea after wheat and vegetable pea after rice under three tillage (zero tillage, bed planting and conventional tillage) options gave higher equivalent wheat yield compared to rice-wheat system. The highest

wheat equivalent yield was recorded with rice-wheat-green gram sequence. Growing summer green gram avoids excessive pumping of water for growing summer rice with benefits of increasing pulse production and reducing nitrogen requirement to succeeding rice crop by about 25%. Continuous inclusion of green gram or cowpea in rice-wheat system will be sustainable with improved soil physico-chemical properties. Additionally, vegetable pea grown between rice and wheat, a short duration catch cum cash crop, will provide a higher income to the rural population around cities.

- The efficacy of sulfosulfuron + carfentrazone was significantly improved when applied with surfactant.
- Soil mixed with ash resulted in reduced efficacy of the herbicides (isoproturon, pendimethalin and pyroxasulfone). For sustainability of rice-wheat system, instead of burning, residue should be retained on surface. Sulfosulfuron is effective against both grassy and non-grassy weeds. Its application before or after first irrigation was found effective in ZT. Tank mix application of sulfosulfuron with metsulfuron or isoproturon with 2,4-D or metsulfuron were effective for the control of complex weed flora. Metsulfuron @ 4.0 g/ha and carfentrazone 20 g/ha were found effective against broadleaf weeds. Tank mix combinations of clodinafop and Fenoxaprop methyl with 2,4-D and metsulfuron were antagonistic.
- Early sowing of wheat (Last week of Oct.) reduces *P. minor* population compared to normal and late sown. Less *P. minor* population were observed in zero tillage compared to conventional because seeds lying in lower layers do not come in the upper layer.

Phalaris minor- a noxious weed of wheat

- *Phalaris minor*, a noxious weed of irrigated wheat in NWPZ had evolved resistance to isoproturon leading to heavy yield reduction. During past few years various herbicides were evaluated for its control and pinoxaden (35-40 g/ha), sulfosulfuron (25g/ha), clodinafop (60 g/ha) and fenoxaprop (100-120 g/ha) were found effective for the control of resistance biotypes of this weed and among these clodinafop, fenoxaprop and tralkoxydim are specific to grasses. However, the continuous use of these alternative herbicides has also resulted in the evolution of multiple herbicide resistance in this weed.

- Littleseed canarygrass (*Phalaris minor*) have evolved multiple herbicide resistance across three modes of action [Photosynthesis at photosystem II site A, ACCase (acetyl-coA carboxylase) and ALS (acetolactate synthase) inhibitor]. This resistance is the major threat to wheat production. Quantification and characterization of herbicide resistance revealed that some of the populations had GR50 (50% growth reduction) values for clodinafop > 12 times higher than that of the most S (susceptible) population. Population resistant to clodinafop exhibited cross-resistance to fenoxaprop (fop group), tralkoxydim (dim group) and pinoxaden (den group). Similarly, population resistant to sulfosulfuron showed cross-resistance to mesosulfuron and pyroxsulam. However, the populations resistant to six groups (phenyl urea, sulfonyl urea, aryloxyphenoxypropionic, cyclohexene oxime, phenylpyrazole and triazolopyrimidine sulfonamide) were susceptible to triazine (metribuzin and terbutryn) and dinitroaniline (pendimethalin) herbicides. Moreover, the multiple herbicide resistant populations showed sensitivity to glyphosate and paraquat. Yield reductions due to multiple herbicide resistant populations can be contained with pre-seeding application of glyphosate and paraquat in combination with pendimethalin or terbutryn in zero-till wheat. The long-term resistance management strategies should include the integration of chemical and non-chemical means of weed management.

C. CROP PROTECTION

The success of the crop protection programme may be envisaged from the fact that there were no major wheat losses due to rusts in India since last 34 years when neighboring countries and countries like United States of America faced rust epidemics.

- Crop health was rigorously monitored during the crop season as well during the off season in the high hills of Himachal Pradesh (Lahaul-Spiti and Kinnaur), J&K (Laddakh) and Nepal hills. Since 2006-07, the stripe rust is occurring in high intensity in one or the other parts of NWPZ and NHZ. Due to congenial weather for stripe rust, two pathotypes 78S84 (*Yr27* virulence, virulent on PBW 343) and 46S119 (*Yr9* virulence) dominated during 2008-13 crop seasons and most of the varieties grown in NWPZ became susceptible. Except for the yellow rust in NHZ and NWPZ, the overall crop health was satisfactory. Policy decision of integrating fungicide spray alongwith deploying resistance and withdrawing susceptible genotypes, awareness campaigns to the farmers through specially designed pocket card and other literature were the major key factors in restricting the stripe rust below economic threshold levels in high disease prone areas. Disease situation in other zones of the country was very comfortable with no report of any serious out break from anywhere. Wheat Crop Health Newsletter was issued every month during the crop season during 2008-2013.

- The host resistance is the main thrust for the management of biotic stresses in a most economic and acceptable manner. During the last five years, more than 12,000 entries of wheat were evaluated in the form of various nurseries.The materials flow through EPPSN, MDSN and the final products go into NGSN where more than 230 entries were contributed in the last five years from this programme. These entries possessed multiple disease and insect pest resistance. Advance entries including checks of AVTs' were also evaluated for stem rust (Ug99) resistance at Kenya and Ethiopia during 2008-2013.

- The post-harvest grain sampling and analysis of grain samples was done for monitoring the status of Karnal bunt (KB) and other seed-borne maladies like black point and discoloration and ear cockle nematode

were also monitored. Based on these analyses, the 'low risk zone', 'high risk zone' and 'no risk zone' have been identified for KB.

KB infected wheat grains

KB in mature spike

Disease	Total samples analysed					
	2008	**2009**	**2010**	**2011**	**2012**	**Total**
Karnal bunt	7764	6126	9564	7778	9280	40512
Black Point	4851	4632	6193	4626	4133	24435
Discolouration	1458	2477	1841	659	2210	8645

- Pathogenic and molecular variation among *Fusarium* spp. causing head scab of wheat and *Tilletia indica* isolates causing Karnal bunt of wheat was studied on a set of wheat varieties and through molecular markers.
- Artificial infection assays using paired monosporidial lines (MLs) in form of sporulating mycelia raised from haploid allantoid sporidia isolated from teliospores collected from various places in the states of north west India revealed 8 mating types (self incompatibility alleles) in this heterothallic fungal pathogen of wheat. Representative MLs of 8 alleles when paired in all possible combinations and inoculated on a set of differential lines produced host – pathogen – interaction matrices of 6 distinct pathotypes designated as KBP1 – KBP 6.

- The entries identified as confirmed sources of resistance to leaf blight caused by *Bipolaris sorokiniana* and *Alternaria triticina* were contributed in NGSN. Since 1997-98 till 2009-10 crop seasons, a total of 107 leaf blight resistant genotypes of wheats (*Triticum aestivum, T. durum* and *T. dicoccum*) and Triticales have been contributed in NGSN. During 2008-10 crop seasons, a total of 724 numbers of leaf blight samples were collected from. On an average basis, amongst leaf blight pathogens, *Bipolaris sorokiniana* was predominant (41.1%) at national level.

Pathogens isolated in blighted samples during 2008-10 crop seasons in different agroclimatic zones in India

Zones	Total samples	Per cent occurrence			
		B. sorokiniana	***A. triticina***	***A. alternata***	***P. tritici repentis***
NHZ	39	31.0	4.0	51.7	20.6
NWPZ	235	40.2	18.0	63.2	12.1
NEPZ	183	54.7	8.7	33.7	28.8
CZ	72	49.9	11.3	64.4	21.3
PZ	173	40.7	7.0	41.5	32.6
SHZ	22	30.0	2.5	50.0	0.0
Av.	724	41.1	8.6	50.8	19.2

- Pest system has been found to be influenced by the tillage system. Powdery mildew incidence was found to be the highest under FIRBS and the lowest under zero tillage. Foliar aphid population was the lowest under FIRBS and at par under zero and conventional tillage. Termites and root aphid were also more under FIRBS, while these were the least under zero tillage among the three tillage systems, *viz*. Zero, conventional and FIRBS.

D. QUALITY IMPROVEMENT

The increase in domestic demand of baked & pasta products and economic liberalisation & global trade have offered opportunities for better utilization of

wheat. Wheat quality needs uppermost attention to meet the trade requirements of the domestic and international markets.

- The quality requirements of wheat for various products like chapati, bread, biscuit and pasta are different. Hard wheat (*T. aestivum*) with strong & extensible gluten and high protein is required for making good bread. For biscuit, the quality requirements are soft wheat, low protein and weak & extensible gluten; whereas for chapati, we need hard wheat, medium to high protein and medium & extensible gluten. For pasta products, we need hard wheat (*T.durum*) with strong gluten, high protein, low yellow berry incidence and high β-carotene content are required.
- During 2008 to 2013, more than forty eight thousand (48000) AICW&BIP wheat grain samples of AVTs, NIVTS, IVTs, Special Trials & QCSN were analysed and product specific wheat varieties were identified for chapatti, bread, biscuit and past products.

Promising genotypes for various wheat products

Wheat Products	Genotypes
Chapati	C 306, PBW 175, HI 1500, HI 1531, HI 1563, HI 1571, K 8027, HD 2864, HD 2888, NIAW 1415, Lok 1, Lok 62, HW 2004, Raj 4120
Bread	HI 977, HD 2189, HD 2781, HD 2864, K 9107, K 0307, MACS 6222, NW 2036, NIAW 34, NI 5439, NIAW 917, NIAW 1415, Raj 4083, PBW 639, Lok 1, Lok 62, WH 1021, WH 1080
Biscuit	Sonalika, HS 490
Pasta	HI 8627, HI 8663, HI 8703, PDW 233, PDW 314, WH 896, WHD 943

Promising genotypes were identified for individual quality parameters in both for *T. aestivum* and *T. durum*. Different quality parameters have shown wide variability.

Variability in quality and nutritional parameters

Parameter	*T. aestivum*		T. durum	
	Mean	Range	Mean	Range
Test Weight (kg/hl)	79.6	69.5-84.6	81.9	75.4-84.8
Protein content (%)	12.5	7.4-18.9	12.7	8.7-17.9
Grain Hardness index	74	18-100	77	48-100
Sedimentation (ml)	45	30-68	30	17-41
Yellow Pigment (ppm)	3.13	1.89-5.11	5.05	3.61-7.51
Iron content (ppm)	34.3	23.5-47.3	33.7	22.2-44.1
Zinc content (ppm)	31.0	21.3-43.5	32.4	23.6-41.1

- One thousand and thirty three (1033) AVT entries including checks were evaluated for High Molecular Weight Glutenin Subunits (HMWGS).

Use of molecular marker technology in Wheat quality improvement

- RILs (175 for HI 977 X HD 2329) for bread quality grown at three agro-climatically different locations viz. Karnal (NWPZ), Kota (CZ) and Pune (PZ) were analysed for various quality parameters and baking evaluation of bread. Genetic analysis of quality traits was carried out to identify recombinant inbred lines. These RILs were evaluated for bread quality score components like loaf volume, stickiness, appearance, crust colour, crumb colour, texture, taste and aroma.

- HI 977 X HD 2329 population was screened with HMWGS *Ax2*, 1Dx5, 1Dy10/1Dy12, 1Dx5, & 1Dy10/D1Dy12, LMWGS Bx7/Bx17, By8, By9, Glu-A3a, Glu-A3-(a,b, c), Glu-A3 (a,c), Glu-A3d, Glu-A3e, GluD3-21/22, GluD3-22, GluD3-23, GluD3-32, γ-gliadins GliA1.1, GliA1.2, GliB1.1, GliB1.2, GliD1.1, GliD1.2, Pin-a AND Pin-b, wild type (Wx-B1a)* and null alleles of the *Wx-B1* gene, wild type *(Wx-D1a)* and null alleles of the *Wx-D1* gene, wild type *Ppo-D1a and Ppo-D1b genes,* wild type *Ppo-A1a* and *Ppo-A1b* genes and *1BL/1RS* translocation. Prospecting 42 released wheat varieties for allelic variation for HMW & LMW glutenins, γ-gliadins, *1B/1BR* translocation, *Ppo loci, PinA-D1 and PinB-D1u* using Molecular Markers. MBL 2 and MBL 5 were registered as genetic stocks for high protein content.

- In association with NCL Pune, large number of STMS, SSR & ISSR primers were used for parental screening and whole population was screened using polymorphic markers. Association of markers with various quality traits on different chromosomes was ascertained. Environmental interaction through differential accumulation of various gliadin proteins with the help of RP-HPLC was studied. Framework map was constructed and QTL analysis for bread loaf volume and bread quality in wheat was carried out. QTLs analysis of mixographic traits was done.

Evaluation of Elite Germplasm for quality using molecular techniques

- During the year 2010-11 to 2012-2013, 206, 205 and 118 lines belonging to NGSN, EIGN-I and EIGN-II were grown at DWR, research farm, Karnal. All the lines of these three nurseries were analysed for processing (test weight, protein content, sedimentation value, grain hardness index, wet gluten and dry gluten) and nutritional (yellow pigment, iron, zinc, copper and manganese) quality parameters. Based on the quality analysis, selected samples were analysed for evaluating wheat products like chapati & bread using molecular techniques. Promising lines were identified for their utilization in the quality breeding programme.

Attempts towards developing product specific varieties

- **Genetic resource for protein content:** Efforts were made to identify protein rich wheat material. After four years performance, QLD 11 was identified for protein content. QLD 11, an entry from DWR, Karnal, is an exotic selection 'MURGA' picked from 15th HRWSN.

- **Development of high protein advance lines:** Every year, 300-400 crosses were attempted and examined for grain protein content in the F_1 itself. Crosses excelling in protein content were detected very early. Combination with GPC 14.5 to 18.0% (at 14% grain moisture), could be noted in the F_1 harvest. Transgression for this quality component could also be noted frequently.

- **Genetic resources for gluten strength, hard and soft grain textures:** Search for soft grain texture was also started to improve biscuit quality of Indian wheat's. Through germplasm screening, sources for high sedimentation value (60-65ml), high grain hardness index (100-114) and low grain hardness index were identified (14-30). Through QCSN, QLD 28 was identified for grain softness and QLD 31 for high sedimentation value. A derivative developed at DWR, namely QLD 49, has GHI as low as 14 and is being tested in the QCSN for wider adaptation.

- **Genetic resource for good product quality:** Four genotypes excelled with score ≥8.5. In bread quality, 73 genotypes including 51 exotic selections had loaf volume in the range of 600–690cc. Nine entries including 8 exotic selections had loaf volume ≥650cc. Excellent bread score (≥8.5), was noted in nine genotypes.

- **Derivatives of enriched product quality:** Some derivatives of improved end-product quality with high yield have reached advance stage of testing. Four of them have reached NIVT's of the Indo-Gangetic plains and another six are chosen for testing during 2012-13.

- **Germplasm sharing:** The genetic resource and the high valued advance derivatives are shared with the co-operators through QCSN. During past four years, 200 F_1 bulks and 54 F_2 bulks were provided to warmer area wheat breeding programme.

- **Role of glutenins in imparting dough strength:** High and low molecular weight glutenin subunits are the major determinants of gluten strength and extensibility. More than 300 wheat varieties released during the last 100 years were evaluated for HMW glutenin subunits using SDS-PAGE technique. t-test analysis was employed to identify the relationship between different glutenin subunits including various combinations and quality traits. This also shows that HMW glutenins subunit 7 can be used as markers in the improvement of biscuit making quality and 17+18 for bread making quality.

- **Allelic characterization of low molecular weight glutenins using molecular markers:** In the present investigation more than 200 varieties of bread wheat in India were characterized for low molecular weight (LMW) glutenins using SDS-PAGE and allele specific polymerase chain reaction (PCR) to assess allelic diversity and their utility for correctly identifying different alleles. Genes representing *Glu3* alleles with lesser consistency have been cloned to develop allele specific primers with greater consistency and having greater utility in germplasm evaluation and breeding.

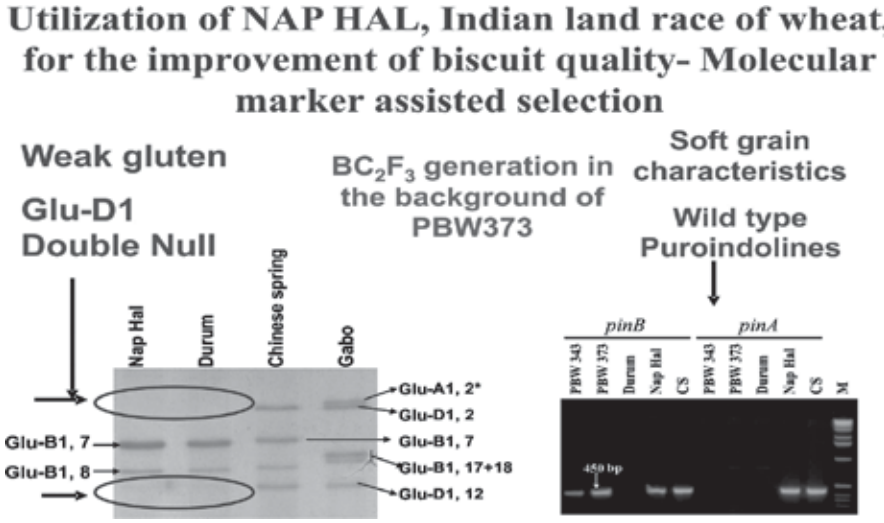
- **Microlevel test for gluten strength (40 mg test):** Swelling index of gluten (SIG) is an alternative test for determining gluten strength in wheat and it is related strongly with the gluten strength. It involves the hydration of flour samples with SDS-lactic solution followed by centrifugation. In this investigation strong relationship was observed between SIG and micro-sedimentation test ($p<0.0001$). In durum samples it showed even stronger relationship with sedimentation value ($R^2 =0.63$). The results also indicated that the SIG test, strongly correlated to mixograph dough development time and alveograph W index.

- **Microlevel test for noodle quality:** In the present investigation, large variations were observed in flour swelling power (FSP) of Indian wheats. The whole meal flour FSP varied from 7.18 to 11.47 with the average value of 9.29, while flour FSP varied from 8.20 to 12.95 with the average value of 10.59. Strong significant positive correlations were observed between peak viscosity in RVA and FSP ($R^2=0.374$; $p<0.001$).

- **Microlevel test for the measurement of yellow pigment: Useful in the improvement of durum quality:** In this investigation, 0.2 g of the flour was used and can be termed as microlevel test. There was strong correlation ($R^2=0.97$) between values of yellow pigment content measured using microlevel test and AACC method. The average values of yellow pigment content measured using microlevel test and AACC method were 5.87 µg/g and 5.83 µg/g respectively.

- **Utilization of soft wheat germplasm for improvement of biscuit making quality using MAS:** High yielding and widely adapted varieties grown in North Western Plains Zone of India namely PBW 343 and HD 2687 were used as recurrent parents and germplasm lines identified with soft grain characteristics namely HPW 114 and EC 378793 as donors. PCR amplification of *Pina* was used in BC_1F_1 populations to select plants with *Pina* (which was absent in both the recurrent parents) and used them in crossing with respective recurrent parent to develop BC_2F_2 plants which were subsequently advanced to BC_2F_6 populations. The SKCS analysis of grain hardness index in BC_2F_6 derived seeds in both the populations exhibited both soft and hard genotypes. The soft genotypes developed exhibited biscuit spread factor (60% higher) in background of HD 2687.

- **Utilization of Nap Hal, unique Indian land race of wheat, and synthetic hexaploids in the improvement of biscuit making quality:** Molecular, biochemical, rheological and baking analysis of Nap Hal exhibited unique characteristics including low sedimentation (3.6 ml) and soft grain texture (HI=35.5), suitable for biscuit making quality. Back cross programme was initiated to transfer *Glu-D1* double null into PBW 373 and UP 2425 backgrounds using molecular approach.



Materials are at different stages of development. PCR amplification was used to identify plants with double null at *Glu-D1* locus and wild allele of puroindolines. The information was used in making backcrosses. BC_1F_3 and BC_2F_3 families demonstrated that many lines were available having soft grain characteristics and *Glu-D1* double null trait. BC_3F_4 seeds harvested from BC_3F_3 plants of a cross between PBW373 and NAP exhibited transgressive segrergants towards low sedimentation under soft background. Transgressive segregants towards very low sedimentation (<15 ml) were identified.

- **Relationship of WXB1 null allele and starch pasting viscosity:** Molecular markers for granule bound starch synthase were used to identify relationship of specific allele at the *Wx* locus with starch pasting properties. t-test was employed to understand the relationship between starch pasting properties and waxy alleles. There was strong positive correlation between peak viscosity and null allele at WxB1 locus. The null allele can be identified by the PCR amplification of the part of WxB1 gene.

- **Improvement of durum quality-Molecular approach:** The role of glutenin subunits in determining gluten strength in durum wheat was identified using RILs developed from a cross between HD4676 and NIDW15 with two fold difference in gluten strength. There was significant difference in gluten strength among RILs having LMW-I and LMW-II glutenin subunits. This demonstrated that LMW glutenins are responsible for imparting gluten strength in durum wheat not the gliadins. This information is being used in marker assisted breeding. HD4676 is used as donor and PDW233 and PBW42 as recurrent parents.

- **Biofortification-micronutrient density in wheat varieties:** In the present investigation Fe and Zn concentrations were estimated in wheat varieties in India to identify cultivars with higher contents of these minerals. Fe concentration varied from 30 to 63 ppm with the average value of 43 ppm and Zn from 24 to 47 ppm with the average value

of 36 ppm in grains of wheat varieties. One year study demonstrated positive correlation between Fe and Zn content.

- **Phytase and phytic acid levels:** The phytate levels varied from 11.65 mg/g to 19.30 mg/g with the average value of 15.96 mg/g among released varieties. In contrast, it varied from 11.07 mg/g to 24.41 mg/g with the average value of 17.55 mg/g among synthetic hexaploids studied. This showed 1.6 fold variations in released varieties and 2.2 fold variations in synthetic hexaploids. In terms of phytate phosphorus, it varied from 2.55 to 5.45 mg/g with the average value of 4.50 mg/g among the varieties and 3.12 to 6.87 mg/g with the average value of 4.94 mg/g among synthetic hexaploids. Two fold variation in phytic acid in wheat showed that it can be manipulated for increasing nutritional quality of wheat.

- **Development of RILs for molecular studies:** Recombinant inbred lines have been developed for different quality traits as yellow pigment content in durum, chapati quality, grain hardness, protein content and gluten strength in bread wheats. K68 and C-306 are used as good chapati making parent and WH157, WH331 and UP2425 as poor chapati making parent. RILs are at different stages of development. RILs were developed among genotypes having high (EDUYT54, DDW01 and NGSN8) and low yellow pigment content (PBW34, HD4502 and MACS 2846).

- **Variability in yellow pigment content:** The data demonstrated large variation in yellow pigment content from 3.58 to 11.06 ppm with the average value of 7.08 ppm in durum wheats. The showed normal distribution of yellow pigment content in this set of durum genotypes indicating oligogenic trait controlled by many genes. Most of the varieties had yellow pigment content in lower to medium range with the highest value in PBW 233 (8.20 µg/g). However, there was higher yellow pigment content in genotypes selected from international nurseries with the highest value of 11.06 µg/g on dry weight basis.

Yellow pigment content varied from minimum of 1.87 ppm to maximum of 5.30 ppm with the average value of 3.19 ppm in bread cultivars.

- **Improving wheat for salt tolerance:** RILs heve been developed using salt tolerant Kharchia 65 as one of the parents. RILs of the cross between Kharchia 65 and HD 2009 and PBW 502 are at F_6 stage and of the cross between salt tolerant KRL-1-4 with PBW 502 are at F_8 stage. Three hundred and fifty microsatellite markers representing all the three genomes were synthesized and used in parental polymorphism survey to identify polymorphic markers for analysis of RILs. The identified polymorphic markers were used in screening RILs. Two of the polymorphic marker showed linkage with salt tolerance.

- **Antioxidant activities of different wheat fractions:** Wheat is a rich source of a number of minerals and other phytochemicals which are beneficial to health and contribute to the antioxidant capacity of the wheat grain. In this study, Indian wheat varieties grown under different agro-climatic zones were evaluated for their antioxidant potential. Different grain fractions (bran, flour, shorts) and the whole meal were tested using two free radicals (ABTS and DPPH) for their radical scavenging activities. The activity was highest in bran followed by whole meal and flour. Irrespective of the method used, the whole meal and the bran of central zone varieties showed the highest and the north western plains zone varieties showed the lowest antioxidant activities. Significant differences in the antioxidant activity were observed between the genotypes. In case of durum wheat, the NWPZ varieties showed higher antioxidant activity than the other zones.

- Effect of Post-harvest Processing on the Antioxidant Potential of Wheat and Wheat Products: The antioxidants in the cereal grains must withstand various post-harvest treatments, food formulations and processing conditions before exerting their potential health benefits. To study the effect of storage temperature and duration on the antioxidant activity, both the whole meal and bran were stored at four different

temperatures (-20°C, 4°C, RT and 60°C) for 60 days. It was observed that in case of both the whole meal and bran, 25 % antioxidant activity was lost after storage at RT and -20°C after 60 days of storage. To study the effect of product making (*chapati*) on the antioxidant potential of wheat, 20 varieties with chapatti score of more than 7.0 were selected. The antioxidant activity was reduced after making chapatti and there was around 30% less antioxidant activity in comparison to the whole meal. The variety HS277 showed the least reduction in the activity in both the years. Other varieties with low reduction in both the years are PBW 343, NW 2036, DBW 14 and HS 240.

E. BARLEY

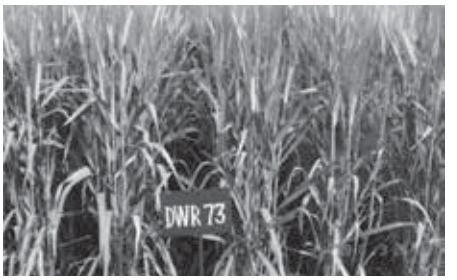
Coordinated evaluation of new genotypes

- In all, 609 varietal evaluation trials including initial varietal trials (IVTs) and advanced varietal trials (AVTs) were proposed, out of which 574 (94.3%) were conducted across the country.

Development of malt type barley

- Fifteen barley varieties were released during 2008 to 2013 for different production conditions. Among them, DWRUB64, DWRB73, DWRB91, BH885 (Haryana) were malt barley varieties, BH902, RD 2715, RD2786, Jawahar Barley 1 (JB110) (MP), PL807 (Punjab) for feed and fodder purpose, UPB1008, BHS380, VLB118, PRB502 (Uttarakhand) were rainfed hill zone varieties, Gokul (HBL391) (H.P.) for cold tolerance hill zone, RD2794 for salinity conditions.

- **DWRB73 (***PL710/DWR17):* Released by CVRC in 2011, two row malt barley for late sown, irrigated condition of North Western Plains Zone (NWPZ).



- **DWRUB 64** *(DL472/PL705):* Released by CVRC in 2012. The first six-row malt barley for late sown, irrigated condition of North Western Plains Zone (NWPZ). This variety was indigenously developed through private – public collaborative research for cultivation through contract farming in Punjab by M/s UB Ltd, Bangalore. DWRUB64 is verified in Punjab & Haryana & western UP under delayed sowings in cotton/ sugarcane belt. The grain even under late sown conditions is bold and has very less processing losses in malting despite its six-row spike type.
- **DWRB 91** (DWR46/ RD2552): This is a two-row malt barley, highly resistant to rusts with good grain yield & quality under late sown conditions of NWP zone conditions.

Development of dual purpose barley

- Already released feed type varieties RD 2035 and RD 2552 have been found equally good to be used as dual purpose type. Two more new varieties RD 2715 for central zone and BHS380 for NH zone have been released as dual purpose barley (forage cum grain crop). Thus barley can serve as supplementary crop for augmenting the green forage demand in the arid/ semi arid areas of northern plains under limited irrigations

and in hills under rainfed conditions. It also gives satisfactory levels of grain yield.

Germplasm enhancement and evaluation through nurseries

- During the last five years, 4501 germplasm lines were received from ICARDA, Syria through different yield trials and observation nurseries, which were evaluated at various centers under AICW&BIP. A number of genotypes have been used in hybridization and direct utilization for varietal development under national programme.
- At national level, National Barley Genetic Stock Nursery (NBGSN) includes the confirmed genetic stocks and were distributed to the cooperating centers for their effective utilization as donor parent in breeding programmes. The Elite International Barley Germplasm Nursery (EIBGN) is constituted from the material selected from the international nurseries/trials every year and shared with the cooperating centres to provide the genetical variability.

Registration of genetic socks

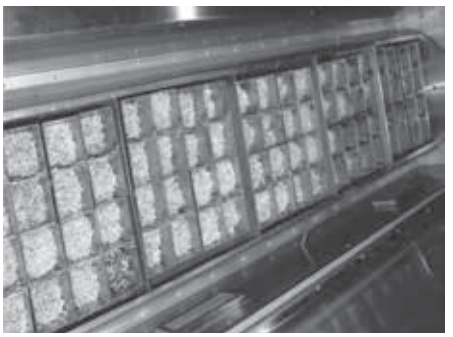
- One barley genetic stock (DWR45) with registration no. INGR 08114 has been registered for resistance to stripe rust in seedling and adult stage. The genetic stock can be used as good source for further genetic studies and in barley breeding programme in country.

Breeder seed production

- Against the indent of 9810 q from the DAC (MoA), a total of 13250 q breeder seed was produced with surplus of 3440 q seed quantity during 2008 to 2013. RD 2035 & RD2552 were the most indented varieties in seed chain.

Quality analysis of malt and feed barley

- In the development of malting purpose varieties, quality analysis support was provided in coordination programme through analysis of 933 samples from timely sown conditions and 753 from late sown conditions. Twenty seven (27) promising genotypes for malting quality were identified in timely sown conditions and twenty one (21) in late sown conditions. A total of 1333 samples were analysed for grain physical parameters and protein content pertaining to feed barley trials in coordination programme.
- Barley varieties were screened for grain beta glucan and protein contents. Varieties with >5% beta glucan (dry weight basis) were BHS-352, Dolma, HBL-276, NB-2 and NB-3. These varieties were also screened for grain protein content and varieties Azad, BHS-352, Dolma, Jagriti and RS-6 have been found to contain crude protein content of >14% (dry weight basis).



Malt analysis in barley

Screening for diseases /pests and their control

- During the last five years, 1543 IBDSN entries, 726 NBDSN entries and 232 EBDSN entries were screened for resistance against various diseases, aphid and CCN in different cooperating centers.

Confirmed sources of resistance

- The genotypes BHS392, NDB1490, RD2765, RD2771, RD2772, RD2774, RD2775, RD2778 were found resistant to all three rusts, NDB1490, PL843 for *Yr+Lr*, JB206, RD2809 for *Yr+Sr* and BHS387, DWR84, NDB1490 for *Lr+Sr*.

Integrated Pest Management (IPM) in barley

- The seed treatment with Vitavax power @ 3g/kg and imidaclorpid 70WS (Gaucho) @ 0.6g a.i./kg + foliar sprays of propiconazole (Tilt 25 EC) @ 0.1% and imidachlorpid (Confidor) @ 20 g a.i./ha reduced the incidence of diseases like stripe and stem rusts, covered smut and foliar blight, as well as aphids. It is therefore recommended for disease/ pest management in barley.
- Foliar sprays of Confidor @ 20 g a.i./ha at the appearance of foliar aphids and later at 15 days intervals till physiological maturity and as per need have been recommended. Foliar spray of new chemical, Clothianidin @ 15g ai/ha is recommended for management of aphids.

Molecular studies on barley

- For leaf rust resistance, molecular marker GMS61 located on 5H chromosome and closely linked with *Rph12* region in barley has been successfully used, that amplified characteristic allele of 145bp in varieties like Clipper, RD2503, RD2035, RD2624 and RD2660 that are reportedly resistant tor leaf rust disease. Similarly, STS marker HVM11 (7H), closely linked to leaf rust resistance loci *Rph19,* is also found effective for screening Indian barley genotypes and validated leaf rust resistance with an amplification of specific band fragment of 181bp (Clipper, RD2715, RD2035, RD2503, VLB1, VLB85, HBL113, BHS352, BHS169 and BG902).
- One marker, HVM67, present on 4H chromosome has been screened positive for Indian barley lines and amplified characteristic band fragment of 116 bp in genotypes like Himani, Kailash, RD2503, Dolma,

Sonu, VLB1, HBL316, BHS353, BG25, BG105 and RD2715 that are identified as resistant lines for stripe rust resistance.

- Molecular markers reported for QTL loci for spot blotch resistance when screened with Indian barley genotypes then only three SSR markers viz. Ebmac705, Bmag606 and Bmag225 located on 3H genomic region were found associated at molecular level with desired spot blotch resistance in Indian conditions in cultivars like RD2552, RD2035, Lakhan and NDB1173. SSR markers like Bmag011, Bmag720, Bmag337 and Bmac213 located on 7H, 2H, 5H and 1H respectively, were also reportedly found associated with spot blotch resistance loci in mapping population developed using Indian barley lines.
- Molecular marker, MGB402, reported for resistance gene *Mla* on 1H chromosome amplified characteristic band of 300 bp for powdery mildew resistance in Dolma, DWR28, K409, RD2552 and RD2668 whereas amplified band fragment of 250bp marked the absence of *mla1H* gene.
- STS marker, GMS61 gave desirable allele for grain protein trait in varieties like BCU73, DL88, K551 and RD2503. These markers screened with Indian barley cultivars have provided important information at molecular level and may be useful during the development of new disease resistant malt barley varieties in future as well.

Resource management in barley

- A total of 91 trials were conducted for evaluating new genotypes during last five years. A total of 159 trials were conducted in different zones during last five years for refine the production technologies.

Dual purpose barley cutting, regeneration and growth

- In northern hills zone, the cut for fodder in dual purpose barley may be practiced at first node stage, irrespective of the days after sowing, under rainfed conditions.

- Isoproturon in combination with either Metsulfuron or 2,4D (Isoproturon 750 g a.i./ha + Met sulfuron 4 g a.i. / ha or Isoproturon 750 g a.i. / ha + 2, 4D 500 g a.i. / ha) can be sprayed at 35 days after sowing for effective control of the broad and narrow leaved weeds in barley.
- Reduced tillage (one harrowing + one cultivator) is enough for field preparation for barley sowing in NEPZ. It gives comparable yield with conventional tillage (two harrowing + two cultivators) and saves energy, labour and time.
- Application of 75% of recommended dosages of fertilizer along with 5 t FYM & biofertilizer (Azatobacter) is recommended for obtaining equal yield on sustainable basis against the 100% inorganic fertilizer.
- In malt barley row spacing of 18 cm with seed rate of 100 kg per hectare should be adopted for obtaining higher yield without adversely affecting the grain quality by farmers in timely as well as late sown production conditions of NWPZ to maximize the productivity.
- In NWPZ (except Durgapura) two irrigations (30 and 85 DAS) are enough for obtaining maximum production. In the production conditions like Durgapura (loamy sand soils and arid climatic conditions) the three irrigations should be given for higher productivity. In case of NEPZ also two irrigations (30 and 85 DAS) are enough for obtaining maximum production.
- For long term sustainability, substitution of 25% of inorganic fertilizer with organic fertilizer (vermicompost) should be adopted in place of 100% application of inorganic fertilizer in NHZ.

F. TECHNOLOGY DISSEMINATION (WHEAT AND BARLEY)

- During 2008 to 2013, more than 3700 wheat front line demonstrations (WFLDs) were conducted at 7949 farmers' fields covering 3857 ha area

across 18 states. The yield gain (%) varied from 29.95 to 73.27 in NHZ, 34.60 to 96.23 in NEPZ, 11.09 to 25.21 in NWPZ, 39.73 to 57.75 in CZ and 16.29 to 30.44 in PZ.

- The Directorate conducted all the wheat (96) and barley (61) demonstrations allotted to Karnal centre covering 81 wheat and 75 barley growers. The barley demonstrations were conducted in collaboration with United Breweries Limited, Patiala across Punjab and Haryana.
- The Front Line Demonstrations' have indicated that the wheat and barley yields could be increased appreciably, depending upon the zones. The farmers have shown keen interest in zero tillage technology. The program has been successful in creating awareness amongst the farmers about resource conservation and other technologies demonstrated.
- The zone wise results revealed that bio-fertilizer was effective in CZ, NEPZ and PZ, where it increased the farmers' margin by Rs. 9242, 6756 and 6281 per hectare, respectively. Durum technology could increase the farmers margin by Rs. 7230/ha in CZ and Rs. 6656/ha in PZ. FIRB technology could add Rs.1938/ha in NWPZ. Improved wheat variety was the most profitable technology among all the zones, it could add Rs. 3562/ha (least) in NWPZ to Rs. 11761/ha in NEPZ. Zero tillage technology increased the farmers' margin by Rs. 4840/ha in NWPZ and Rs. 3835/ha in NEPZ.
- The entrepreneurship development programme for women indicated their interest in new business, provided they get enough time to train themselves on manufacturing wheat products and marketing.
- Front line demonstrations have popularized the two row barley varieties in Punjab, Haryana and Uttar Pradesh. Survey conducted in Punjab, Haryana and Rajasthan has clearly revealed interest of farmers in contract farming due to better price for malt barley. The two row malt barley variety DWRUB 52 developed by the Directorate has wider adoptability at farmers' field and acceptance by the industry for its

quality. The area of DWRUB 52 under contract farming has gone up to 50,000 acre.

- Survey was conducted on weed management strategies adopted by the farmers in Haryana and Punjab. The farmers need to be educated about weed management strategies i.e. crop rotation, increased seed rate, crop residue and advance sowing to control weeds. They should also be made aware of herbicide rotation, use of flat fan nozzle, proper dose and timings of herbicide application in wheat crop. *Phalaris minor* continues to be major problematic weed in both the states.
- The Database has been updated for all the districts of India on the parameters like area, production, productivity, inpute usage, marketing, storage etc.
- Ten training programmes were organized and 449 trainees were trained including farmers, entrepreneurs and extension officers. The Directorate organized/ participated in 56 exhibitions and produced one video film. Thirty five farmers' days/ seed days were also organized. The scientists delivered 17 TV talks and technologies were popularized through print media also for better and faster adoption by the farmers. Visits of students, farmers, entrepreneurs were coordinated during this period. Organized two workshops on "Opportunities and challenges in wheat marketing in India" and "Expert system on wheat crop management", one short course on "Participatory research and extension management", Stakeholders' meeting, traveling seminar and two awareness programmes on "Protection of Plant Varieties and Farmers' Rights". Visit of 6854 delegates was coordinated and the Directorate won 13 best stall award in various exhibitions during 2008-2013.

G. DWR REGIONAL RESEARCH STATION, FLOWERDALE

- During this period, all the wheat and barley rusts were observed; however, there was minimal prevalence of wheat rusts except for the large scale occurrence of yellow rust in northern India during 2010-12.

- Three rust resistant genetic stocks FLW28 (INGR08001), FLW29 (INGR08002) and FLW30 (INGR08003) were registered with NBPGR, New Delhi.

Name	INGR no.	Pedigree	Trait
FLW28	INGR08001	WH542/WC1	Resistant to brown and yellow rusts
FLW29	INGR08002	PBW343/CDPBW343/FLW7	Resistant to all the rusts
FLW30	INGR08003	PBW343/Yr15/pbw343/Lr28	Resistant to all the rusts

- Eleven new pathotypes were identified. In *P. graminis tritici*, four new pathotypes were identified. Pathotype 58G13-3(40-2) rendered *Sr25* susceptible.This gene was resistant to black rust in India. Another pathotype 127G29(40-3) and 123G15(15-1) are virulent on *Sr5*, *Sr*8, *Sr*9e, *Sr*11 and *Sr30*. Prior to that there was no pathotype having virulence for *Sr8*+*Sr*30. Fourth pathotype 55G1(184-1) is a variant of pathotype 53G1(184). In *Puccinia triticina* seven new pathotypes were identified. *Lr*28, which was resistant to brown rust in India became susceptible to pathotype 377R60-1 (77-10). Other pathotype 121R60-1(77-9), 93R45 (12-5), 49R45 (12-8), 93R37-1(12-9), 125R28-1(77-11) and 93R57 (104-4) were also identified. Rust resistance sources/ varieties were also identified against these pathotypes. During the review period none of these pathotypes have become predominant in wheat growing areas of India.

- More than 5537 samples of different rusts of wheat were analyzed. Pathotypes 77-5, 104-2 of *Puccinia triticina*, 40A, 40-1 of *P. graminis tritici*, 46S119 and 79S84 of *P. striiformis* were widely distributed in sixteen states of India, neighboring countries Nepal, Bangladesh and Bhutan.

Predominant pathotypes of Puccinia species in India and neighboring countries during 2008-2013

Rust	Pathotypes	Remarks
Brown	121R63-1(77-5), 21R55(104-2), 21R63(104-3)	All the pathotypes are virulent on *Lr*1, *Lr*3, *Lr*13, *Lr*23, *Lr*26.
Black	62G29 (40A), 62G29-1 (40-1), in Ladakh 10G13(34-1)	Both the pathotypes are virulent on *Sr*5, *Sr*8,*Sr*9e, *Sr*11 and later two are virulent on *Sr*24
Yellow	46S119, 78S84 in Northern India, CI, CII, CIII in Ladakh, 38S102 (I) in Nilgiri hills.	Both 46S119 and 78S84 are virulent to *Yr*9, later is virulent to *Yr*27 also

- To identify rust resistance sources, characterize rust resistance genes and confirm the targeted genes in wheat lines More than 6000 lines of wheat and barley including AVT, NBDSN, EBDSN and breeders material were evaluated. DBW51, HI1569, HI1571, HW5211, HUW638,

Seedling evaluation for stripe rust resistance

PBW6617 and RAJ4201 were resistant to all the wheat rusts. In addition, 315 lines were resistant one or more rusts.

- National repository of rust pathotypes was maintained by looking after of 125 cultures of different rust pathogens in pure form. To enable creation of artificial epiphytotics and conducting of genetic studies, nucleus inocula of different pts. were supplied to 51 researchers in different parts of India.

- Based on repeated adult plant rust resistance studies, it was observed that wheat lines viz. HD3059, HD3065, HS507, HS541, HS542, VL892,

VL907, DBW 50/PBW621, WH1021 and HD3043 were found to confer adult plant resistance both to brown and yellow rusts. Some of these lines are being promoted in Northern India to have rust free wheat crop.

- To know the performance of predominant wheat varieties in different parts of India, occurrence of wheat diseases and their spread, wheat disease monitoring nurseries were planted at 38 locations. In addition, SAARC wheat disease nurseries were also planted in 14 locations in India and equal number in Nepal, Bhutan, Bangladesh, Pakistan and Afghanistan. A perusal of data on wheat rusts indicated that incidence of yellow rust was more in India in comparison to Pakistan and Afghanistan. It is indicative of racial differences.
- With the identification of new pathotypes, the differential system was re-casted and new differential were added.
- With an eye on the occurrence of yellow rust in northern India and Ug99 in some parts of the world, efforts are on to develop rust resistant genetic stocks with diverse resistance. Some populations have reached F_6 stage and are being evaluated.
- More than 1000 lines comprising of rust differentials, nearest isogenic lines and other indigenous as well as exotic stocks are being maintained in pure form. Purity of these is being checked through host pathogens interactions.

H. DWR REGIONAL RESEARCH STATION, DALANG MAIDAN, LAHAUL & SPITI, H. P.

Generation advancement of wheat and barley : During 2008-2013, a total of 1,32,458 lines of wheat were grown by more than 19 cooperators at Dalang-Maidan for generation advancement. The year wise break is given below:

S. No.	Year	Number of lines
1.	2008	21738
2.	2009	23972
3.	2010	26700
4.	2011	23819
5.	2012	36229
	Total	**132458**

Hybridization: Every year 500-1000 crosses were attempted by the researchers across the institutes. In year 2012, about 1000 crosses were attempted in which DWR, Karnal attempted 254 crosses followed by IARI, New Delhi (232 crosses). A new initiative for doubled haploid production was also initiated by the scientist of DWR in which 500 spikes of wheat were crossed with maize pollen collected from nearby areas. In order to utilize the potential of winter wheat a new experiment has been initiated in the current year for establishing winter wheat crossing block.

Screening important wheat and barley material against rust: The station provides good location for screening for yellow rust and powdery mildew. Every year approximately 10,000 lines were screened by various centers.

Natural repository for wheat and barley germplasm: The regional station acts as natural repository for wheat and barley germplasm and at present 8697 accessions of wheat germplasm are being conserved under natural conditions. After eight year of storage at Dalang Maidan, the germination was recorded >90%. It is concluded that DWR-RS, Dalang Maidan is a cost effective site for conservation of germplasm.

Wheat X Maize system of Doubled Haploid production in Wheat: New initiative at Dalang Maidan: The purpose of this initiative was to establish the protocol for haploid production via maize pollination in wheat at DWR, RS, Dalang Maidan. The off-season facility at Dalang provides a good option for developing haploids during off season and then transferring the plantlets to Karnal during the main season (Oct-March). This not only provides favourable

environment required by the plantlets to grow, but is also helpful in application of colchicine for doubling the chromosomes as the number of tillers are more in main season than during the off-season. This also enhances the frequency of doubled haploids plants produced. About 400 F1's were sown in the month of May, 2012 for the purpose of producing Doubled Haploids (DH). The F_1's were made with the purpose of incorporating disease resistance into commercially grown wheat varieties. Major focus was on yellow rust, leaf rust, loose smut and karnal bunt. Out of 500 maize pollinated spikes, 120 embryos were harvested and cultured.

SALIENT RESEARCH ACHIEVEMENTS AICW&BIP CENTRES

The progress of AICW&BIP Centres was reviewed and significant achievements and specific recommendations of each centre are presented below:

Northern Hills Zone

There are three AICRIP centres in NHZ and all of them are located in the state of Himachal Pradesh. Significant achievements of each centre for the period 2008 to 2013 are given hereunder:

Malan

- Wheat variety HPW 249 having postulated seedling resistance genes to leaf rust and yield potential of 49.2q/ha and 26.0q/ha under irrigated and rainfed conditions, respectively has been identified for cultivation in mid-hills of Himachal Pradesh.
- HPW 251, a high yielding (34.4q/ha) and yellow and brown rust resistant variety has been released by CVRC for early sown rainfed condition of NHZ.
- HPW 349 was released by CVRC for NHZ in 2013. It has mean grain yield of 28.6q/ha and 46.3q/ha under rainfed and irrigated conditions, respectively, with high degree of resistance to yellow and brown rusts.
- 130 q breeder seed of different varieties was produced and conducted more than 100 FLDs and on-farm trials in last five years.
- 25.6 – 29.5% reduction in grain yield was estimated due to powdery mildew. Two sprays of Tilt 25 EC at 15 days interval efficiently controlled the powdery mildew.
- Trifloxystrobin + Tebuconazole (Nativo 75WG) @ 0.06 %, Pyraclostrobin 13.3% + Epoxiconazole 5% (Opera 18.3% SE) @ 0.2%, Epoxiconazole @ 0.3%, Tebuconazole 430 SC (0.08, 0.1 and 0.12%) and (Picoxystrobin +

Propiconazole) 20SC (0.25%) were found effective in controlling both yellow rust and powdery mildew diseases.

- Seed treatment with Triticonazole 4% + Pyraclostrobin 8%FS (Insure Perform 12%FS) @ 0.75 and 1.00 ml per kg or Mavistin @ 2.5g per kg seed were found effective for the combined control of loose smut and hill bunt. However, seed treatment with Tebuconazole 060FS (w/v) or Raxil 060FS @ 0.250 and 0.333 g/ kg effectively controlled the loose smut of wheat only.

Bajaura

Barley:

- A two rowed hulled barley variety HBL 391 (Gokul) was released by SVRC for the cultivation in Himachal Pradesh in 2007.
- Three splits dose of 60kg N/ha (1/3 as basal, 1/3 at 75 days or after fodder cut and 1/3 at the flowering stage) under rainfed conditions was recommended for the economic grain and fodder production of dual purpose barely varieties in HP.
- The 25% recommended dose of inorganic nutrients can be replaced through the application of either FYM or vermin-compost under INM.
- Two sprays of either Tilt or Bayleton or Folicur @ 0.1% at 15 days interval with the appearance of disease was found effective in controlling yellow rust.

Wheat:

- Variety DH 114 (Him Pratham) evaluated at the centre and released by the SVRC for cultivation in the snow bound areas of Himachal Pradesh.
- 140 q and 39 q breeder seed of wheat and barley varieties was produced during last five years, respectively.

- A row to row spacing of 18 cm was recommended for higher grain yield compared to normal spacing of 23 cm under irrigated conditions of the NHZ.

Dhaulakuan

- During the period under report, two wheat varieties HPW 236 and HPW 211 have been released by SVRC. Besides, station was involved in the release of varieties namely HPW 249(SVRC), HPW 251(CVRC) and HPW 349(CVRC).
- HPW 211, selected from germplasm from the CIMMYT nursery has been recommended for cultivation in Zone-1 of HP under timely sown irrigated condition. This variety conferred resistance against Karnal bunt, yellow and brown rusts and powdery mildew diseases.
- The Station has produced 610 q breeder seeds of various wheat varieties.

North Western Plains Zone

This is the most productive wheat zone of the country. There are six centres in this zone located in six different states namely J&K, Punjab, Haryana, Rajasthan, UP and Uttarakhand. Significant achievements of each centre for the period of 2008-2013 are given hereunder:

Ludhiana

- Five bread wheat varieties (PBW 550, PBW 596, PBW 590, PBW 621, PBW 644), two triticale varieties (TL2942, TL2969) and one variety each of durum (PDW 314) and barley (PL 807) were developed and released.
- Gene pyramided rust resistance lines namely PBW 693, PBW 697 and PBW 701 were developed through wide hybridization.
- Two hundred eighteen lines were evolved through doubled hapoid technique, which are presently in yield trials.

- QTLs for higher grain micro-nutrients were identified and transferred from *T. dicoccoides* and *T. boeticum* through wide hybridization. Material is in BC_2F_5 generation.
- Spray of Shine 25 EC or Bumper 25EC or Folicur or Bayleton @ 200 ml/ acre or Bayleton 25EC @200g/acre was found effective for the control of yellow and brown rust of wheat in addition to Tilt 25 EC. Seed treatment with Vitavax/Thiram and one spray of Tilt @0.1% or Folicur @0.1% was found effective for the control of leaf blight.
- Foliar spray of Dantop (clothianidin 50WDG)@12g/acre or Imidacloprid 200SL or thiamethoxam 25 WG was found effective in controlling the aphids. Rice stemborer can be controlled with granular application of Foratox 10G (phorate) @ 5kg/ac.
- Surface residue retention of 4t/ha with four irrigations should be practiced for higher wheat productivity and water-use efficiency in NWPZ.
- In dual purpose barley, in addition to basal dose (1/2) nitrogen should be applied in two splits after green fodder cut (half after cut and half 30 days after cut) instead of full immediate after cut in NWPZ.

Hisar

- Four bread wheat varieties (WH1021, WH1025, WH1080, WH1105), two barley varieties (BH885, BH902) and one durum wheat (WHD943) were notified and released during 2008 to 203.
- The variety WHD948 (durum) have been identified for release in PZ for timely sown irrigated conditions.
- Two genetic stocks namely WH1063 (INGR 10128) and WH1080 (INGR 10129) were registered with NBPGR for high gluten content (11.1%) and high sedimentation value (62 ml), respectively.

- Genotypes WH1021, WH1063, WH1043, WH1076, WH1061, WH1052, WH0938, WHD948 and WHD950 were found multiple disease resistant genotypes.
- In barley genotypes BH936, BH917 and BH902 were found confirmed sources of resistance for yellow rust. stem rust and leaf blight, respectively.
- Genotypes BH 935, BH942, BH953 and BH968 posses excellent malting traits.

Modipuram

- A total of 10 entries were contributed in NIVT and 11 entries in state varietal trials.
- A total of 295 crosses were made beside selection was performed in National & International nurseries.
- A total of 1217.78 q breeder seed of different wheat varieties was produced.

Pantnagar

- Four varieties of wheat (UP 2584, UP 2684, UP 2628 and UP 2748) and one variety of Barley (UPB 1008) were released during 2008 to 2013 for cultivation in different sowing conditions and agro-eco situations.
- Three novel germplasm (UP 2642, UP 2696 and UP 2698) were registered with NBPGR, New Delhi.
- Wheat yield reduced significantly under rice–vegetable pea-wheat cropping sequence, but the economics of rice-vegetable pea-wheat cropping sequence is better than other cropping sequence. Conventional system gave higher wheat yield than FIRBS and Zero tillage.
- Recommended fertilizer dose (150:60: 40) along with application of 0.5% solution of $MnSO_4$ was found beneficial for wheat crop.

- Low temperature hardening treatment not only shortened the time for 80% emergence and first tiller formation but also improved plant stand as indicated by its higher plant population per unit area.
- Application of calcium and potassium during booting stage had beneficial effect on wheat grain yield.

Jammu

- Wheat variety RSP 561 was released by State Seed Subcommittee.
- The nucleus and breeder seed was produced as per the indent of DAC and SAD.

Durgapura

- During the last five years, 6 wheat varieties namely Raj 4083 (Irrigated, late sown conditions of PZ), Raj 4120 (Irrigated, timely sown conditions of NEPZ), Raj 4079 (Irrigated, timely sown conditions of Rajasthan), Nematode resistant wheat variety Raj Molya Rodhak 1 (CCN infested soils of Rajasthan), Raj 4229 (Irrigated, timely sown conditions of NEPZ) and Raj 4238 (Irrigated, late sown conditions of CZ) were developed and released for cultivation in different wheat zones/states.
- During the last five years, four barley varieties namely RD 2668 (two rowed malt barley for timely sown, irrigated condition of NWPZ), RD 2715 (first dual purpose barley variety for irrigated, timely sown condition of Central zone), RD 2786 (feed barley variety suitable for irrigated, timely sown condition of Central zone) and RD 2794 (Saline-sodic soil resistant variety for irrigated, timely sown condition of NEPZ and NWPZ) were released for cultivation in different barley growing zones of the country.
- An aphid resistant genotype was developed to redress the existing aphid problem in the barley cultivation.

- 11,600q breeder seed of wheat and 10,877q breeder seed of barley varieties was produced, which enhanced the SRR in the state and helped in maximization of production and productivity.
- A unique natural screening facility for CCN was developed.

North Eastern Plains Zone

There are eight AICW&BIP centres in NEPZ located in five states namely UP, Bihar, Jharkhand, West Bengal and Assam. Significant achievements of each centre for the period 2008 to 2013 are given hereunder:

Kanpur

- Medium duration (120-125 days) wheat variety K0607 (MAMTA) was released by SVRC for timely sown, irrigated conditions of UP.
- An early maturing (90-100 days) wheat variety Golden Halna (K0424) possessing high degree of terminal heat tolerance at grain filling stage was released by SVRC for late and very late condition.


Golden Halna (K 0424)

- A high yielding, medium duration (120-125 days) wheat variety Mahi (K0402) was released by SVRC for TS-IR condition.
- Durum wheat variety KD9851 (Sona) was released by SVRC for general cultivation under irrigated conditions of Bundelkhand region having yield of 35-40 q/ha.
- High chlorophyll fluorescence Fv/Fm, larger CTD and less reduction in chlorophyll content were found to be associated with thermal tolerance in wheat.

- Fipronil 5SC @ 0.3gai/kg (6ml/kg of seed) was found effective in managing the termite damage in wheat crop.
- Imidacloprid (confidor 200SL) @20gai/ha (100ml/ha) and coragen (18.5SC) chlorantanilpride (110ml/ha) was found effective in controlling foliar aphids in barley.

Faizabad

Wheat

- Wheat variety NW 4018 was released by SVRC in its 27th meeting for restricted irrigation condition of U.P.
- NW 3087 was found resistant to three rusts and karnal bunt in NGSN and majority of the breeders using it in their crossing programme. NW 4091 was found resistant to LS + KB +PM and moderately resistant to leaf blight at National level.
- NW 5064 was promoted to AVT-LS-IR of NEPZ and peninsular zone.
- Genotypes NWL 8-7 and NW 6-2 recorded high number of tillers/m at National level and YCSN, respectively.
- NWL 5-10 was found better for sedimentation value and NW 8-16 for protein content on the basis of one year testing.

Barley

- Barley variety NDB 1445 was released by SVRC for salinity condition of U.P.
- A hull-less barley variety NDB 943 notified during 2009, has more farmer acceptability in eastern U. P.
- Barley entry NDB 1544 was found tolerant to leaf blight and identified for inclusion in EBDSN.

- Genotypes NDB 1245, 1276, 1410, 1445, 1461, 1465 and 1496 were found tolerant to Salinity/Alkalinity such as high pH =8.9-9.8, ECE= <4.00, ESP=60-65, mortality percent (<10), plant stand at harvest (>70%), tillering ability (5-8) and better grain yield.

Varanasi

- Six genotypes of wheat were promoted to various AVTs from NIVTs during last year.
- Maintaining RILs population of *Yangmai 6 x Sonalika*, *Ning 8201 x Sonalika* and *Chiria 3 x Sonalika*.
- Maintaining CSISA spot blotch nursery comprising of 310 lines.
- QTLs for spot blotch resistance viz., *QSB.bhu2B-* (*Xgwm 148*), *QSB. bhu7D-* (*Xgwm 111*) and *QSB.bhu5B-* (*Xgwm 067*), tested in RILs and CSISA populations.
- Maintaining repository of *Bipolaris sorokiniana* in their pure form.
- All lines nominated from this centre in IPPSN were found resistant to brown rust, whereas 90% of lines were resistant to black rust and 81% lines to yellow rust.
- Ten resistant lines from spot blotch nursery were identified and crosses were made with elite varieties HUW 234 and HUW 468.

Sabour

- 20 genotypes were contributed to coordinated trials for testing.
- Three to four irrigations were adequate for wheat cultivation under Sabour condition.
- CRI and heading stage were the most critical period for moisture stress.
- Resource conservation tillage technology (RCTs) viz; zero tillage and surface seeding of wheat were found effective under rice- wheat

cropping system in term of advancing sowing time by reducing turnaround time along with reduced cost of cultivation. Surface seeding can be used under low land rice-wheat cropping system where excessive soil moisture is the constraints for taking wheat after rice.

Ranchi

- Birsa Gehun-3 was released by SVRC for rainfed condition of Jharkhand State.
- In rainfed condition, 60kg N/ha produced significantly higher grain yield as compared to 40kg and 80kg N/ha.
- No response of Boron was observed on grain yield of wheat genotype.
- Wheat varieties sown at 20 cm spacing in weed free situation produced significantly higher grain yield (41.18 q/ha) as compared to rest of the row spacing.

Coochbehar

- Genotype DWR-TS-33 was found promising under shuttle breeding programme.
- Genoype Francolin was found suitable for late (15th December) and very late (30th December) conditions.

DWR-TS-33

- Seed treatment with vitavax followed by single Propiconazole spray at panicle initiation stage with soil application of 120:60:60 kg N:P:K/ha was found effective in controlling foliar blight in wheat under integrated nutrient management.

- Zero tillage had considerably reduced the weed pressure. However, it caused shifting of weed flora from *Polygonum* and *Stellaria media* to *Hydrocotyl ranunculoides*

Kalyani

- The following wheat varieties were identified for different situations in West Bengal

  Irrigated timely sown (18-25 November): PBW 343, HD 2733, K0307, CBW 38, K 9107 and DBW 39 (Yield 30-35 q/ha).

  Irrigated late sown (15-22 December): K 0911, HI 1563, NW 2036, HUW 234 and DBW 14 (Yield 25-30 q/ha).

  Irrigated very late sown (1-7January): HI 1563, NW 2036 and DBW 14 (Yield 20-25 q/ha).

  Rainfed timely sown (10-15 November): HD 2888, MACS 6145, HD 3070, K 8027 and C 306 (Yield 15-20 q/ha).

  Salt tolerant high yielding wheat varieties: KRL 19, KRL 210 and KRL 213 (Yield 20-25 q/ha).

- Requirement of N, P_2O_5 and K_2O for newly released high yielding wheat varieties grown under different situations have been recommended as follows:

- Irrigated timely sown (18-25 November) wheat : 150 : 60 : 40 kg/ha (one third nitrogen, full phosphorus and potash as basal and the remaining 1/3rd nitrogen at 21 DAS and another 1/3 N at 42-45 DAS; Seed rate : 100 kg/ha)

- Irrigated late sown (15-22 December) and very late sown (1-7 January) wheat : 120 : 60 : 40 kg/ha (fertilizer application same as above, Seed rate : 125 kg/ha)

- Rainfed timely sown (10-15 November) wheat : 80 : 40 : 30 kg/ha (basal application of fertilizers, Seed rate : 125 kg/ha)

Technologies developed

- ZT (tillage for sowing only) in sandy loam to silty loam soils after *kharif* rice advances wheat sowing for a week or two and minimizes the cost of cultivation resulting in economic return.
- Application of 2,4-D-E (500 g a.i./ha), Carfentrazone (20 g a.i./ha), Metsulfuron (4g a.i./ha) and Metsulfuron+ carfentrazone (Ready mix) (25 g a.i./ha) at 30-35 DAS is most economical method of weed management resulting in higher net return.
- Five irrigations (at CRI, tillering, jointing, boot and milk stage) produced 35 % and 14.4% higher yield as compared to one at CRI stage and three at CRI, Tillering and Boot leaf stage, respectively. Three irrigations (at CRI, tillering, boot) produced 18% higher yield as compared to one at CRI stage.

Shillongani

- Varieties DBW 14 and HUW 468 were recommended for cultivation in the state of Assam.
- Incorporation of rice residue (DSR) produced 15-27% higher grain yield of wheat than removal, burning or surface retention of residue in R-W system.
- Azotobacter+PSB with 75% of recommended dose of fertilizer produced 28% higher yield.
- Storing of wheat seeds in polythene bags with treatment of black-pepper powder @6 g/kg of seed effectively controls the rice weevil (*Sitophilous oryzae*), grain moth (*Sitotroga cereallela*) and red flower beetle (*Tribolium castaneum*) in high humid situations like Assam.
- Sixteen pre-harvest sprouting resistance/tolerance lines were selected in F_6 generation through direct and participatory selection with farmers.
- Four aphid resistant lines were identified from advanced breeding lines.

Central Zone

This zone comprised of nine centres and which are mainly concentrating on durum/quality wheat. Significant achievements of each centre are as follows:

Vijapur

- Three varieties viz. GW 11 (SVRC), GW 366 (CVRC) and GDW 1255 (SVRC) were released for cultivation. Among these, GDW 1255 is a value added durum variety for irrigated conditions with high β carotene content and excellent grain quality. GW 11 was identified for late sown and restricted irrigation conditions, while GW 366 is for timely sown irrigation conditions.
- Two genetic stocks i.e. GW 2002-18 (IC 553919) and GW 2002-51(IC 553917) of the centre were registered.
- 13376 q breeder seed was produced against the indent of 11667q of 9 varieties with requisite back up of NSS I & NSS II
- Drip irrigation helps in water saving of 43, 24 and 14% with concomitant yield enhancement of 16, 28 and 32% at 0.6, 0.8 and 1.0 IW/CPE ratio, as compared to flood irrigation, respectively. However, the principle of CEF was not feasible in wheat crop particularly in light soils.
- Consequent upon ban on endosulfan 35 EC recommended earlier for bridling termite menace in Gujarat, Bifenthrin seed treatment @ 0.2g a i/ kg seed was effective replacement. In standing crop; Fipronil broadcast @ 0.08 kg a. i. or Fipronil 5SC 1.6 l/ha was useful.

Junagadh

- Developed and released wheat variety GW 366 suitable for cultivation under timely sown irrigated conditions in Central Zone.
- The farmers of South Saurashtra agro-climatic zone growing irrigated wheat were advised to take wheat variety GW 322 with six irrigations (skipping irrigation at boot stage) instead of seven irrigations.

Kota

- The newly released wheat varieties namely HI 1544, HI1531, HD 2932 and barley variety RD 2552 have been included in the package of practices of the zone V of Rajasthan.
- Lok 1 variety was found suitable for very late sown condition i.e. 1st to 7th January.
- In iron deficient soils, incorporation of 5 kg/ha iron (25 kg ferrous sulphate) at the time of sowing resulted in higher productivity of wheat.
- Barley variety RD 2552 earlier recommended for grain purpose also recommended for fodder.

Udaipur

- On the basis of two year experiment, 20 cm row spacing gave maximum yield but it was at par with 22.5 cm row spacing and significantly superior over 17.5 and 15.0 row spacing.
- The zero tillage system reduced the yield over conventional practice but found to reduce cost of tillage substantially.
- The sowing of sole wheat on beds i.e. FIRB system significantly reduced wheat yield by 15 - 20 percent over conventional sowing.

- Dual (fodder + grain production) purpose barley variety Jyoti was found most appropriate for zone IVa of Rajasthan. Other barely varieties RD 2035, RD 2552 and RD 2715 were also found suitable for dual purpose barley.

Gwalior

- Bread wheat variety 'Raj Vijay Wheat 4106' was released for late sown irrigated condition by SVRC.
- Application of 120 kg N/ha in two splits i.e. 1/3rd at sowing and 2/3rd at FN stage gave the maximum yield and improved the productivity and quality of wheat grain.
- Close plant spacing of 15 cm gave highest grain yield (5385 kg/ha) followed by 17.5 cm (5007 kg/ha) over spacing of 20cm (4266 kg/ha).
- Two irrigation at CRI and late tillering stage gave significantly higher grain yield (3928 kg/ha) compared to one (3288 kg/ha) and no irrigation (2613 kg/ha).

Rewa

- Developed and released barley variety "JB 58" through SVRC for rainfed condition. Developed and released barley variety "JB 1" through SVRC for irrigated condition.RD 2552 was identified for dual purpose barley.

Sagar

- 60:40:20 kg NPK/ha, 90:60:30 kg NPK/ha, 120:60:40 kg NPK/ha and 100:50:25 kg NPK/ha recommended for rainfed, restricted irrigation, irrigated timely sown and late sown conditions, respectively.
- Under irrigated conditions, early sown (05-11 Nov.), late sown (03-09 Dec.) and very late sown (24-31 Dec.) reduced the wheat yield drastically respectively over timely sown (20-25 Nov.).

- The grassy weeds in wheat crop effectively controlled by use of weedicide Clodinofop 60 g or Isoproturon 1.0 kg or Sulphosulfuron 25 g and Fenaxaprop 120 g ai/ha with 500 l of water at 25-30 days crop stage. To control both grassy and broad leaved weeds the use of clodinofop 60 g a.i./ha + 2, 4 – D 0.5 kg a.i./ha with 500 litters of water at stage of 25-30 days crop.
- Seed treatment with bio agent trichoderma viride @ 10 g/kg seed+Vitavax 75 wp @ 1.25 g/kg seed was found effective in controlling the loose smut disease and also have PGPR effect.

Powarkheda

- Developed and released three wheat varieties namely MP 1203 (LS-IR), MP 3288 (LS-IR), MPO 1215 (TS-IR) through CVRC and five wheat varieties namely MP 1201(TS-IR), MP 1202(TS-IR), MP 1142 (TS-IR), MP 3211 (RF/RI) and MP 3269 through SVRC.
- 42171 q breeder seed of different wheat varieties was produced.
- Fertilizer recommendations for maximum production of wheat crop is as under:

  I. Irrigated timely sown :- 120:60:40 NPK Kg/ha

  II. Irrigated late sown :- 90:60:40 NPK Kg/ha

  III. Rain fed/restricted irrigation condition :- 60:30:20 NPK Kg/ha
- Spray of clodinofop @ 60g ai/ha + 2-4-D 0.5kg a.i./ha at 25-30 days after sowing controlled both grassy and broad leaf weeds.
- Zero Tillage technique in black soil is also advantageous. The wheat can be sown by giving irrigation followed by sowing with zero tillage technique.
- Raised bed system of planting with the help of DWR planter may be adopted for getting higher yield of wheat.

Bilaspur

- Developed and released wheat variety 'Ratan' through SVRC for rainfed/restricted irrigation conditionsof Chhattisgarh.
- Wheat varietal demonstrations were conducted in 14 districts of Chhattisgarh through KVKs.

Peninsular Zone

There are four centers located in two states namely Karnataka and Maharashtra. Dharwad centre is mainly working on *dicoccum* wheat, while Mahbaleshwar centre is working on rust screening. Significant achievements of each centre are as follows:

Niphad

- The wheat variety NIAW 1415 was released and notified for rainfed and restricted irrigation conditions of Peninsular Zone during 2010 by CVRC.
- The wheat genotype NIAW 1342 was registered with NBPGR as genetic stock (INGR 10130) for higher grains per spike(52).
- In all, 2,666 q of breeder seed and 15,888 q of truthful/certified seed of seven varieties was produced during the review period.
- Yield increase from 11 to 14 % was recorded due to use of different recommended technologies in FLD's.
- RKVY was implemented at 75 farmer's field. Highest yield of 75 q/ha was recorded by wheat variety NIAW 34 followed by Tapovan (62.5 q/ha).

Mahabaleshwar

- 1155 AVT-Ist & IInd year entries and 1524 NIVT entries were screened against stem and leaf rusts.

- Samples collected from Peninsular India recorded 40A, 117-3 and 122 pathotypes of stem rust and 77-1 to 77-6 & 77A,162-1,162A & 104-3 pathotypes of leaf rust.
- Maintained stem (28) and leaf (40) rust pathotypes and supplied inoculums to the needy research institutes.

Pune

- MACS 6222 a high yielding bread wheat variety was released by CVRC for commercial cultivation in the states of Maharashtra, Karnataka, Andhra Pradesh and Tamilnadu for timely sown, irrigated conditions.

MACS 6222

- MACS 2971 (*Triticum dicoccum*) a new dicoccum wheat variety was notified by CVRC in 2009 for commercial cultivation in PZ.
- MOU signed with ITC as PPP for rapid dissemination of technologies and helping for smooth seed supply to industry. As a result, ITC is conducting 15 FLD's for MACS 6222 and 10 for MACS 2971 (*dicoccum*) and taken up production of MACS 6222 on 100 ha for industrial usage.
- Synthetic hexaploid wheat was developed from crossing of synthetics with elite Indian wheat varieties viz. MACS 6222, NIAW 302 and GW 322. Synthetic hexaploid wheats (140) are in F_6 generation and ready for comparative evaluation.

Dharwad

- One dicoccum variety DDK 1029, three durum wheat varieties DWR 1006, UAS 415 and UAS 428 and one aestivum wheat variety UAS 304 were released by CVRC during 2008 to 2013.
- One genetic stock DDK 1037 has been registered at NBPGR, New Delhi.

- Sixty-nine free-threshable dicoccum wheat lines have been identified and characterized for the DUS traits. Forty five amber coloured free-threshable dicoccum wheat lines have been identified.
- *Lr24* and *Lr28* leaf rust resistant genes have been introgressed in the back ground of DWR 162 (popular variety of PZ). Presently the material is in the BC_2 stage.
- Molecular characterization of free-threshable mutants was conducted with SCAR marker.
- Developed value added based therapeutic and nutrient enriched products of dicoccum wheat
- The following emmer wheat products for diabetes patients were developed
    - Enriched buns
    - Instant sadaka uppuma mix for diabetes subjects
    - Micronutrient enriched flour mix

Comments of the QRT on the performance of AICRP Centres on Wheat and Barely

The performance of the centres was evaluated and comments of QRT on the performance of AICRP centres is given hereunder :

Centre	QRT comments
Northern Hills Zone	
Malan (Palampur)	This center should focus on double haploid production, spring x winter wheat, rust, powdery mildew, frost tolerance, development of varieties for restricted irrigation. Further improvement in research output is required.
Bajaura	Center needs to concentrate more on rusts, powdery mildew, barley - dual purpose and malt barley, hulless.
Dhaulakuan	Center should focus on yellow rust, powdery mildew, head scab, rainfed varieties and frost resistance.
Northern Western Plains Zone	
Ludhiana	This centre has been doing excellent work and should concentrate on Pre-breeding, doubled haploid production, yellow rust, powdery mildew, Karnal bunt, hybrid wheat, early sowing varieties, conservation agriculture (CA) and in barley –feed/fodder/malt.
Hisar	This centre has been doing good work and should concentrate on drought and heat, brown rust, salinity, short duration varieties, cropping system specific varieties (cotton-wheat), specific varieties for zero tillage and malt barley. No synergy exists from biotech unit to wheat project.
Durgapura	The performance of the centre is excellent. The centre should give more emphasis on drought and heat, Cereals Cyst Nematode, water use efficiency, conservation agriculture for light soils and in barley – feed, fodder and malt.
Pantnagar	The centre should focus their work on rusts, quality and conservation agriculture. The centre needs immediate improvement. There has been slackening, hence needs revival of overall activities.

Modipuram	Centre should focus on development of system perspective varieties (sugarcane-wheat system) suitable for late sown condition. Centre needs overall improvement as performance is poor.
Jammu	The centre should work on development of varieties suitable for restricted irrigation, yellow rust, powdery mildew, conservation agriculture. Majority of experiments were poorly managed when QRT visited Jammu on March 31, 2013. Overall improvement is badly required.
North Eastern Plains Zone	
Kanpur	This center may put its research efforts on short duration, terminal heat, brown rust, alkalinity, system perspective variety (wheat –potato), Barley – feed, food, leaf blight & rust. Centre needs improvement.
Faizabad	The centre should focus on water logging, alkalinity, heat, brown rust, foliar blight an in Barley – feed & grain, leaf blight, salinity/alkalinity. There has been slackening in the performance of this centre, hence needs revival of activities.
Varanasi	The centre should concentrate on rainfed, rust and blight, quality, CA-tillage options, barley – feed, grain and leaf blight. Slackening is evident, hence revival is anticipated. Centre needs immediate overall improvement in its performance.
Sabour	The centre should focus on development of short duration varieties suitable for late sown condition and work on leaf blight, heat tolerance, brown rust, surface seeding, system perspective varieties (Rice-wheat).
Ranchi	This center should focus their work on leaf blight and brown rust, drought (RI), acidic soils, iron toxicity.
Kalyani	This center should concentrate more on late heat, short duration, water use efficiency, nutrient use efficiency.
Coochbehar	This center should concentrate on screening of material for foliar blight and pre-harvest sprouting, breeding varieties for timely and late sown conditions in collaboration with DWR under shuttle breeding programme and nutrient deficiency (B, Fe, Zn).
Shillongani	This center should give more focus on nutrient deficiency (B, Fe Zn), foliar blight, pre-harvest sprouting, short duration varieties and improving plant stand.

Imphal	The centre should work on nutrient deficiency (B, Fe, Zn), foliar blight, pre-harvest sprouting.
Central Zone	
Kota	The centre should focus on durum breeding, biotic and abiotic stresses and water use efficiency.
Udaipur	The centre needs to intensify the work on resource conservation. Immediate improvement is required.
Vijapur	Contribution of the centre is appreciated. They should focus their work on drought, heat, wheat quality, durum improvement.
Sagar	This center lacks its own breeding programme hence they should be provided with more advance bulk material for selection. The centre should work on drought, heat and WUE. Performance needs immediate improvement.
Junagarh	Contribution of the centre is appreciated. They should focus their work on black rust, drought, heat and wheat quality.
Gwalior	The centre should focus on drought, heat and resource conservation.
Rewa	Centre should intensify the work on breeding rust resistant barley varieties for feed & grain. There is need to improve the performance.
Powarkheda	Contribution of the centre is highly appreciated. They should work on drought, heat, wheat quality and durum improvement.
Bilaspur	The centre should focus on developing shorter duration varieties and work on drought and heat.
Peninsular Zone	
Pune	Centre should intensify their work on drought (WUE), heat, leaf blight, black rust, dicoccum & durum improvement.
Niphad	Progress is appreciated by the QRT. The centre should work more on drought, heat, black rust and durum quality.
Dharwad	Centre should concentrate their work on drought, heat, brown and black rust, leaf blight, durum quality, dicoccum improvement.
Mahabaleshwar	Centre should intensify the work on rust screening and pathotyping. There is need for overall improvement.

ACTION TAKEN REPORT ON RECOMMENDATIONS OF QRT (2002-2007)

Organizational, Administrative and Financial Management

1. We propose to ICAR to establish 2 more Centres of excellence on the same patterns to DWR, Karnal. These should be based in one NEPZ and second in CZ/PZ.

   Strengthening IARI Regional Research Centre at Indore in Central Zone and IARI Regional Research Station at Pusa Bihar in NEPZ is not under the purview of DWR. However, in NEPZ centers like Cooch Behar, Ranchi and Sabour are being strengthened. Moreover, effort are being made to acquire land near Lucknow through talks with Uttar Pradesh Government involving ICAR.

2. Because we were not able to examine in details the financial aspects and administrative setup of DWR, it is recommended that a separate committee examines this issue in due time as part of this review.

   As per ICAR comment, the financial and administrative aspects of DWR are regularly reviewed by the mandatory audits and also by Institute Management Committee and others from time to time. Hence there is no need of a separate Committee. Hence, no action has been taken.

Policy and Perspectives

3. Performance of different varieties is assessed based on their grain yield per unit of land. This is a important indicator but with climate change and emerging scarcity of water and energy, other indicators like stability and efficiency are also acquiring importance. It is suggested that in future due consideration should be given to varietal attributes like (a) resilience to withstand climatic aberrations and (b) input use efficiency. Thus assessment of performance of different varieties should be based on a composite index which incorporates all important attributes by assigning suitable weights to them.

Action has been taken as suggested. Resource management group is conducting trials of final year testing genotypes for days to sowing and different levels of fertilizers. A trial for evaluating performance on heat tolerance has also been started.

4. DWR undertakes large number of FLDs. Yield gain in FLDs is reported to range from around 20% in NWPZ to 113% in SHZ. These FLDs can be used as a effective tool for creating multiplier effect of technology and for resource generation for DWR through appropriate marketing of produce of FLDs. DWR should forge links between farmers and private sector for sale of good quality output of FLD crop as seed, so that this output takes technology of improved seed to large number of farmers. DWR is also engaged in development of high quality wheat like durum. However, produce of such high quality wheat often faces problem of marketing. DWR should explore possibility of supplying such seed to private sector interested in procuring quality wheat. The private sector can then use option like contract farming to promote production of quality wheat. This kind of move is consistent with the new guidelines of ICAR on commercialization of technology. It is also important to find out exact causes for variation in yield gap in different states and region

   Action has been taken as suggested. Newly developed durum genotypes are evaluated for end product quality and high yellow pigment content so that industry people are attracted. Meeting with NGOs and stakeholder was organized and product specific varieties were told to them.

5. ICAR should write to Commission on Agricultural Costs and Prices (CACP) to consider MSP for wheat based on quality as is the case with paddy, sugarcane and some other crops.

   This issue is being highlighted in meetings with officials of Ministry of Agriculture, GoI.

6. DWR and its cooperating Centres have developed a large number of location specific varieties and technologies. The Centre has some

information on state wise and technology wise impact of various technologies on yield. This information needs to be widely publicized. It is highly pertinent to find out effectiveness of FLDs as a tool of technology dissemination. This can be done by studying the state of technology at the farmers field in the post FLD year. DWR should take up studies on yield level at farmers field after one to three years from the period when FLDs were conducted. The impact of technology goes beyond yield. DWR should take up some studies on impact of their technologies.

As new economist has joined recently at DWR, this activity is being taken up.

7. Patents are becoming very important not only for protection of intellectual property but also as a means of future wealth and as an indicator of achievement in science. DWR should consider patenting of its innovative technologies.

A total of 87 wheat varieties have been registered with PPV&FRA under extant category, while another 15 varieties are under consideration of the Authority for registration.

8. Rice - wheat rotation is the most important crop sequence in the country and this fact sometimes diminish importance of other crop sequences. For instance, a very high percent of wheat research at DWR is concentrated on wheat as a part of rice-wheat rotation. It seems we have overlooked the fact that area under rice- wheat rotation does not cover even 50% of the total area sown under wheat in the country. But there is very less emphasis on wheat research in the other crop sequences. This needs to be balanced.

As suggested action is being taken. The wheat breeding programme of the country is developing varieties with varying maturity durations to fit well in timely, late and very late plantings and thus suitable for different crop rotations like rice-wheat, sugarcane-wheat, maize-wheat, soybean-wheat, cotton-wheat, potato-wheat, pigeon Pea-wheat etc.

Research Achievements and Future Thrusts

9. We strongly recommend the implementation of six Networks on Marker assisted wheat breeding, hybrid wheat, salt tolerance, thermal tolerance, drought tolerance and conservation agriculture.

Six Network projects namely Bioinformatics, Development wheat hybrids through CMS system, Improvement of salt tolerance in wheat using molecular approach, Thermal Tolerance In Wheat: Phenotyping for adaptive mechanisms to facilitate MAS based wheat breeding, Drought tolerance in Wheat :Phenotyping for adaptive mechanisms to facilitate MAS based wheat breeding and Genetic enhancement and conservation agriculture for improving the productivity, profitability and sustainability of rice-wheat cropping system were initiated during the XIth plan.

10. We recommend exploitation of spring x winter, Ae. squarrosa based synthetic wheats, super wheats and hybrid wheat as a methodological and genetic options to increase yield potential and yield stability along with market acceptable grain quality. We also recommend RCT including water use efficiency and nutrient use efficiency as traits for selection.

The breeding efforts are already being made to utilize winter wheat gene pool, synthetic wheats and super wheats (buitres) in the development of new varieties. Breeding wheat varieties specific to RCT (tillage options) is also being undertaken. Research on identifying water-use and nutrient use efficiency traits is under progress and these will be used in selection process.

11. It is necessary and prudent to examine the worth of AICW&BIP trials conducted under station management. It appears logical that in most cases station lands have deteriorated in fertility due to poor management over 50 years of establishment.

As described this is being taken up prudently. Necessary instructions are given to centres in this regard.

12. Targeted production of 93 million ton by 2020-21 would be achieved through large scale training of farmers through FLDs and their multiplier effects. We recommend cautious and widespread demonstration and training of farmers and trainers in the KVKs.

FLDs are being regularly conducted During 2007-08 to 2011-12, 3703 wheat front line demonstrations (WFLDs) were conducted at 7949 farmers' fields covering 3857 ha area across 18 states. The yield gain (%) varied from 29.95 to 73.27 in NHZ, 34.60 to 96.23 in NEPZ, 11.09 to 25.21 in NWPZ, 39.73 to 57.75 in CZ and 16.29 to 30.44 in PZ.

13. FLDs are the best option to close the gaps in wheat productivity. We recommend that all districts and Panchayats are covered by capable extension workers/ NGOs reaching out to farmers.

FLDs are being conducted by DWR at maximum number of locations and as per resources availability.

14. Surveillance program should be strengthened to include wheat zones in the country. It should be organized in networking mode and fully supported by DWR.

Surveillance programme has been strengthened under AICW&BIP with major focus on crop health in NWPZ/NHZ. In XII plan a Network project on Biotic stresses has been proposed which will further strengthen this programme in various zones, including NWPZ.

15. A lot of variation in pathogenic and molecular variability in Karnal bunt and spot blotch pathogens has been reported from different centers. There is need to generate the uniform information so that durable resistance be identified in the germplasm for affected areas.

Variations in KB pathogen and isolates exist. Wheat genotypes were evaluated at multilocations with the prevailing isolate of the area for ensuring the durable resistance.

16. The powdery mildew will be a future disease and its incidence has increased in recent years and particularly in raised bed method of cultivation. To manage the disease, the information should be generated on its epidemiology, pathogenic variability, role of cropping system and management through IPM.

Powdery mildew has been included in the XII Plan under the network project on Biotic Stresses which will cover the enlisted aspects. At present, multilocation trials on disease control and search for new molecules and sources of resistance are being conducted under AICW&BIP.

17. The DWR generated very good information on IPM module against pests and diseases of wheat in the farmer's field. The results have shown at least 10% increase in yield. This module should be tested at different locations for validation and promotion on large scale.

The IPM modules are being promoted in Karnal and Kaithal districts on large scale. The extension wing of DWR has also undertaken it under demonstrations. These modules have also been extended to NEPZ and PZ under AICW&BIP for the last 3-4 crop seasons.

18. In view of globalization in trade, the work should be initiated to develop reliable molecular methods to detect the seed borne pathogens (Karnal bunt, spot blotch and *Fusarium* scab etc.) in the seed lots of wheat and barley. It will help issuing the sanitary and phytosanitary certificate for export and import.

Molecular markers are being used for differentiating these pathogens at molecular level.

19. The efforts should be made to estimate the losses caused by emerging diseases and pests like, powdery mildew and aphids.

Losses caused by powdery mildew disease have been estimated through multilocational trials in NWPZ and NHZ. For aphids also, trials are being conducted.

20. At present, for promotion and identification of wheat entries, the system of A. C. I. (Average Coefficient of Infection) of rusts is being followed for enhancement of rust resistance under artificial epiphytotics (PPSN). The present level of ACI has been kept as 15 for irrigated timely sown conditions, 20 for entries showing statistically superior yield whereas ACI of 25 is kept for stress conditions like alkalinity-salinity trials. The susceptibility of identified entries will increase many folds as soon they reach farmers fields. Therefore, it is suggested/recommended that the level of ACI should be reduced and kept as 10, 15 and 20, respectively in the above cases. The level of rust disease should not be more than 20S in normal conditions and 30S in case of stress conditions. This will help in selecting and promoting highly resistant materials for identification.

This issue was discussed in the Plenary session of the 50th All India Wheat & Barley Workers Meet, held in September 2011. The breeders proposed to increase the level of ACI beyond 15, 20 and 25. However, it was not agreed upon and for the time being, the present system of ACI level is continuing. Efforts will be made again in future to keep the level of rusts upto 20S with ACI <10.0 under irrigated trials.

21. The losses to food grains in storage due to insect pests is estimated about 12-16 million metric tones annually. This problem can be managed by identifying sources of resistance against major storage insect pests and pathogens of wheat, incorporating resistance in superior agronomic backgrounds and identifying non chemical methods for integrated management.

Studies are being undertaken under AICW&BIP for identifying the sources of resistance and the host response in case of AVT entries and released varieties at multilocations. One project on storage pest management through IPM was formulated at DWR, Karnal but due to non-availability of an Entomologist at DWR, it has been kept in abeyance, for the time being.

22. Increase the slow rusting and adult plant rust resistance in Indian wheat cultivars. Also design wheat plant for diverse dwarfing genes and photoperiodic response.

Materials have been identified for slow rusting and adult plant rust resistance in Indian wheat through studies involving AUDPC in advance lines, and new and diverse sources of resistance.

23. High temperature and drought tolerance traits must be studied physiologically and defined through QTL traits. Marker assisted selection is needed for rapid progress. DWR needs to get involved in transgenics for abiotic stress tolerance. Collection of synthetic wheats should be studied for heat and drought tolerance.

New dwarfing genes like Rht 8 and Rht13 have been used to diversify the germplasm. These genes do not reduce the coleoptile length.

24. CTD should be used as selection method in small plot trials as one of the criteria to select suitable germplasm for stressed environment.

Canopy temperature depression (CTD) is being used to evaluate the heat and drought tolerant genotypes. Many genotypes have been identified on this basis.

25. A minimum of 11.5% protein content on 12% moisture basis and with minimum test weight of 78 kg/hectoliter be made mandatory for the release of bread wheat variety irrespective of trial conditions and zones.

Genotypes with >80 kg/ha weight are preferred while releasing a variety except for varieties for biscuit where low protein is required.

26. For the development and production of durum wheat specifically for making pasta products, the activities should be restricted to CZ and PZ. Minimum grain protein content of 13% and beta-carotene of 7.0 ppm.

Agreed as far as the identification and release of durum wheat varieties are concerned for the Central and Peninsular Zones. Protein content (12.0 %) and beta-carotene content (6.00 ppm) are considered. Attempts will be made

to enhance the protein content to 13.0% and beta-carotene to 7.0 ppm as our future strategy.

27. DWR should have a full fledged biotechnology facility for molecular markers, functional genomics, doubled haploid production, transformation and bioinformatics.

DWR now has a full fledged biotechnology facility working on molecular markers, double haploid, transformation and bioinformatics. DWR also has an Agri Bioinformatics Promotion Programme.

28. MAS should become integral part of the breeding programs

The application of MAS is already being adopted in the breeding programmes of the Directorate as well as at important cooperating centres.

29. Breeders in various centres should be made aware of the MAS technique and be given minimum required training to enable them to understand and appreciate the utility of the system.

Several scientists from DWR as well as AICW&BIP centres have been trained in international advanced laboratories.

30. There should be a strong durum breeding, quality and agronomy program in CZ and PZ only. Such programs in other zones should not be funded from ICAR resources.

DWR, Karnal being a nodal agency,will continue with the activity of germplasm enhancement of durum wheat and its sharing with durum wheat scientists located in the CZ and PZ. Activities will be further strengthened.

31. More Dicoccum based products should be promoted in Indian diets because of their therapeutic advantage.

UAS, Dharwad is proactively working for promoting Dicoccum based products.

32. A strong barley breeding is recommended at Karnal and Durgapura. All the other locations should serve as testing sites. Malting trait should be the highest priority for breeding along with yield and disease

resistance. Molecular marker use should be accelerated. Durgapura should be provided with micro malt testing facility.

The recommendation for strong barley breeding is recommended at Karnal and Durgapura for malting and other objectives. However the proposal "All the other locations should serve as testing sites" is not agreeable since rest of the five funded centres have been created with zone / area specific objectives under the Barley Network. They are addressing issues of rainfed, saline alkaline soils, besides feed and forage barley with incorporation of resistance to diseases and pests. A network project involving major barley research centres has been proposed during XIIth plan, in order to address the issues raised by the QRT in its recommendations.

33. A large number of voluntary centres are contributing to the conduct and collection of data from coordinated trials. The role of these centres needs to be reassessed. These Centres should be provided with some contingency grants. Since most of the SAUs seem to be reeling under financial constraints, support will ensure proper collection of data and increase its reliability.

Need-based contingency are being provided to effective voluntary centres for conduct of trials.

34. There seems to be some amount of subjectivity in reporting data from coordinated trials. To have more independent and reliable data, coding of varieties entered in coordinated trials may be introduced. This may requied lot of efforts from DWR, since the trials have to be constituted at Karnal and sent to other locations.

The coding of entries of all trials has been started since 2011-12.

35. The role of SVRC vis-a-vis CVRC needs to be more delineated. From the presentation of the coordinated centres, it appears that; the centres are using this mechanism to bypass critical testing in the coordinated trials. While agriculture is a state subject, it: cannot be different from national priorities. The system requires a thorough overhaul. One suggestion

is as follows: The workshop, on the basis of coordinated trials, should make a recommendation that a line is suitable for a particular state, if does not qualify for consideration for the entire zone. The breeder, on the basis of this recommendation, submits a proposal to the state varietal release committee. It is for the breeder to generate multilocation data on the genotype, if it is a requirement of the state. The system of pulling out varieties from NIVT stage for consideration of SVRC should be stopped. It is for the breeder to choose varieties which will be good for the state for conducting multilocation trials. The release proposal for SVRC should be submitted only after the workshop recommends to that effect.

This issue is being discussed in the Annual Wheat workshop and in other meetings. It is being emphasised that AICW&BIP data must be given due consideration and that any rust susceptible variety should not be released through SVRC.

36. The breeder should also have a choice to request for reconsideration of the identification of a genotype for the zone. When the proposals for identification of varieties are submitted to the workshop, it should be possible to give reasons for not considering the variety for identification, just as the reasons for identifying a variety are given. This will give more transparency. The breeder may be given an option to request for reconsideration by an independent committee.

Not agreed by the ICAR. Reasons for non-consideration of variety for variety identification are clearly spelt out and provided in a transparent manner. One is always free to mention to the Council if one find any real fault. Hence, no action required.

37. Quality parameters have to be given more importance while recommending varieties for cultivation. All the Centres should have minimum facilities for rapid screening of lines for quality parameters. A two-tier or three-tier level of sophistication need to be developed in

the country for developing product-specific wheat and product-oriented research.

Action continues as suggested. Work is already in progress. Facilities for quality analysis have been created at DWR, Karnal; PAU, Ludhiana; GBPUA&T, Pantnagar; BHU, Varanasi and UAS, Dharwad. These centres take care of the analysis of all the entries of coordinated trials as well as experiments.

38. Germplasm development adapted to Surface Seeding, Zero-tillage, raised- bed planting and deeper sowing under different wheat based cropping systems.

The breeding of wheat varieties to suit to zero tillage cultivation and other RCTs is already in progress. The advance materials (AVT-II stage) may likely be tested under various RCTs in the coordinated programme.

39. Identify germplasm resistant to sprouting situation for eastern plains.

Cooch Behar and Shilongani centers identified many pre-harvest sprouting resistant genotypes, which are being used in crossing program. DBW 14 is found tolerant to pre harvest sprouting.

40. Designing experiments of high yielding varieties under different sowing dates and fertilizer applications, water regimes to identify varieties adopted across the production conditions.

The dates of sowing, water regimes and fertilizer levels experiments are being conducted for identifying and release of test genotypes as varieties for different production conditions.

41. Research on integrated residue management will help correct N:P:K Fertilizer imbalances, micro-nutrient deficiencies and sequester soil carbon besides mitigating climate change effects and adapting to it.

The long term experiments addressing the crop residue management issue are in progress at the Directorate of Wheat Research. Under coordinated set up

also experiments were conducted in different zones on residue management in wheat based system.

42. Research on input efficiency through adoption of better machinery and implements including - Laser land leveling and turbo-seeder multi-crop planter (conservation agriculture).

The long term experiments on conservation agriculture using rotary disc drill are in place. Moreover, laser land leveling is a proven technology and large scale adoption is being done by the farmers.

43. Develop better adopted varieties for improved straw quality to meet the nutritional aspects of health of livestock.

Necessary action is being taken in this regard.

44. We suggest parallel research on alternative sources of growth like para/relay cropping in sugarcane and cotton, surface seeding after rice in wetlands and wheat after short duration pigeon pea should be undertaken.

The experiments were and are being conducted on these aspects in different agro-climatic conditions.

45. We suggest that a large number of young scientists with Ph.D. entering into the DWR/AICW&BIP system should have Post-Doctoral Program in foreign countries or at CG centres funded through ICAR. This would broaden their outlook, intellectual capabilities and leadership ability.

Enhancing the HRD is the key area in ICAR system and training of scientist in frontier areas including biotechnology and marker assisted selection breeding is being taken up and this was further strengthen during the last five years.

46. We also recommend that the courses on leadership, team spirit should be organized by DWR of Karnal at regular basis.

Scientists are participating in such courses being organized at NAARM, Hyderabad.

47. We highly recommend that DWR should have a first class facility for holding training courses including trainee hostels.

This could not be taken up as resources were not available.

48. We recommend cost benefit analysis and impact of varieties and technologies on regular basis to judge the efficiency of program

With the joining of new Economist at DWR this study has been initiated.

Interaction and linkages between DWR, State Agricultural Universities (SAUs) and International Centres

49. All the funded centres must be asked to initiate pre-breeding activities on top priority to generate variability for screening for location-specific traits.

Work has already been initiated and good progress has been made at some centres like PAU, Ludhiana; ARI, Pune. A flagship programme has also been mooted in XII Plan on pre-breeding involving several centres.

50. The Durgapura centre may be shifted to central zone, since other centres in Rajasthan, viz. Udaipur and Kota are in Central Zone. This will resolve operational problems in the state.

Not Agreed. Both Kota and Udaipur centres and the area of Rajasthan within their jurisdiction is in the Central Zone and under the control of a newly created SAU i.e., MPUA&T, Udaipur. The shifting of Durgapura centre from NWPZ to CZ will render the northern Rajasthan unattended which is very close to the climatic conditions of NWPZ than CZ.

51. Wherever facilities are available, use of MAS should be encouraged by involving molecular biologists in breeding program.

Action has been taken and this is now in place.

52. Vast amount of data is being generated by the cooperating centres in the form of coordinated trials. This data is only being used for varietal

promotions and release. Efforts should be made to make use of the data for measuring G X E interactions and other relevant information.

The data is being be used to generate relevant information regarding wheat trial evaluation and improvement thereof. The long term data is also used to analyse production trends in different wheat production zones of the country.

53. Centres which have consistently shown poor performance in conduct of trials should be asked to improve if they wish to be continued in the ACIW&BIP

Project Director is constantly monitoring the performance of centres with respect to conduct of trials. Visits to most of the centres have been conducted and the issue has been discussed with Director of Research/Vice Chancellor of the respective centre.

54. We support renewed collaboration between ICAR and CIMMYT on wheat research and human resource development. However, we caution that the priorities of this collaboration must coincide with ICAR's priorities.

Collaboration between ICAR and CIMMYT on wheat research has been considerably improved with regards to human resource management. A large number of wheat researchers have being trained at CIMMYT, Mexico, Nepal and Kenya. Germpalsm in form of nurseries and trials are being from received from CIMMYT every year and well distributed. Good collaborative work on wheat improvement under CSISA and on resource management have been done.

55. Similarly, we propose a strong relationship with ICARDA on issues related to wheat progenitors and prebreeding and improvement of malting irrigated barleys.

During the XIth plan germplasm was imported from ICARDA, particularly the wild species and barley germplasm in the form of nurseries. A joint project

was formulated for tapping the vast germplasm resources in the primary centre of evaluation of wheat with ICARDA.

Science Quality in DWR/ AICW&BIP

56. The scientific output of the centres is not very impressive. The DWR should motivate the centres to produce quality research and publication in refereed journals.

The Project Director has been constantly monitoring all the centres and improvement in the quality of research is now seen.

Infrastructure and Facility Needs of the DWR and AICW&BIP

57. We strongly support the investment of Rs. 21.6 crores for infrastructure in Eleventh Plan. We also recommend that the use of these implements is verified for efficiency and effectiveness.

This was properly reflected in the XI Plan document. Construction of second phase building is long due at DWR with the increase in staff and equipments facilities. However, this could not be taken up during XI Plan due to escalation of costs.

OVERALL RECOMENDATIONS

Quinquennial Review Team (QRT) reviewed in depth the progress of research, coordination, and technology transfer of DWR and AICW&BIP. The team was provided with "Background Information" related to progress made during the period 2008-2013. The detailed reports of DWR and all the 31 centres (24 centres exclusively for wheat, 6 centres devoted both to wheat and barley and one centre exclusive for barley), technical bulletins, RAC and IRC proceedings, interaction with IMC members list of research projects and their status, linkages, SWOT analysis etc. QRT also visited various centres and interacted with scientists, Heads, Directors and Vice Chancellors. Based on materials submitted and interactions with stakeholders, the Team is giving the following recommendations to further strengthen the research, coordination, infrastructure facilities for meeting the future challenges of maintaining national food and nutritional security.

DIRECTORATE OF WHEAT RESEARCH

Policy issues

- ICAR should strengthen Barley Coordination Unit with a regular Coordinator from the existing Principal Scientist position of barley, under the overall administrative control of Project Director, DWR. It is also felt that the Principal Investigators of the various coordinated programme should be positioned based on expertise and experience rather than seniority.
- DWR/ICAR should explore the possibility of enhancing Public-Private Partnership in seed production and malt barley research for its evaluation, popularization and commercialization. This needs a clear guidelines from the council.
- The Directorate should develop mechanisms to distinguish between better quality wheat and ordinary wheat, so that a separate and

premium Minimum Support Price for high quality and nutrient content may be fixed by the CACP.

- Coordination with CG Centres – While acknowledging the significant contributions of CIMMYT and role of Dr. N.E. Borlaug in introduction of semi-dwarf varieties in the past, it is now felt that either the CG Centres will continue the similar role in serving the farming community or may like to deviate from true partnership and prefer a role of competitor in various research and development activities in the country. ICAR may like to evolve certain criteria/parameter in this regard.

General issues

- Scientists should also make major efforts to write good R & D projects for funding from DBT, DST, UGC, ICAR, DOAE, etc. Wherever possible and necessary, they should develop multi-institutional and multi-disciplinary collaborative programs both at the national and international level.
- To improve emphasis on durum wheat, research should be assigned to one centre in each durum growing state. This is necessary because several wheat research centres in the country are being involved in breeding durum wheat, though the area in their states under durum wheat is relatively marginal.
- Niche areas in NWPZ should be explored for the testing and cultivation of Dicoccum wheat (may not be on a large scale). In this connection, some project(s) could be initiated in association with medical specialists, since dicoccum wheat is being sold at a premium due to its therapeutic value, especially for diabetics.
- Research on rainfed wheat should be curtailed, especially in Punjab and Haryana, where area is limited and efforts should be diverted to limited irrigation conditions (one supplemental irrigation at seeding stage or two irrigations, one at seeding stage plus other at critical growth stage

of wheat). Since previous crop and soil management practices affect the soil moisture supply, cropping system based research on rainfed wheat need to be conducted in future.

- Efforts should be made to extend wheat to non-traditional areas. In earlier experiments coordinated by DWR at 2-3 locations in Andhra Pradesh revealed that wheat was more successful and yielded more than 4 tonnes per hectare with economical use of water than rice.

Crop Improvement and Biotechnology

- Gene pool needs to be widened through alien sources; this should be prioritized for creating diversity. Utilization of alien genetic variation should be exploited in a targeted manner for the development of interspecific/intergeneric or intraspecific chromosome segment substitution lines (CSSLs). Wide hybridization should involve synthetics, land races, wheat progenitors and other related *Triticum* species. Research on hybrid wheat, which is currently insignificant, needs to be scaled up with more concerted efforts involving the competent cooperating centres.
- Wheat breeders should incorporate more than one effective resistant gene in a variety for increasing the longevity of a variety (this is possible through use of marker-assisted selection); such varieties with pyramided resistance genes should be given preference during the process of identification and release. Ludhiana centre has done good work in developing wheat material resistant to yellow and brown rusts with more than one effective different resistant genes. These lines are in advance stages. At least one more centre should undertake this type of project for targeted resistance for yellow rust as a long term strategy.
- Genetics of pre-harvest sprouting tolerance should be studied and utilized in breeding programme, particularly for the development of wheat varieties for the north-east region.

- Some work in the field of alternate dwarfing genes for drought and heat should be initiated in network mode, for which facility needs to be developed. It is also recommended that a National facility for screening of material for heat and drought tolerant be created at DWR.
- Marker-assisted selection (MAS) should be an integral component of plant breeding involving both biotechnologist and plant breeders. The facility for MAS should also be strengthened at few deserving AICW&BIP centres.
- Doubled haploid (DH) facility and expertise should be strengthened, so that it becomes a routine exercise to produce DH plants in large number to be shared with coordinating centres. For this purpose, walk-in growth room facility should be made available and well maintained by dedicated staff.
- DWR should enhance the work on shuttle breeding on the pattern of CIMMYT; generate, advance and share the material as per the need of specific coordinating centres in general and those which are unable to make the crosses and generate the breeding material, in particular.
- Feasibility of initiating work in the field of genomic selection (GS), genomic estimated breeding values (GEBV) should be explored. This should be particularly utilized for development of water/nutrient use efficient material by involving physiologist and breeder.
- Biotechnology should develop and grow in the area of quantitative genetics and genomics research to generate knowledge that is useful for breeders. There should make full use of the biparental mapping populations for interval mapping, joint linkage analysis, joint linkage association mapping (JLAM), etc. Multi-parental mapping populations like multiparental advanced generation intercross (MAGIC) populations should be developed for further genetic analysis.
- Efforts may also be made to develop wheat HapMaps so that instead of markers, in future haplotypes may be used for genetic analysis and

MAS. If possible, research should be strengthened in the area of statistical genetics/genomics, both in terms of manpower and infrastructure (computational capacity). Comparative genomics utilizing the available databases on genomic sequences (wheat genome sequence being now available) is another area, which can be initiated.

- DWR should develop a road map for developing transgenic wheats, including capacity building required for this advanced area of research. There is a need to initiate work in the area of wheat transgenics for heat and drought tolerance for which variability is not available within the available wheat germplasm.
- Genotyping using high throughput systems such as New Generation Sequencing (NGS) including genomic selection should generally be outsourced, since it has now become cost-and time effective.
- Bioinformatics facility at DWR must be strengthened to serve as a nodal agency for all wheat workers in India. It should include exhaustive information on plant breeding, wheat genetics, genomics, molecular markers (SSRs, SNPs, DArT and RAPD markers), world-wide MAS derived varieties, mapping populations for different traits, QTL and marker-trait associations databases, etc., either in the form of DWR's own databases, or in the form of links to other sources. There is a need to develop online database of coordinated trials since 1965, by the Directorate.

Crop Protection

- Strategically deploying stripe rust resistant diverse genes in Northern Hills Zone (NHZ) and North Western Plains Zone (NWPZ) and creating awareness amongst farmers should be continued on priority. This can be effectively managed through varietal replacement in such areas.

- In order to increase diversity and identification of additional source of resistance for black rust, advance lines screening against Ug99 pathotype of *Puccinia graminis tritici* be continued at Kenya and Ethiopia.
- In order to make Indian wheat suitable for export, especially to countries having zero tolerance to Karnal bunt, enhanced efforts in developing KB resistant wheat varieties should be undertaken. Powdery mildew is gaining notoriety, hence the need to strengthen research on epidemiology, variability and assessment of losses etc.
- Controlled poly-house facility for studying the host-pathogen interaction is recommended for DWR Karnal.
- Research should be strengthened on cropping system based studies on nematode infestation and its control including biological control in wheat and barley.
- Modern tools, such as remote sensing and GIS, should be developed and used for disease and pest surveillance. Changes in pests and diseases dynamics due to climate change should also be studied.

Resource Management

- DWR has already initiated studies on developing nutrient (N, P and micronutrient) efficient germplasm; this should be applicable to all the situations and regions. The work on developing P efficient genotypes, should particularly be prioritized for acid soils where P use efficiency is much lower than on the alkaline soils. The work on Mn efficient genotypes should be confined in the northwestern plain region where severe deficiency of Mn is wide-spread. DWR may identify few potential centres' which should focus their research on developing nutrient efficient strains.
- Conservation agriculture (minimum tillage, residue retention and crop rotation) is spreading to large areas in many parts of the world; India is also making good progress in this area of research. There is a need

for developing need-based wheat genotypes suited to CA. Information on change in the dynamics of weed flora and pest population in wheat should be made available.

- Cotton- wheat/barley is an important cropping system, which needs special attention in terms of developing new genotypes or resource management technology.

Quality improvement

- Research (utilizing MAS) may also be initiated for developing wheat germplasm suitable for consumption by people suffering from celiac disease. Projects in collaboration with some Medical College/Hospital may be prepared and submitted to DBT for funding wheat research dealing with celiac disease.
- Breeding for more nutritionally superior varieties rich in protein, iron and zinc and other micronutrients should be undertaken

Social Sciences

- The Directorate needs to develop a data warehouse covering global, national, state and district-wise information on area, production, productivity, prices, trade, and improved varieties and resource management technologies.
- Impact assessment of improved varieties and resource management technologies should be taken up by the Directorate. The study may also assess constraints to adoption of promising varieties and technologies for their refinement.
- The Directorate should document various market outlooks (such as FAO, ACIAR, USDA, etc) for wheat and barley and develop a synthesis for government to take informed decision on prices, procurement and trade. The Directorate should also develop expertise on modelling wheat and barley outlook on a regular basis.

- DWR should document and analyze existing and innovative value chains for wheat and barley, and propose strategies for up-scaling and/or out-scaling best practices to improve the value addition and marketing efficiencies.
- Large gaps exist between wheat yields at research farm and the farmer field as well as between farms within the same area. To increase wheat productivity by bridging the yield gaps, DWR should develop a special project/ programme in collaboration with state departments of agriculture and utilizing manpower provided under KVKs. ICAR and Ministry of Agriculture could be approached for financial help to implement the program. Special FLDs for enhancing yield through RCTs, zero tillage, cotton relay sowing, etc should be initiated.

Barley

- DWR should explore utilization of wild germplasm (other *Hordeum* species) for the improvement of grain malting quality and disease resistance.
- DWR should undertake comprehensive studies involving losses due to aphids; this may include assessment of losses, control measures by chemicals and also development of high yielding aphid resistant barley varieties using better donor such as EB 921 and other available sources through conventional and marker assisted breeding.
- DWR should explore the possibility of barley cultivation in non-traditional areas such as rice-fallow system, saline areas and also to work out the demand projection and supply of barley by 2020-2030.
- To enhance the dwindling barley area in the country, research and extension on malting barley need emphasis with premium on good quality malt barley. Public & private partnership initiated under DWR on malt barley needs further strengthening.

DWR, Regional station Flowerdale, Shimla

- DWR, Regional station Flowerdale, Shimla is maintaining more than 125 pathotypes in pure form on living plants. Hence, proper cryo-preservation facilities should be developed for the maintenance of these pathotypes. At emperature controlled plastic tunnel is recommended for DWR, Regional Station, Flowerdale, Shimla for studying the pathotype specific adult plant resistance in AVT material.

DWR, Regional Station Dalang-Maidan, Lahaul-Spiti

- Doubled haploid facilities along with infrastructural support need to be developed at Dalang-Maidan, Lahaul-Spiti for conduct of research in the off-season.

OVERALL ASSESSMENT

Based on the quality and volume of research work, varieties in wheat and barley developed, released and commercialzed, technologies generated and publications made, the QRT is pleased to rate the performance of DWR as **Very Good**.

ALL INDIA COORDINATED WHEAT AND BARLEY IMPROVEMENT PROJECT

After reviewing the progress of work and identifying the constraints of 31 funded centres the QRT proposes the following recommendations to further improve the efficacy of AICW&BIP.

- QRT recommends re-organization of AICW&BIP centres with in a single SAU or among SAUs within a state, where the new universities are created and the demand for set up of new centre is increasing. This will prevent undue expansion of AICW&BIP centres, manpower and save ICAR from huge economic burden.

- Since wheat and barely are single season crop, the few months of centre staff remains not fully utilized, hence they should be utilized for undertaking other studies related to region cropping systems or some related activities.
- At many centres, number of posts is lying vacant for 2-5 years. QRT feels that ICAR should frame strict norms so that a post does not remain vacant for more than a certain period (say >2year) without any valid reason. If a vacant position is not filled within a reasonable period of two years, such post should be withdrawn and transferred to another deserving centre.
- Trial conducting locations that are regular defaulters should be brought to the notice of their authorities through ICAR. Discontinuing conduct of trials at these sick centres is no solution unless alternate locations are selected.
- Publication record of majority of centers is very poor (except Ludhiana, Coochbehar, Dharward and Pantnagar). It is strongly recommended that scientists be encouraged to write and publish results of their studies in national and international journals of repute.
- DWR should pay special attention to centres where breeding programme is poor and needs support. It is recommended that breeding material should be developed and supplied to such centres in NEPZ, Far NEPZ and SHZ.
- Shifting of centre from state-mechanised farm complex, Lamphenphet, Manipur to Central University, Imphal or some alternative location is recommended, since there is no response from the centre and the centre has failed despite several reminders about the work related to wheat.
- Jabalpur is an important voluntary centre for wheat research, which has good contribution for increasing the production and productivity of wheat in Madhya Pradesh. Hence, Jabalpur is recommended as a new

AICW&BIP centre. This centre requires an Assistant wheat breeder to be deployed from Sagar by converting existing post of Agronomist for conducting the breeding trials.

- The following redeployments are recommended based on the requirements of deserving centres:

  a. At Ludhiana centre, there are two posts of Biochemists for quality analysis of improved wheat germplasm. One post of biochemist is enough for doing quality work. However, there is a need of additional pathologist to look after wheat and barley crops. Hence, one post of Sr. Biochemist may be converted to Plant Pathologist.

  b. The Kalyani centre in West Bengal is an important centre, where an Assistant. Breeder is required for developing varieties to boost productivity of wheat in this state under NEPZ. There are three sanctioned positions of Assistant Breeder at Faizabad, wherein two breeders, one each in wheat and barley, are in position, while the third position of Assistant Breeder is lying vacant for many years. Hence, it is recommended to redeploy one position of Assistant Breeder from Faizabad to Kalyani as Assistant Breeder.

  c. Faizabad centre is situated in such an area where salinity/alkalinity is a major edaphic factor hindering gains in yield. The position of Assistant Soil Scientist has not been filled up; instead an Assistant Plant Physiologist is working on salinity related aspects. Hence, it is proposed that the position of Assistant Soil Scientist be converted to that of Assistant Plant Physiologist at Faizabad itself.

  d. The Udaipur centre, being a funded centre under MPUA&T (Rajasthan) has only one sanctioned position of Assistant Agronomist. There is a need to provide a position of Assistant Breeder at Udaipur so that varietal development could also be undertaken for this area of Rajasthan affected by harsh climatic conditions. Hence, one

vacant position of Assistant Botanist at Durgapura is recommended for being redeployed at MPUA&T, Udaipur.

e. There is a need for conducting experiments in resource conservation technologies in peninsular zone, hence it is recommended that Cereal Analyst position in Kanpur may be redeployed as AssistantAgronomist at Pune.

OVERALL ASSESSMENT

The QRT appreciates the very good coordination by DWR that resulted in release of 43 wheat and 15 barley varieties during the period under report. Most of the centres have performed very well baring a few that requires encouragement and support from their Universities. The performance of individual centre is reflected in the report (page no. 102-104).

Overall Comments based on Terms of Reference of QRT

A. Institute

i. Research Achievements and Impact

The DWR and AICW&BIP centres have made remarkable contributions in all areas of research leading to sustainable productivity of wheat and barley. The dedicated hard work of wheat scientists is reflected from the fact that a record wheat production of 94.8 million tones was achieved in 2011-2012. It was due to the development of high yielding improved varieties and production technology. The major achievements of the Directorate are reflected at pages 41-82.

A major impact of wheat production technology developed through wheat research in India can be realized by working out the farm area saved for other land uses. During 1965, India was producing 12.3 mt of wheat from an area of 13.4 m ha with the productivity level of 0.91 t/ha but during 2011-12 we produced 94.8 million of wheat from an area of only 29.3 mha. If there had not been any increase in the productivity after 1965, we would have required 100 million hectares of area for producing 93.7 mt of wheat. In this way, over 60 m ha of area has been saved by enhancing the productivity of wheat varieties.

Similarly major impact of barley production technology developed through research in India can be realized by working out the increased demand of malt barley being met indigenously and avoiding the import of grain for malting and brewing.

ii. Research Relevance and Budget allocation

Adequate enhancement of budget was provided during the XIth plan (page 28), even then QRT recommends that additional funds should be given to the Directorate for infrastructure development and modernization of laboratories.

iii. Relationship/Collaboration with SAUs and other Stakeholders

There was more than 95 per cent conductance of All India Coordinated Trials reflecting efficient coordination efforts. However, for further strengthening the collaboration with stakeholders, the Directorate had organized stakeholders meeting on 19th December, 2011.

iv. Linkages with Clients/end users

It has been suitably reflected under the chapter linkages (pages 26-27).

v. Proposed changes in Organizations, Programmes and Budget

The changes have been suitably reflected in the recommendations of the QRT.

vi. Constraints

The Directorate has performed exceedingly well during the period of report and as such there were no constraints. However, the QRT feels that a premier national research institution on wheat and barley should have excellent facility of auditorium and guest house. There is limited space for scientists and laboratories; hence the urgent need to expand the DWR main building. Shortage of farm land is also one of the critical constraints which has now been taken care to a certain extent by providing 200 acres of land at Hisar. The QRT also observed that the Directorate should have a state-of-art facility for doubled haploids.

vii. Looking forward

The wheat programme is one of the important programmes in the country and has been very vibrant, as indicated by the production, productivity and other achievements. But there is no room for complacency and the programme needs to be more responsive to the new emerging needs under the present scenario. Therefore recommendations have been made for further strengthening of ongoing work.

B. AICW&BIP

1. To analyze growth of manpower number of co-operating centres', both in terms of funds as well as staff resources

   It is adequately covered under the chapter Manpower and Budget (page number 28-31).

2. **To critically examine and evaluate achievements of the AICRPs in research with reference to**

   i. focus on national programmes

   The AICW&BIP has a mandate to develop and evaluate wheat and barley varieties and production technologies as per the national mandate.

   ii. multi-locational testing

   Multilocation evaluation of varieties and production technology is the crux of the AICW&BIP and has been successfully undertaken.

   iii. evaluation of pests and diseases

   Research at the Directorate and cooperating centres has effectively kept the incidence of pest and diseases, especially rusts at bay for more than three and half decade.

   iv. exchange of scientific information

   There is a consistent flow of information between the Directorate and its funded and voluntary cooperating centres.

   v. inter-institutional and inter-disciplinary linkages

   Inter institutional and inter disciplinary mode of research is followed effectively. In-house projects are multidisciplinary

while external funded projects are multi-disciplinary as well as inter institutional.

vi. development of strategic plans

Strategic plans in terms of Vision 2030 and more recently Vision 2050 have been prepared by the Directorate, which envisages a road map for increasing wheat and barley production in the country by involving the cooperating centres. Moreover, each year work plan is formulated in the annually held Wheat and Barley Research Workers' Meet.

vii. linkages with international programmes

DWR has an effective and rewarding linkage with international institutions like CIMMYT, ICARDA, CSIRO, and University of Sydney. Many new collaboration are in the making.

viii. information on technology base

DWR has developed large number of technologies as is evident from various publications and reports.

ix. encouragement and guidance by the PC

The QRT is satisfied on this aspect.

x. off-season nursery facilities

DWR has an excellent off-season nursery at Dalang Maidan which is well utilized by the Directorate as well as cooperating centres.

xi. healthy competition in Annual Workshops and professional challenge

The conduct of proceedings in the Workshop in a transparent manner is very encouraging and provides for a healthy competition.

xii. quality of recommendations of the Annual Workshops (group meetings) and follow up on those recommendations

Good quality recommendation have emerged from the Workshops which is submitted to ICAR each year and is effectively implemented.

xiii. whether research is of routine nature on trodden path or they are breaking new grounds

Besides conducting multi-locational trials new research ideas are discussed in the Workshops and implemented in the network

xiv. whether there is an individual initiative

The AICW&BIP works with a collective initiative where all the centres participate. However, those centres that are found lacking are advised from time to time.

xv. whether there is too much regimentation/ rigidity and

The AICW&BIP is transparent and there is no rigidity

xvi. whether the resources including manpower are optimally utilized.

Yes, these have been properly utilized.

Budget

3. There is 74% increase in budget from the preceding plan and outcome is commensurate with the budget (page number 28).

Organization and Management

4. Integration of research-whether the work being carried out under the coordinating project derives full support from other related programmes, including basic and strategic researches.

In some of the universities there is complete integration, but in some it is lacking. During the review meeting, it was emphasized to integrate the ongoing programme with other disciplines especially to biotechnology discipline.

5. **What is the monitoring mechanism of the coordinated project in the cooperating centres to avoid distortions/duplication/overlapping in programmes of AICRP and SAUs including those at regional stations.**

   The detailed mechanism is provided in the chapter Management (Pages13-18).

6. **Whether a strategic plan for the respective crop, commodity or natural resources with major emphasis on sustainability of production system has been developed by the coordinating unit in close collaboration with cooperating centres?**

   Yes. It has been given in Annexure VI (Page 126).

7. **How much operating funds does each scientist get under coordinated projects? Is it at least Rs 60,000 per scientist per year?**

   Currently each scientist in AICW&BIP is getting 1.2 lakh as contingency.

8. **Whether the PC is located in the ICAR institute or the SAU? Whether institute scientists working on coordinated projects from the cadre strength of the institute, and their work forms the priority work of the institute? Do they get additional funds for the travel for the work of coordinated project?**

   At the Directorate the Project Director looks after the work of PC and scientists from the cadre strength of the Directorate are also taking care of the coordinated activities. Funds are no constraints.

Annual Workshops (Group Meetings)

9. **How the Annual Workshop is organized? Is it serving as a focus of generation of new ideas? Do the senior officials from the Departments**

of Agriculture and Extension attend the workshops? Do scientists from private sector participate?

Conduct of Annual Wheat and Barley Research Workers' Meet is organized annually the details of which have been reflected in chapter Management (pages 17-25). Very few officials from the Departments of Agriculture and Extension attend the workshops. However, it has been observed that since last two years the number of such participants is on the increase, which was mainly due to the proactive role of DWR as well as Ministry of Agriculture.

10. Is a policy brief prepared after the workshop for use by policy makers and planners? If so, what has been the outcome? Does the coordinating unit maintain an extensive database on the crop/ commodity/ natural resource?

The proceeding and recommendations of the workshop is being circulated to policy makers and planners. The university officials include the recommendations in the package of practices of their respective state based on the recommendations of the workshop. Database of wheat and barley is available at the Directorate. An online wheat variety database is also available at www.indianwheatdb.com which was an effort under AgriBioinformatics Promotion Programme at DWR.

11. How is the HRD programme organized for the young scientists working in the project and also other staff working in the project?

Generally in house training is being organized for the young scientists and other staff joining the project. Besides this scientists are being trained abroad under ICAR-CIMMYT, ICAR-ACIAR, BGRI, USCB, Bioversity collaborative programmes.

ANNEXURE I

INDIAN COUNCIL OF AGRICULTURAL RESEARCH
KRISHI BHAVAN: NEW DELHI-110001.

F.No. 16-7/11-IA.IV Dated the 28th May, 2012

OFFICE ORDER

The Director General, ICAR has been pleased to constitute the Quinquennial Review Team (QRT) to review the work done by Directorate of Wheat Research, Karnal and AICW&BIP during the five years period from 2008 to 2012. The composition of the QRT will be as under :-

Sr. No.	Name & Address	Designation
1.	Dr. B. Mishra, Vice Chancellor, University of Agricultural Sciences & Technology of Jammu, Administrative Building, Chatha, jammu(J&K)-180009	Chairman
2.	Dr. G.S. Nanda, Ex-Wheat Breeder & Director Research, PAU, Ludhiana	Member
3.	Dr. P.K. Gupta, Hon. Emeritus Professor & NASI Sr. Scienitst, Meerut University, Meerut.	Member
4.	Dr. S.K. Nayar, Ex-Head, RRS DWR, Flowerdale Station, Shimla	Member
5.	Dr. Yadvinder Singh, INSA Sr. Scientist, Department of Soils, PAU, Ludhiana	Member
6.	Dr. S.C. Gulati, Ex-Principal Scientist, IARI, New Delhi	Member
7.	Sh. P.K. Joshi, Director(South Asia) IFPRI, New Delhi	Member
8.	Dr. R. Chatrath, Principal Scientist(Plant Breeding), DWR, Karnal	Member Secretary

FUNCTIONS :

The QRT shall conduct the review of the work of the DWR, Karnal, keeping in view the relevant guidelines thereon and submit its recommendations on future research thrusts through its report to the Council within 6 months from the issue of this order for further submission to the General Body of ICAR. Terms and references for the QRT is enclosed in Annexure I.

PROCEDURE :

The Chairman of the Review Team will initiate action to convene the meeting of the Team as early as possible. The Chairman will also inform the Project Director, DWR, Karnal to provide the information required by the Team in regard to the work done and other relevant information, as may be required for conducting the review.

The Director of the Institute will provide necessary stenographic, technical. logistic administrative assistance etc. to the QRT members for the efficient functioning of the Committee and preparation of the report.

The T.A. of the Non-official Members of the QRT for attending its meeting will be paid by the DWR, Karnal in accordance with the relevant rules of the Council.

(Girish Bhatt)
Under Secretary(CS)

DISTRIBUTION :

1. Chairman, QRT for DWR, Karnal
2. All members of the QRT - as per list
3. Director, DWR, Karnal. The T.A. of the non-official members of the QRT will be met by the Institute for which necessary budget provision in the Institute's budget may be made under other charges and not under T.A. which is meant for the staff of the Institute. The copy of Revised Guidelines for QRT is enclosed for reference and record. It is requested that the photocopy of same may be provided to Chairman for guidance.
4. DDG(CS), ICAR
5. ADG(FFC), ICAR
6. Director(Finance), ICAR
7. DD(F), ICAR
8. Accounts Officer, DWR, Karnal
9. Budget Section, ICAR
10. Guard file

ANNEXURE II

Proceeding of QRT meeting to review progress of work under All India Co-ordinated Wheat and Barley Improvement Project held at DWR, Karnal

October 20-21, 2012

Meeting of the Quinquennial Review Team (QRT) was held at DWR under the chairmanship of Dr. B Mishra, Former Vice Chancellor, SKUAST, Jammu at Directorate of Wheat Research, Karnal on 20-21 October, 2012 to review the progress of AICW&BIP centres.

The QRT members namely Dr. PK Gupta, Hon. Emeritus Professor & NASI Sr. Scientist, Meerut University, Meerut; Dr. SK Nayar, Ex-Head, RRSDWR, Flowerdale Station, Shimla; Dr. Yadvinder Singh, INSA Sr. Scientist, Department of Soils, PAU Ludhiana and Dr. S.C. Gulati, Ex-Principal Scientist, IARI, New Delhi attended the meeting. Incharges of all the 31 cooperating centres, except from Manipur participated in the meeting From Directorate of Wheat Research, Project Director, Dr. Indu Sharma along with Principal Investigators of various programmes participated in the meeting.

Dr. B. Mishra, Chairman initiated the meeting by inviting the comments of QRT Members. Dr. PK Gupta in his remarks stressed on the integration of modern techniques with conventional plant breeding and advised that breeder should use the modern tools in their breeding programme, especially when conventional plant breeding does not have the solution. He further stressed that transgenic wheat is gaining momentum in other parts of the world; hence one should start work in India too. Dr. Nayar in his remarks mentioned that we should do our job judiciously and suggested that we have to pay more attention to rust and should also consider the new races like *Ug*99. Dr. Yadvinder Singh in his remarks said that we have to concentrate more on natural resource management, soil health and resource conservation technologies in view of climate change.

Dr. SC Gulati in his remarks said that tremendous progress has been made in the barley improvement project during last fifty years. Varieties for malting, yield, quality, different zones have been developed and hope that this work will continue in future.

Dr. B. Mishra, Chairman, QRT in his remarks said that wheat and rice research and production technologies together brought in sense of self-respect, confidence, pride and honor to the country. These two crops contribute more than 75% to national food security and imparts major role in nutritional security to vast masses of our population. The country needs to double the food grain production by 2050 to feed the ever growing population and which is a major challenge specially at the time when the yield is plateaued, soil and water continues to be degraded, biodiversity being depleted, ever increasing multi-nutrient deficiencies along with increasing biotic and abiotic stresses, decreasing efficiency of inputs-use, and of course along with many other problems and limitations. Food prices are breaking all the records and yet the proportion/margin that reaches the farmers are substantially low. Therefore, concerted efforts need to be intensified for enhancing the productivity and profitability on an ecologically and economically sustained basis. Similarly, barley, being a health cereal is very important and needs further promotion. The Chairman then invited the presentation by Principal Investigators of each center.

The following action points emerged out from the centre wise presentation:

Dr. Rana while presenting the progress report of Rice and Wheat Research Station, Malan (H.P.) highlighted the reasons for low productivity of wheat and barley in Himachal Pradesh. PD (Wheat) suggested to push the recently released varieties into seed chain in place of susceptible one. Dr. Yadvinder Singh said that some varieties are performing well under zero tillage condition, therefore he suggested to identify/list the traits of better performing varieties and provide them to the breeder. The best yield at farmers field was 3.7t/ha,

whereas state average is 1.7t/ha, hence Dr. Y Singh suggested to replicate the same thing in other parts of the state for increasing productivity.

Dr. Naval Kishore presented the progress report and salient achievements of Bajaura Centre. It was suggested by the QRT to take the help of pathologist from Palampur or Dhaulakuan centre for disease recording and concentrate more on dual purpose barley. Dr. Dhanbir Singh presented the progress report of HAR&EC, Dhaulakuan (H.P.). It was suggested by Dr. PK Gupta to develop proper work plan for heat and drought screening.

Dr. Bains presented the spectrum of wheat varieties developed by PAU, Ludhiana (Punjab). Dr. PK Gupta suggested take 3-4 varieties more in MAS work rather than concentrating more on PBW 343. Replying to Dr. Indu Sharma query, Dr. Bains informed that it is feasible to develop 10,000 double haploid plants per season. Chairman and members appreciated the excellent work of the PAU during last five years.

Dr. Verma presented the progress report CCS HAU, Hisar (Haryana). Dr. Nayar queried about the genes being used in resistance breeding, while Dr. Indu Sharma suggested for targeted gene incorporation in the elite background and in this regards collaboration can be made with PAU and DWR. Dr. Jaiswal presented the achievement of Pantnagar centre. The Chairman remarked that Pantnagar is very important centre and strategically located. Emphasis on biotechnology applications in breeding should be given more importance. There is need for improvement at earliest.

Dr. Pooran Chand presented the progress report of SVPUA&T, Modipuram (UP) and informed that Modipuram got the status of funded centre in 2010-11 with one post of Plant Breeder. They have requested for more scientific and supporting posts in next plan. Dr. Shrimali presented the progress report ARS, Durgapura (Rajasthan) and informed that during last five years, Durgapura centre has developed 6 wheat (4 from CVRC + 2 from SVRC) and 4 barley (all from CVRC) varieties. The Chairman appreciated the work done at the centre.

Dr. Tuhina Dey presented the progress report of the SKUAST, Jammu. She expressed the serious constraints of labour during present season, which is creationg problem in conduct of trials. Dr. Indu Sharma suggested that they should send sample to Shimla centre at an early stage of the crop for the correct identification of rust pathotype. Dr. Nayar suggested not to introgress common gene postulates of leaf rust in elite back ground. Dr. Mishra suggested to collaborate with PAU for varietal improvement programme.

Dr. NB Singh presented the progress report of CSAUA&T, Kanpur (UP). Dr. PK Gupta commented that there is need to understand the heat tolerance mechanism properly. Dr. Indu Sharma responded that initially genotypes giving higher yield under very late sown condition were considered as heat tolerant genotypes. Now, systematic work have been started under controlled condition, wherein genotypes are exposed to higher temperature (>5^{o}C from normal) at grain filling stage for 21 days and heat tolerant genotypes are being identified.

Dr. SR Vishwakarma presented the salient achievements of Faizabad centre. Commenting on the performance of centre, QRT Chairman showed his dissatisfaction over the recent achievements of the centre. Dr. SS Vaish while presenting the progress report of BHU, Varanasi (UP), highlighted the importance of the centre. The Chairman expressed his concern over the number of crosses attempted, not releasing any variety through central system during the last five years and poor performance. Dr. Nitish De presented the progress report and informed the house that all the coordinated pathological, agronomical and breeding trials were conducted successfully. Dr. PK Gupta advised them not to put each and every thing in future plan and rather be focused. Dr. Indu Sharma suggested them to strengthen the work on development of early maturing varieties suitable for late sown condition.

Dr. Surya Prakash presented the progress report of BAU, Ranchi (Jhar.). Dr. Indu Sharma suggested to conduct FLDs with full package of practices for harnessing full potential of the variety. Dr. Saikat Das presented the progress

report of UBKV, Pundibari, Coochbehar (WB). He informed that the centre has developed various production and protection technologies keeping in view the typical agro-climatic situation of the area. Dr. Mukhopadhyay presented the progress report of BCKV, Kalyani centre and requested for one post of breeder in next plan. Dr. PK Deb Choudhary presented the research highlights of AAU, Shillongani (Assam). Replying to Dr. PK Gupta query, he informed that various white/amber grained pre-harvest sprouting tolerant lines are available with them.

Dr. AK Sharma informed that Research Station Kota fall under South-East Zone or Zone V of Rajasthan and wheat productivity of this region is higher than National average. Dr. Indu Sharma suggested more rigorous efforts are needed to increase the area under newly released varieties. Dr. Jagdish Choudhary presented the salient achievements of MPUA&T, Udaipur (Rajasthan), while Dr. S Acharya presented the report of Vijapur centre. Project Director enquired about the reason behind the declining area and production of wheat in Gujarat and possible solution in the ensuing season? Dr. Acharya replied that due to failure of cotton and groundnut and late onset of rain the area and production of wheat will increase during 2012-13. He also informed the house that in their area Karnal bunt is absent but black point exists. Dr. Yadvinder Singh asked how the farmers of the region are disposing the cotton stalk and in this response Dr. Acharya said that most of the farmers are burning stalk and few are incorporating with the help of rotavator. Dr. Kamlesh Dabhi presented the report of Junagarh centre and said that the centre successfully conducted all the allotted co-ordinated trials. Dr. Indu Sharma suggested that shifting of scientists from one centre to other is not good for the programme. Dr. B Mishra appreciated the work even though lot of reshuffle had taken place.

Dr. UK Tiwari, presented the progress of Sagar centre, while, Dr. VS Kandalkar presented the progress report of Gwalior centre. Dr. Indu Sharma suggested them to fill all the vacant post immediately. Dr. AK Singh presented the progress report of the Rewa centre. Dr. Gulati asked why the centre has not contributed any entry in NIVT/AVT during the last five year and to this Dr. Singh replied

that they are not able to screen the material for disease resistance. Dr. RPS Verma suggested them to select the material from national and international nurseries, whereas, Dr. Mishra requested Dr. Verma to provide them advance bulk material for selection. Dr. Indu Sharma asked them to prepare a report on 'Scope of Barley Cultivation in MP'.

Progress report of Powarkheda centre was presented by Dr. PC Mishra. QRT appreciated the good work done by the centre. Dr. Ajay Agrawal presented the progress report of Bilaspur (Chhatisgarh). Replying to Dr. Indu Sharma query Dr. Agrawal said they are trying their best to increase the wheat productivity even though water is scarce. Dr. Indu Sharma further suggested to test the barley varieties on trial basis in Chatisgarh, whereas Dr. PK Gupta suggested to develop varieties for restricted irrigation. Dr. Mishra suggested them to take advance bulk material from Powarkheda for testing. The progress of Niphad centre was presented by Dr. PN Rasal. The Chairman appreciated the work of Niphad centre. Dr. RT Sapkal presented the progress report of Regional Wheat Rust Research Station, Mahabaleshwar. The Project Director showed her concern why the fee is being charged from other co-operating centres for screening of breeding material against rust pathotype. The progress of Pune centre was presented by Dr. SC Mishra. Project Director asked why all the agronomic trials are not being conducted and in this regard Dr. Misra replied that it was due to lack of land. PD also suggested that since it is difficult to raise the DH at Pune due to very high temperature, collaboration may be initiated with UAS, Dharwad. The committee appreciated the work of Pune centre.

The salient achievements of the Dharwad (Karnataka) centre was presented by Dr. Rudra Naik. While replying about the scope of *dicoccum* in other zone, Dr. Naik said that we have good germplasm and due to premium price of *dicoccum* there is scope of its cultivation in other zone. Dr. Gulati asked about the yield potential of free threshable wheat and in this regard the reply was that it is yet to be evaluated. Dr. B. Mishra pointed out that Dharwad centre can become a good centre for applications of biotechnology in breeding.

Remarks by Members and Chairman

Based on the presentations made by various co-operating centres, several suggestions were made by the QRT members. Considering the future challenges in mind, Dr. PK Gupta emphasized the need to study the heat tolerant, water use efficiency and quality traits in details and suggested that a national level programme may be developed. He further added that root traits govern abiotic stress tolerance, therefore he stressed on the studying root architecture without damaging them. He also informed that earlier, majority of pre harvest sprouting tolerant genotypes were red grained, but since now white grain pre-harvest sprouting tolerant genotypes are available with some of the centres, genetics of pre-harvest sprouting tolerance should be studied for proper utilization in breeding programme. For hastening the breeding programme Dr. PK Gupta suggested that a well proven double haploid technology facility may be created at one or two stations. PAU has developed lot of genetic stocks using alien genetic variation, therefore Dr. PK Gupta suggested that a national programme should also be developed to make use of alien genetic variation. He indicated his skepticism on the success of hybrid technology in wheat.

Dr. SK Nayar suggested that for increasing the longevity of a variety the breeder should incorporate more than one effective resistance gene in a variety and such varieties should be given preference for release. He also advised that some work should also be done on Karnal bunt, powdery mildew and aphid.

Dr. Yadvinder Singh in his remarks emphasized on screening and development of varieties for conservation agriculture (CA) and zero tillage system, for this few centre may be identified. He informed that generally the varieties having long coleoptile and early vigour performs better under CA. He also pointed out that research publication is poor at many centres and that good publication must be brought out from the good work being done.

Dr. SC Gulati suggested that since there is hardly 10-15% yield improvement in barley over the last few years, inter F_2 crosses should be attempted in order to increase the genetic variability in barley.

Dr. Indu Sharma suggested that all the Incharges should educate their respective State Department of Agriculture to place the indent of breeder seed of newly released varieties to Department of Agriculture and Co-operation, GOI rather than old popular released varieties. Seed Replacement Rate (SRR) is meaningless if it does not involve the new varieties. Work on bio-fortification must be carried out for the nutritional food security. She also suggested them to develop linkages with industries and adoption of contract farming. She showed her concern over the position lying vacant in some of the centres. She told that if these posts remain vacant for a long period, then she will request the Council to redeploy these posts to some other centres. She further urged that frequent changes of the staff should be avoided and emphasized to generate matching grant from the State. She further requested the cooperating centres should utilize the summer season facility at Dalang Maidan, Mahabaleshwar and Wellington more effectively. The available diversity in the quality traits has been worked out at some of the centres, hence she urged the breeder to make use of it in ongoing breeding programme.

Dr. B Mishra, Chairman in his concluding remarks congratulated all most of the co-operating centres for developing good synergy with DWR, Karnal during last five years. He pointed out the need to think 'out of box' for enhancing the productivity. He advised them to give greater focus on widening of gene pool through alien sources, hybrid wheat development (though at present may not be successful) and gene pyramiding through MAS. He also pointed out that farmers are not leaving some of the old varieties because of various good traits and breeder must focus on such traits while developing a new variety. Dr. Mishra suggested that facility for double haploid technology need to be developed at DWR during XIIth five year plan so that it should act as a nodal agency like CIMMYT for generation of material. He advised that factors responsible for producing good quality wheat in Madhya Pradesh and Maharashtra needs to be identified. He also pointed out that temperature and drought should be the priority area of research in the XII Plan. Commenting on the performance of certain centres he exhorted the need to revive some of

the centres like Faizabad, BHU and GBPUA&T. While appreciating the barley improvement work he laid emphasis on promoting barley, being one of the prominent health cereal and having better tolerance to abiotic stresses like drought, salinity etc.

The meeting ended with vote of thanks to the Chair.

(R Chatrath)
Member Secretary

ANNEXURE III

Proceeding of QRT meeting to review progress of work of DWR, Karnal

Quinquennial Review Team Meeting February 11-12, 2013

Directorate of Wheat Research, Karnal

The meeting of the Quinquennial Review Team (QRT) was held at Directorate of Wheat Research, Karnal on February 11-12, 2013 to review the work carried out by DWR during 2008 to 2013. Chairman QRT, Dr. B. Mishra (Former VC, SKUAST(J) and Former Director DRR+DWR) and all the QRT members namely Dr. PK Joshi, Director (South Asia), IFPRI, New Delhi; Dr. GS Nanda, Former Director Research, PAU, Ludhiana; Dr. PK Gupta, Hon. Emeritus Professor & NASI Sr. Scientist, Meerut University, Meerut; Dr. SK Nayar, Ex-Head, RRSDWR, Flowerdale Station, Shimla; Dr. Yadvinder Singh, INSA Sr. Scientist, Department of Soils, PAU, Ludhiana and Dr. S.C. Gulati, Ex-Principal Scientist, IARI, New Delhi attended the meeting. The meeting was attended by all the PIs, Incharges and scientists of the Directorate. Dr. Chatrath, introduced the QRT team to the house. Dr. (Mrs.) Indu Sharma, Project Director informed that producing more wheat to match the demand of population growth is a major challenge under changing climate scenario. Therefore, enhancing per unit productivity is very important and the QRT team will advise for future planning.

The Chairman, Dr. Mishra initiated the meeting and expressed his happiness over the presence of all the learned QRT members. He complimented each and every QRT members for providing views during the first phase of the meeting. He stressed the need to revive some of the poor performing centres like SKUAST, Jammu, BHU Varanasi, GBPUA&T Pantnagar, IGKVV, Rewa centre and NDUA&T, Faizabad during the next plan. The chairman further stressed that the PIs of each programme to assess the contribution of each AICW&BIP

centre. The chairman invited the views of QRT members namely Dr. PK Joshi and Dr. GS Nanda, who could not attend the first phase of meeting. Dr. PK Joshi in his remarks said that since India ranks 67 in Global Hunger Index, we have to produce more not only to strengthen over food security but also nutritional security. As our dietary patterns are changing there is a need for developing nutritionally superior and product specific varieties to meet the requirement of food industries. He stressed that the cost of production of wheat is higher than the wheat produced by other countries like Australia, Canada and USA. If we have to compete with them then we have to reduce the cost of cultivation. Dr. Nanda in his remarks said that the quality of Indian wheat is much better than the wheat produced in other parts of the world and hence has great export potential.

Thereafter, Chairman invited Principal Investigators for presentations.

Discussion and action points emerged out from Crop Improvement

Dr Vinod Tiwari presented the research highlights of the Crop Improvement at DWR, Karnal during 2008-2012.

- Dr Gupta suggested to develop online database of the coordinated trials and Dr. Tiwari replied that the coordinated data will be made online very soon as the wheat database construction is at the final stage of release. He also suggested intensifying the work on water and nutrient use efficiency.
- Dr. Nanda inquired whether coding of coordinated trail entries has helped in evaluation to which Dr. Indu Sharma replied that the coding has helped the system and many breeders are very happy with the development. Dr. Tiwari added that data reporting has improved due to coding.
- As, yield gaps are very high in U.P., Bihar, M.P. and Uttarakhand, Dr. Joshi suggested to provide more focus in these regions. He also asked to collaborate with NBPGR for characterization of genetic

material and focused research on nutritional aspects. Dr. Indu Sharma informed that NBPGR is short listing the entries for various traits and DWR is collaborating with them.

- Dr. Gulati suggested collaboration with other organizations for alien species introgression and integration of biotechnology with conventional breeding for breaking yield barrier and undesirable linkages. Dr. Tiwari informed the house that wild species available with IARI have been obtained and are being maintained and utilized in pre-breeding programme.
- Dr. Mishra advised to initiate the work on hybrid wheat systematically as the work on hybrid wheat is not moving fast as expected.

Discussion and action points emerged out from Biotechnology

Dr. Rattan Tiwari highlighted the achievements in areas of wheat biotechnology at DWR.

- Dr. Gupta suggested to validate the markers before applying them and further recommended the outsourcing for sequencing analysis.
- Dr. Nayar suggested identifying the postulated genes by linking them with markers.
- Dr. Nanda suggested more active involvement of bio-technologist with breeders for identification of desired plants at F_3 to F_6 generations through molecular tools during the crop season.
- Dr. Joshi suggested developing a road map of transgenic wheat and capacity building needed in this advanced areas of research.
- Dr. Mishra suggested not to use the markers unless validated and suggested developing a collaborative programme by involving 3-4 institutes on priority traits. While citing the very good MAS and MABB work achieved in rice programme he pointed that, by now, in wheat products must have been commercialized. He

advised for immediate improvement in team approach involving interdisciplinary scientists.

Discussion and action points emerged out from Agricultural Bioinformatics Promotion Programme

Dr. Rajender Singh presented the highlights of Agricultural Bioinformatics Promotion Programme.

- Dr. Gupta suggested to develop a unique database for wheat workers by incorporating all the developments (QTL detected for any traits, mapping population, SNP marker) in the database.

Discussion and action points emerged out from Crop Protection Programme

Dr. Saharan highlighted the achievements of Crop Protection, while Dr. Bhardwaj presented the highlights of DWR RS, Shimla.

- Dr. Nayar stressed to initiate the work on powdery mildew epidemiology, management and assessment of yield losses in different varieties. Since DWR Regional Station is maintaining large number of rust pathotypes and storing all the pathotypes for 15-20 years, he advocated the need of proper maintenance of generators, liquid nitrogen and ultra-freezers.
- Dr. Joshi advised to use remote sensing and simulation models to know the changes in pests and diseases dynamics due to climate change. He also advised that the impact of IPM should not be based only on yield increase and that it should also include cost per unit of output.
- In a query to Dr. Nanda, Dr. Bhardwaj replied that prevalent rust races in a particular location are only distributed to the scientists as they don't supply the races which are not prevalent in that region.

He also suggested to increase the utilization of NGSN in breeding programme.

Discussion and action points emerged out from Resource Management:

The Dr. Sharma highlighted the achievement of Resource Management.

- Dr. Gupta suggested examining the herbicide for their environmental impact.
- Dr. Singh asked not to emphasize on fertilizer nutrients ratio but on site specific nutrient management. He also asked whether there is any report on any new weed flora under various tillage practices. He further asked as to how to escape terminal heat in March by means of some agronomical manipulation and suggested to identify suitable varieties.
- Dr. Joshi suggested location/site specific integrated crop management recommendation. He asked whether NPK ratio 4:2:1 used in 1960 is still valid or is there any need to revisit it. He also suggested to improve the nutrient use efficiency as huge subsidy is involved and to develop technology for particular situation.

Discussion and action points emerged out from Wheat Quality

Dr. Gupta highlighted the wheat quality achievements and presented a list of promising genotypes identified for various products and quality traits, while Dr. Sewa Ram highlighted molecular aspects of wheat quality research at DWR and presented the quality requirements for chapati, biscuit, cake, pan bread, wheat noodles and pasta, which is highly appreciated by the QRT.

- Dr. Joshi suggested approaching commission on agriculture cost and prices to fix premium price for quality varieties as in the case of rice and sugarcane.

- Dr. Gupta queried on the extent pre-breeding materials or registered stocks are being used. Dr. Indu Sharma replied that breeders are using them extensively. He further suggested submitting more concept note to DBT for funding and involving medical personnel if area of research involves some experimentation on human/animal. He further advised to interact with Advisor/Secretary DBT and highlight achievements and infrastructure available with DWR.
- Dr. Joshi asked any plan for breeding varieties for higher protein and other nutrients and Dr. Gupta replied that work is going on under Harvest Plus programme and genotypes having up to 14% protein are available. He further queried as to how wheat crop is going to be affected if there is shift in rainfall to which Dr. Indu Sharma replied that 85% of wheat area is under irrigation, therefore shifting of rainfall will not affect the wheat production.
- Dr. Joshi suggested developing a programme to overcome phytic acid problem in future and public private partnership for pasta making..

Discussion and action points emerged out from ICAR-CIMMYT Collaboration

Dr. Indu Sharma made presentation on ICAR-CIMMYT collaboration.

- Dr. Mishra suggested explore the possibility of collaboration with Consultative Group on International Agricultural Research (CGIAR) institutes other than CIMMYT and ICARDA, though with prior approval from ICAR. He further stressed not to send any material outside the country unless cleared by all the concerned authorities and any deviations by any cooperating centre in this regard should be reported to ICAR. For increasing the efficiency of AICW&BIP, he suggested rating of the performance of each funded AICW&BIP centres so that the constraints faced by them shall be eliminated/improved.

Discussion and action points emerged out ACIAR Network projects

Dr. Chatrath presented the developments of India-Australian projects sanctioned during XI Plan.

- The house suggested continuing Indo- Australian projects in the XII plan also.
- Dr. Joshi felt the need of strong collaboration with international agencies but Council guidelines should be followed.
- Dr. Gupta suggested invite the members of various task force/ funding agencies like DBT, DST and make them aware about DWR achievements and take their advice for getting the research projects.
- Chairman told this is an era of collaboration therefore he strongly advised that the scientists be encouraged to take more and more collaborative projects but follow the council guidelines.

Discussion and action points emerged out from Barley Network

Dr. RPS, Verma presented the achievements in barley network including breeding, crop protection, resource management and quality aspects.

- As there is problem of lodging in barley, Dr. Y Singh asked whether there was any scope of developing dwarf barley and Dr. Verma replied that dwarfing source is available and Dr. SC Gulati advised to use wild germplasm in breeding.
- Dr. Gupta suggested utilizing sequenced genome of barley for candidate or gene discovery and association mapping.
- Dr. Joshi suggested to explore the possibility of barley cultivation in non-traditional areas such as rice-fallow system, saline areas and also to work out the demand projection and supply of barley by 2020-2030.

- Project director informed that priority wil be given to promote malt barley by developing strong linkages with industry and stream line the work according to the scenario.
- The Chairman complemented Dr. Verma for his good work especially in the development of high malt quality barley varieties.

Discussion and action points emerged out from Social Sciences

Dr. Randhir Singh highlighted the achievements of social sciences.

- Dr. Joshi advised to have district wise wheat database and track the outlook of wheat globally for developing future strategies. He suggested to work on impact assessment by means of systematic empirical analysis on technologies developed. He suggested blend of business model for target domain using GIS or any other tool and choice the experiment on farmers' field i.e. finds the areas for introduction of RCT, demands for seed, laser land leveling among farmers. The constraints should form the basis for developing research gap and research project.

Discussion with PIs and Scientists

Dr. Mishra appreciated the overall good work and congratulated PD and PIs for their excellent presentation. He invited the suggestion from PIs and scientists:

- Dr. V Tiwari suggested redeploying some of the posts from one centre to another centre. He was advised by the Chairman to make a plan internally with PD and other PIs of DWR and submit for necessary action.
- Dr. RPS Verma suggested that there is a proposal that DWR is going to be elevated to Indian Institute of Wheat Research, so he stressed upon the establishment of barley coordinating unit within DWR to safeguard interest of barley as it is not truly represented in any meeting.

- Dr. Sharma informed that frequent shifting of scientific staff is hampering the work/trials at some of the centres, so he suggested the scientist may be posted at least for five years.
- Dr. Chatrath requested the need of national facility on doubled haploid at DWR. Dr. B. Mishra suggested that DWR should work on the pattern of CIMMYT; generate and advance the material and share it with coordinating centres.
- Replying to Dr. PK Joshi query, regarding monitoring and evaluation mechanism, Dr. Indu Sharma said DWR has very strong programme on monitoring of trials by team of interdisciplinary scientists, survey and surveillance by protection scientists and research projects by QRT, IRC, RAC and by respective PIs.

Remarks by Chairman and Members

- MAS should be a part of plant breeding and biotechnologist should concentrate on generation of knowledge, QTL analysis and comparative genomics for gene discovery.
- Facility to be developed for transgenic and double haploid and its maintenance on self-sustain basis.
- Strengthening of Bioinformatics facility and capacity building which should encompass all kind of data relevant to research.
- Work on multi-parental advanced generation intercross population (MAGIC) has to be initiated.
- Chromosomal segmental substitution population needs to be developed.
- Publication of more papers on mapping population.
- Regarding establishment of six centres for MAS, Dr. R Tiwari informed that a network project has been framed under XIIth plan.

- Strengthening of experimental facility at DWR Regional Station, Dalang Maidan.
- Take Plant Breeder Rights on all the released varieties.
- Utilize the alien genetic variation in targeted manner.
- Maintenance of the purity of pathotypes at DWR regional station Shimla.
- Separate scientists for coordinated work and research work for increasing more efficiency of the system.
- Work on water use efficiency, rooting behaviour, evaporation losses, transpiration losses, micro irrigation through drip / sprinkler irrigation studies need to be strengthened.
- Development of more nutrient efficient wheat varieties.
- Barely malting work need to be strengthened with the help of Public Private Partnership. Promotion of contract farming for malt barley will lead to increase in barley area.
- Strengthening of barley project by providing them more breeding post.
- Some innovative approaches are needed for breaking the yield barrier in barley like inter-mating of some superior segregant at early generation based on knowledge of multi-location testing.
- Breeding for more nutritionally superior varieties rich in protein, iron, zinc and other micro nutrients.
- Increasing nutrient use efficiency through physiological parameters or conservation agriculture.
- Use of advanced tools for disease surveillance such as GIS, GPS or remote sensing.

- Development of strong database for wheat including all kind of wheat related issue.
- Building partnership with international organizations and if possible outside NARS such as NGO's, technical universities etc.
- Capacity building of new scientists in advance areas of research.
- Preparedness and research work related to climate change and global warming.

Dr. Indu Sharma, Project Director provided the following priority areas:

- Double haploid facilities are being developed in Dalang Maidan.
- MAS, DH, Hybrid wheat and transgenic will be prime area in breeding.
- Studies in area of proteomics and patho-genomics will be initiated after joining of new scientists in crop protection.
- Yield traits enhancement with moderate resistance to diseases will be the priority in physiology.
- In resource management, conservation agriculture, micro irrigation and preponing of date of sowing in cotton and sugarcane cropping system will be considered in future.
- In quality, industrial linkages for bio-fortification will be undertaken.
- In social sciences, decision support system for rust management, development of database, digitization of publication database and dissemination of technology will be the priority areas.
- In barley the steps will be taken to increase the area in barley.

Dr. B Mishra, Chairman in his concluding remarks advised DWR Scientists and Director to give greater focus on the following points:

- DWR is known for the coordination, it should remain as first priority but with more synergistic approach. At the same time better basic and strategic research cannot be ignored rather to be enhanced through target oriented and mission mode..
- Biotechnologist can play important role by pyramiding rust resistance gene through MAS in well adapted varieties to break yield plateau.
- In MAS there is a need to first validate the marker before using it in the programme.
- There is no substitute of conventional breeding but it does not mean one should overlook the modern tools which are very effective and have started giving good results. He advocated the need of integration of modern tools with conventional breeding.
- Water use efficiency programme, precision farming should focus on development of low cost technology and should be specific to the target site.
- The conservation agriculture should focus on multi nutrient deficiency management.
- Surveillance and monitoring of new pathotypes remain priority and testing of new molecules for diseases is also important activities in crop protection.
- Make a database on conservation agriculture, in this regard social scientist can be hired.
- There is a need to keep abreast in knowledge hence the need to browse the literature to gain insights of global research. Keeping

malnutrtion and hidden hunger research on improving nutritional quality is essential.

- Since barley is a versatile crop for abiotic stress, it can be promoted in fragile areas. Dual purpose use of barley should be properly exploited.

Meeting ended with vote of thanks given by Dr. Ravish Chatrath, Member Secretary, QRT.

ANNEXURE IVa

List of AICW&BIP centres and Staffing Pattern of Scientific Staff during 2008-2013

Centre name	Year of start	Breed.	Agro.	Plant Path.	Ent.	Bio-chem.	Nem.	Phy.	Bar. Breed	Bar. Agro.	Bar. Path.	Jr. Bot.	Asstt Cer. Ana.	Gent.	Food and Nutr	Total
NHZ																
Bajaura	1967		1						1							2
Dhaulakuan	1982	1		1												2
Palampur	1975	1	1	1												3
Imphal			1													1
NWPZ																
Durgapura	Bar 1966, Wheat 1971	2	1	1	1	1	1		1	1	1	**1**				11
Hisar	1971	1	1+**1**	1		1	1	1	1							8
Jammu	2002	1		1												2
Ludhiana	1970	2	1	1 Jr	1	1	1						1			8
Modipuram	2010	Asstt. Wheat Breeder* (Filled through Deployment till the regular appointment)														1
Pantnagar	1965	1	1	1	**1**	1										5
NEPZ																
Faizabad	1987	1	1	1+**1**				**1**	1							6
Kanpur	1970	1	1	1	1			**1**	1				1			7
Kalyani	1973		1													1
Coochbehar	2001	1		1												2
Ranchi	1982	1	1	1												3
Sabour	1988	1	1	1												3
Shillongani	1975	1	1	1												3

Centre name	Year of start	Breed.	Agro.	Plant Path.	Ent.	Bio-chem.	Nem.	Phy.	Bar. Breed	Bar. Agro.	Bar. Path.	Jr. Bot.	Asstt Cer. Ana.	Gent.	Food and Nutr	Total
Varanasi	1975	1	1	1					1							4
CZ																
Bilaspur	1984	1	1													2
Gwalior	1987	1	1													2
Rewa	1982								1							1
Junagadh	1976	1	**1**													2
Udaipur	1975		**1**													1
Kota	1983	1 *	1													2
Powarkheda	1961	1	1	1												3
Vijapur	1971	1+**1**	1	1		1										5
Sagar	1978	**1**	1	**1**												3
PZ																
Dharwad	1970	1+1	1	1										1	1	6
Mahabaleshwar	1971			2												2
Niphad	1971	1	1	**1**									**1**			4
Pune	1974	1		1												2
Total		**29**	**25**	**22**	**4**	**5**	**3**	**3**	**7**	**1**	**1**	**1**	**3**	**1**	**1**	**107**

Bold values indicate that these posts are lying vacant
*Filled through Deployment till the regular appointment

ANNEXURE IVb

List of AICW&BIP centres and Staffing Pattern of Others Staff during 2008-2013

Position	Res. Asstt.	Tech.	Ag. Super	Lab. Asst.	Lab. Att.	Field man	Admin./ Jr. Astt.	SS.	Driver	Security guard	Total
NHZ											
Bajaura		2				3	1	1			7
Dhaulakuan		1				3					4
Malan		3		1		3	1				8
Mantrikpuri											
NWPZ											
Durgapura	1	6		3		7	1	1	1		20
Hisar		1+6		2	**1**	7	1			1	19
Jammu						2	1				3
Ludhiana					19						19
Pantnagar		6+**1**		1+**1**	1	3+**1**					14
Modipuram											
NEPZ											
Faizabad		3+**1**				3+**1**	1	1		1	11
Kanpur		4+**2**		1		4+**3**	3	1	**1**	1	20
Kalyani		1				1					2
Coochbehar		1				**1**					2
Ranchi						2					2

Position	Res. Asstt.	Tech.	Ag. Super	Lab. Asst.	Lab. Att.	Field man	Admin./ Jr. Astt.	SS.	Driver	Security guard	Total
Sabour		3				3					6
Shillongani		1				1+**1**	1				4
Varanasi		2+**3**				1+**3**	1				10
CZ											
Bilaspur		1				2	1				4
Gwalior						2					2
Rewa		**2**				**2**					4
Junagadh	2					3					5
Udaipur		**2**	1+**1**								4
Kota											
Powarkheda		1+**2**		1+**1**		**3**		1			9
Vijapur		2+3				4	1				10
Sagar		1		1		3+**1**	1				7
PZ											
Dharwad		2+**1**		2		3					8
Mahabaleshwar		4							4		8
Niphad				**1**		1	**2**		1		5
Pune	4 Jr. Sc. Asst.							2			6

Bold values indicate that these posts are lying vacant

ANNEXURE V

LIST OF PROJECTS

i) Institute Research Projects (2008-2010)

Project No.	Project Title	PI	Associate
DWR/RP/07-1	Multilocational and Multidisciplinary research programme on wheat and barley improvement	SS Singh Project Director	All PIs
DWR/RP/07-2	**Germplasm Improvement for Northern, Eastern and Central parts of India**		
DWR/RP/07/2.1	Establishment and maintenance of a crossing block of winter wheat and alien gene donors at regional station, Dalang Maidan	B Mishra	J Kumar, Raj Pal Meena Plant Breeder (Awaited)
DWR/RP/07/2.2	Genetic enhancement in wheat for salt tolerance	B Mishra	Ravish Chatrath, Sewa Ram, PC Sharma and Neeraj Kulkshreshtha
WR/RP/07/2.3	Improving durum wheat with respect to grain yield, better quality and disease resistance	Jag Shoran	BS Tyagi, RK Gupta and SK Jain
DWR/RP/07-2.4	Breeding wheat genotypes for rice-wheat cropping system of northern plains	Ravish Chatrath	SK Singh, J Rane, Ratan Tiwari, MS Saharan, M Prashar, B Mishra
DWR/RP/07-2.5	Improving wheat genotypes for spot blotch resistance and yield component traits under Indo-Gangetic plains of India	Gyanendra Singh	DP Singh and Jag Shoran

DWR/ RP/ 07-3	**New avenues for yield enhancement**		
DWR/RP/07-3.1	Utilizing winter wheat gene pool for improvement of spring wheat	Vinod Tiwari	Lakshmi kant
DWR/RP/07-3.2	Floral biology and parental diversification for development of hybrids in wheat	SK Singh	Ravish Chatrath
DWR/RP/07-3.3	Exploiting the wild and non-conventional gene pool for wheat improvement through pre-breeding approach	BS Tyagi	Gyanendra Singh Sindhu Sareen, SK Jain
DWR/RP/07-3.4	Collection, maintenance and utilization of cytogenetic stocks of wheat	Sindhu Sareen	Rekha Malik, S Kundu
DWR/RP/07-4	**Molecular approach towards wheat / barley improvement**		
DWR/RP/07-4.1	Molecular approach towards wheat improvement-molecular characterization of adult plant resistance for stripe rust resistance	Rattan Tiwari	MS Saharan, J Kumar M Prashar and B Mishra,
DWR/RP/07-4.2	Molecular evaluation of yield attributing characters in indigenous wheat germplasm	Rekha Malik	S Kundu
DWR/RP/07-4.3	Genetics and molecular cytology of heat tolerance in wheat	Sindhu Sareen	BS Tyagi, J Rane
DWR/RP/07-4.4	Physiological investigation to support conventional and molecular approach for heat and drought tolerance	J Rane	Project discontinued
DWR/RP/07- 5	**Seed Production of Wheat and Barley**		
DWR/RP/07-5.1	Maintenance breeding of recent wheat and barley varieties and their quality seed production	Raj Kumar	-
DWR/RP/07-5.2	Refinement of economically viable seed production technology	Raj Kumar	AS Kharub, DP Singh KS Babu, Ajmer Singh RS Chhokar

DWR/RP/07- 6	**Biodiversity in Wheat and Barley**		
DWR/RP/07-6.1	Evaluation and maintenance of biodiversity in wheat and barley	S Kundu	Rekha Malik, Sindhu Sareen, B Sarkar RPS Verma
DWR/RP/07- 7	**Malt Barley Improvement**		
DWR/RP/07-7.1	Breeding for malting quality improvement in barley	RPS Verma	B Sarkar, Selvakumar Sneh Narwal
DWR/RP/07-7.2	Resource conservation and input management for enhancing crop productivity and quality in barley	AS Kharub	RPS Verma Mangal Singh Jat
DWR/RP/07-7.3	Molecular approaches in barley improvement for biotic stresses and malting quality	Rekha Malik	RPS Verma Sneh Narwal
DWR/RP/07- 8	**Development of suitable plant protection technology through IPM**		
DWR/RP/06/8.1	Studies on host resistance, variability and management of head scab of wheat	MS Saharan	AK sharma BS Tyagi
DWR/RP/06-8.2	Managing biological entity in soil to regulate nematode population in wheat base cropping system and integrated management of CCN and ECN	AK Singh	-
DWR/RP/07-8.3	Integrated management of leaf blight complex in wheat caused by Biopolaris sorokiniana, Alternaria triticina and Pyrenophora tritici repentis with special emphasis on host resistance	DP Singh	SC Tripathi
DWR/RP/07-8.4	Virulence mapping of karnal bunt pathogen (Tilletia indica) of wheat in India	J Kumar	MS Saharan AK Sharma

DWR/RP/07-8.5	Further studies on basic research of field and storage insect pests of wheat	KS Babu	-
DWR/RP/07-8.6	Pest system under new agronomical innovations and promotion of IPM under rice wheat system	AK Sharma	KS Babu, MS Saharan Randhir Singh, and MC Jat
DWR/RP/07- 9	**Wheat and Barley Rusts and Genetics of Rust Resistance**		
DWR/RP/07-9.1	Studies on brown rust of barley(Puccania hordei) and preliminary studies on novel resistance against rusts and powdery mildew	YP Sharma	M Prashar SC Bhardwaj SK Jain
DWR/RP/07-9.2	Variability in yellow rust of wheat and barley and genetics of resistance	M Prashar	YP Sharma, SC Bhardwaj, SK Jain
DWR/RP/07-9.3	Variability in brown rust of wheat and genetics of rust resistance	SC Bhardwaj	YP Sharma, M Prashar SK Jain
DWR/RP/07-9.4	Variability in black rust pathogen in India genetics of rust resistance	SK Jain	YP Sharma, M Prashar, SC Bhardwaj
DWR/RP/07-10	**Resource Conservation Technologies, Diversification and Integrated Nutrient & Weed Management for the Sustainability of Rice-Wheat System**		
DWR/RP/07-10.1	Resource Conservation technologies and residue management for the sustainability of rice-wheat system	RK Sharma	Subhash Chander Gill, RS Chhokar and KS Babu
DWR/RP/07-10.2.	Diversification/ intensification of rice –wheat for enhancing the soil and crop productivity and profitability	SC Tripathi	Subhash Chander Gill and Raj Pal Meena
DWR/RP/07-10.3	Integrated Nutrient Management for the sustainability of rice-wheat system	Subhash Chander Gill	RS Chhokar, Karamjit Singh and RK Sharma

DWR/RP/07-10.4	Developing effective weed management strategies in wheat	RS Chhokar	SC Gill, Karamjit Singh and RK Sharma
DWR/RP/07-11	**Quality Improvement of wheat for Industrial and Traditional Products**		
DWR/RP/07-11.1	Use of Molecular Marker Technology approach in wheat quality breeding	RK Gupta	Rattan Tiwari
DWR/RP/07-11.2	Genetic Improvement in grain protein content for bread wheat of the NWPZ	D Mohan	RK Gupta
DWR/RP/07-11.3	Charaterization of biochemical and molecular components associated with processing and nutritional quality of bread and durum wheat	Sewa Ram	B Mishra BS Tyagi
DWR/RP/07-11.4	Improvement of quality of bread and durum wheat for biscuit and pasta quality respectively, utilizing molecular approach	Sewa Ram	B Mishra BS Tyagi
DWR/RP/07-12	**Information, Technology, Refinement and Impact Assessment**		
DWR/RP/07-12.1	Problems and Prospects of Malt barley cultivation in North west India	Randhir Singh	Satyavir Singh Ajmer Singh Anuj Kumar
DWR/RP/07-12.2	Transfer and validation of improved production technologies	Satyavir Singh	Randhir Singh Ajmer Singh, Anuj Kumar
DWR/RP/07-12.3	Impact assessment of wheat production technologies	Ajmer Singh	Satyavir Singh Anuj Kumar
DWR/RP/07-12.4	Women empowerment through entrepreneurship development	Anuj Kumar	Randhir Singh RK Gupta, Satyavir Singh

New Project Approved in 2008			
DWR/ RP/08/12.5	Development of wheat production information system (WPIS) in terms of area, yield and production parameters	Suman Lata	R Chatrat Ajmer Singh
DWR/RP/08/ 4-.5	Genetic analysis of pre harvest sprouting resistance and seed dormancy in wheat	Rajinder Singh	Gyanendra Singh and Ratan Tiwari
DWR/RP/08/ 7.4	Studies on blotch diseases of barley and their management using bio control agents	Selvakumar	AS Kharub
DWR/RP/08/ 11.5	Evaluation of different wheat types and their end products for phenolic acid and antioxidant activity	Sneh Narwal	RK Gupta
DWR/RP/08/ 10.5	Root and microbial studies in rice wheat system under various nutrients, water management and RCTs aiming to improve soil health	Anup Das	SC Tripathi, DP Singh and RP Meena
New Project Approved in 2009			
DWR/RP/10/8.4	Detection of Cereal Cyst Nematode (CCN) resistant genes in Wheat & Barley genotypes and development of technologies for CCN management	Dr AK Singh	Pardeep Sharma
DWR/RP/10/8.3	Development of IPM Modules for the management of storage insct pests in wheat and barley under ambient conditons	Dr Mangal Chand Jat	PB Singh, IARI,Karnal, AK Sharma

ii) Institute Research Projects (2010-15)

Project No.	Project Title	PI	Associate/s
DWR/RP/10-2	**Germplasm Improvement through pre- breeding India**		
DWR/RP/10-2.1	Utilisation of diverse sources including wild species for introgression of genes for biotic and abiotic stress tolerance in wheat	Bhudeva Singh Tyagi	S Sareen, Satish Kumar, MS Saharan, Ratan Tiwari, Sewa Ram, Mrs Sushila Kundu and Vishnu Goel
DWR/RP/10-2.2	Redesigning plant architecture of wheat for higher yield potential in changing climatic conditions	Satish Kumar	Gyanendra Singh, K Venkatesh
DWR/RP/10-2.3	Development of doubled haploids in wheat	Raj Kumar	R Chatarath
DWR/RP/10-3	**Wheat improvement for biotic and abiotic stresses under changing climate scenario**		
DWR/RP/10-3.1	Wheat improvement for high productive environments in Northern India	Ravish Chatrath	Satish Kumar MS Saharan Ratan Tiwari, SC Gill, Sewa Ram AK Singh and K Venkatesh
DWR/RP/10-3.2	Wheat Improvement for Eastern and Far Eastern regions of the country	Gyanendra Singh	Charan Singh, DP Singh, Rajender Singh RP Meena and S Ram
DWR/RP/10-3.3	Wheat Improvement for warmer areas of the country	SK Singh	Bhudeva Singh Tyagi, V. Tiwari, RK Gupta, CN Mishra, Pradeep Sharma, DP Singh and RS Chhokar

DWR/RP/10-3.4	Improvement of spring wheat through introgression from winter wheat gene pool	V. Tiwari	CN Mishra, Ratan Tiwari, K Venkatesh and Lakshmi Kant (Almora)
DWR/ RP/10-4	Maintenance and evaluation of wheat and barley germplasm	Sushila Kundu	Charan Singh and B Sarkar
DWR/RP/10-5	**Molecular and basic studies for wheat improvement**		
DWR/RP/10-5.1	Constitution of genotypic group for association mapping studies and molecular characterization of adult plant rust resistance gene(s) in wheat	Ratan Tiwari	Rajender Singh, SK Singh and MS Saharan
DWR/RP/10-5.2	Molecular characterisation of Indian wheat for assaying stem rust resistance gene(s)	Rekha Malik	Rajender Singh, Sindhu Sareen and SC Bhardwaj
DWR/RP/10-5.3	Molecular characterisation of DREB gene(s) in Indian wheat (Triticum aestivum)	Pradeep Sharma	Sonia Sheoran
DWR/RP/10-5.4	Molecular characterisation of antioxidant enzymes released during abiotic stress in Triticum aestivum L.	Sonia Sheoran	Sneh Narwal
DWR/RP/10-5.5	Development and utilisation of TILLING population for important traits of agronomic importance	Rajender Singh	Ratan Tiwari and SK Singh
DWR/RP/10-5.6	Genetic studies on abiotic stress tolerance in wheat	Sindhu Sareen	BS Tyagi, CN Mishra Pradeep Sharma and Vishnu Goel
DWR/RP/10-6	Improvement of wheat seed multiplication ratio through agronomic, pathological and technology interventions	Raj Kumar	Charan Singh, RS Chhokar DP Singh and Vishnu Goel

DWR/RP/10-7	**Improvement of barley varieties, protection and production technologies.**		
DWR/RP/10-7.1	Barley improvement for malting quality and resistance to prevalent biotic / abiotic stresses	RPS Verma	B Sarkar, R Selvakumar and Dinesh Kumar
DWR/RP/10-7.2	Improvement of barley for feed and dual purposes	B Sarkar	RPS Verma, R Selvakumar and AK Singh
DWR/RP/10-7.3	Molecular markers assisted improvement of barley for disease, pest and malt quality	Rekha Malik	RPS verma, Dinesh Kumar, R Selvakumar and MC Jat
DWR/RP/10-7.4	Studies on biochemical parameters of grain in relation to the malting quality of barley	Dinesh Kumar	Mrs Sneh Narwal
DWR/RP/10-7.5	Studies on host pathogen interaction of leaf blight and rust diseases in barley	R Selvakumar	-
DWR/RP/10-7.6	Resource management in barley for enhancing productivity and quality	AS Kharub	Dinesh Kumar and MC Jat
DWR/RP/10-8	**Crop protection**		
DWR/RP/10-8.1	Mapping of pathogenic variability in leaf blight pathogens wheat in scenario of climatic change, maintenance and use in evaluation of host resistance	DP Singh	MS Saharan
DWR/RP/10-8.2	Studies on host resistance, epidemiology, variability and eco-friendly management of Karnal bunt and fusarium head blight (FHB) pathogens of wheat in India	MS Saharan	AK Sharma

DWR/RP/10-8.5 (RRS Shimla)	Monitoring variability in wheat and barley rusts and rust resistance in wheat and barley	SC Bhardwaj	
DWR/RP/10-9	**Resource Management**		
DWR/RP/10-9.1	Resource conservation agriculture practices for the sustainability of rice-wheat system	RK Sharma	Subhash Chander Gill, RS Chhokar, DP Singh, MC Jat and Ms Anita
DWR/RP/10-9.2	Intensification of rice-wheat system with inclusion of legumes for enhancing the soil and crop productivity	SC Tripathi	Subhash Chander Gill, Raj Pal Meena
0DWR/RP/10-9.3	Effective nutrient management strategies for enhanced productivity and profitability of rice-wheat system	Subhash Chander Gill	RK Sharma, RS Chhokar, Karamjit Singh, Raj Pal Meena and Ms Anita
DWR/RP/10-9.4	Integrated weed management in wheat with special focus on resolving the problem of herbicide resistance in P. minor	RS Chhokar	RK Sharma, SC Gill, Karamjit Singh, Rajender Singh
DWR/RP/10-9.5	Developing strategies for increased water use efficiency in wheat crop	Raj Pal Meena	SC Tripathi, Karamjit Singh
DWR/RP/10-10	**Quality and basic sciences**		
DWR/RP/10-10.1	Biochemical and molecular studies for the improvement of processing and nutritional quality of bread and durum wheat	Sewa Ram	Bhudeva Singh Tyagi
DWR/RP/10-10.2	Genetic improvement to enrich product quality of bread wheat in Northern India	Devinder Mohan	RK Gupta
DWR/RP/10-10.3	Evaluation of elite germplasm lines for quality and molecular components	RK Gupta	Devinder Mohan, Sneh Narwal, Sonia Sheoran

DWR/RP/10-10.4	Studies on the effect of processing conditions on the antioxidant potential and phenolic compounds of wheat and barley end products	Sneh Narwal	RK Gupta
DWR/RP/10-11	**Information & Technology dissemination feedback and Impact Assessment**		
DWR/RP/10-11.1	Technology transfer, validation and impact assessment	Randhir Singh	Satyavir Singh, Anuj Kumar
DWR/RP/10-11.2	Factors affecting wheat yield in western U.P.	Satyavir Singh	Randhir Singh, Anuj Kumar
DWR/RP/10-11.2	Impact assessment of resource conservation technologies in wheat in Haryana	Anuj Kumar	Randhir Singh, Satyavir Singh
DWR/RP/10-12	**Computer Section and information technology**		
DWR/RP/10-12.1	Study the impact of climatic change on wheat yield through GIS techniques	Suman Lata	D Mohan, Ravish Chatrath
DWR/RP/10-12.2	Developing decision support system (DSS) for selecting wheat cultivars, based on disease resistance in different agro climatic conditions	Suman Lata	AK Sharma, Yogesh Sharma
DWR/RP/10-12.3	Developing statistical software and online analysis support to wheat and barley research workers	Ajay Verma	-
DWR/RP/10-12.4	Designing and maintaining of wheat and barley database in statistical parameters: E book	Ajay Verma	-

ii) ICAR-ACIAR Collaborative Projects

Project	Centres	Budget
Molecular marker technology for faster wheat breeding	DWR, Karnal; PAU, Ludhiana & NRCPB, Delhi	AUS $ 430,910* 13 lakhs
Root and establishment traits for greater water use efficiency in wheat	DWR, Karnal, IARI, New Delhi / Indore and ARI, Pune	75.40
Wheat improvement for waterlogging, salinity and element toxicities in Australia and India	DWR, Karnal and NDUAT, Faizabad	Aus $ 61, 036* 30.82 lakhs
Biotic stress (rusts)	DWR, Karnal, DWR RS, Shimla, IARI, New Delhi, IARI RS, Wellington, MPKVV, Mahabaleshwar and JNKVV, Powarkheda	75.65 lakhs
Wheat Grain Quality	DWR, Karnal, IARI, New Delhi, PAU, Ludhiana and UAS Dharwad	77.22 lakhs

*ACIAR fund

iii) Network Projects

Sr. No.	Network Project Title	Name of centres included	Budget Rs. In lakhs
1.	Bioinformatics	DWR, Karnal and PAU, Ludhiana	13.00
2	Development of wheat hybrid through CMS system	DWR Karnal, IARI New Delhi, PAU, Ludhiana and MPKVV-ARS, Niphad	55.22
3	Improvement of salt tolerance in wheat using molecular approach	DWR, Karnal, CSSRI, Karnal and NDUA&T, Faizabad	54.62
4	Thermal Tolerance In Wheat : Phenotyping for adaptive mechanisms to facilitate MAS based wheat breeding	DWR, Karnal, CCSHAU, Hisar and BHU, Varanasi	49.29

5	Drought Tolerance In Wheat : Phenotyping for adaptive mechanisms to facilitate MAS based wheat breeding	DWR, Karnal, CSAUAT, Kanpur and ARI, Pune	58.42
6	Genetic enhancement and conservation agriculture for improving the productivity, profitability and sustainability of rice-wheat cropping system Creation of national hybridization facility for wheat	DWR Karnal, PAU Ludhiana, GBPUA&T Pantnagar, NDUA&T, Faizabad, CCS HAU, Hisar and RAU, Samastipur DWR, Karnal	5.036

iv) Other Externally Funded Projects (2008-13)

- Enhancing farm profitability in North West India and South Australia by improving grain quality of wheat
- Initial establishment of a farmer-based experimentation network in the Indo-Gangetic Plains (IGP) region: Pilot project for on-farm participatory climate change adaptation and visualization.
- Contracting and syndication options for the Happy Seeder in NW India
- Salient Improvement of biscuit making quality of Indian wheats utilizing molecular approach funded by DBT.
- DUS project in wheat
- DUS project in barley
- Pathogenic and molecular variation among *Tilletia indica* monosporidial lines/ isolates causing Karnal bunt of wheat.
- *Puccinia tritcina* genomics network on *de novo* genome sequencing, itness, variation and pathogenicity (DWR Flowerdale, Shimla)
- Genetic enhancement of a wheat and pyramiding rust resistance genes though molecular approaches
- Agri-Bioinformatics Promotion Programme
- Identification and validation of genomic regions involved in spot blotch resistance in barley

ANNEXURE VI

Zone-wise research priorities

Northern Hill Zone

- Wheat improvement for rainfed areas, high altitude and early sowing, longer duration and cold tolerance
- Tackling yellow rust and powdery mildew
- Pre-breeding efforts involving winter x spring hybridization

North Western Plains Zone

- Enhancing yield potential through strong pre-breeding efforts utilizing genetic resources including diploid progenitors and synthetic hexaploids
- Tackling biotic stresses mainly yellow and brown rusts as well as herbicide resistant weed management.
- Residue management, tillage practices and balanced fertilizer use technologies
- Improving processing and nutritional quality of wheat
- Developing doubled haploid production facilities at lead centres
- Strengthening CCN facility in Rajasthan

North Eastern Plains Zone

- Development of short duration wheat cultivars to fit after late harvest.
- Developing tolerance to post harvest sprouting for far-east region of the country.

- Major emphasis would be put on heat stress, leaf blight resistance, salinity stress, waterlogging and micronutrient deficiency/toxicity

Central Zone

- The main emphasis will be put on heat and drought tolerance with a special emphasis on development of varieties for restricted irrigated conditions
- Tackling brown and black rust and leaf blight
- Strengthening durum wheat breeding to improve quality

Peninsular Zone

- Improving resistance to brown and black rust
- Developing wheat having heat and drought tolerance
- Improving durum and dicoccum quality
- Strengthening rust screening and pathotyping studies

Southern Hill Zone

- Major emphasis in this zone will be on rust screening and pathotyping to develop resistance stocks for further use in breeding.


February 11
DIRECTORATE OF WHEAT
Dr. Ravish Chatrath
Dr. Indu Sharma
Dr.B.Mishra
Dr. PK Joshi

भाकृअनुप
ICAR

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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