वार्षिक प्रतिवेदन
ANNUAL REPORT

2012-13

गेहूँ अनुसंधान निदेशालय
(भारतीय कृषि अनुसंधान परिषद्)
करनाल – 132001 भारत

DIRECTORATE OF WHEAT RESEARCH
(Indian Council of Agricultural Research)
Karnal - 132001 India

MANDATE

- 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.

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.

भाकृअनुप
ICAR

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DIRECTORATE OF WHEAT RESEARCH
(Indian Council of Agricultural Research)
Karnal - 132001, Haryana, India

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PREFACE

India recorded all time high 94.88 million tonnes of wheat production from an area of 29.90 million hectare during 2011-12. The country needs to produce 100 million tonnes of wheat by 2030 to feed the ever-growing population, which is a major challenge under changing climatic scenario. Therefore, concerted efforts are needed to intensify the research on enhancing the productivity in terms of per unit area on ecologically and economically sustained basis.

Directorate has taken several initiatives to combat emerging issues like climate change, dynamics of pests and diseases, deteriorating soil nutrients, increasing cost of cultivation, global price changes, export import policies and changing consumption pattern etc. These include widening of gene pool through alien sources; gene pyramiding of rust resistance gene in popular varieties through MAS; development of RILs for terminal heat tolerance and spot blotch; and resource conservation technologies like zero tillage, rotary tillage and precision laser land leveling. Bio-fortification and enhanced bioavailability of micro-nutrients are important part of quality breeding. Directorate is focusing on developing nutritionally superior (high protein, zinc, iron, low phytate) genotypes to combat hidden hunger and product (bread, biscuit, and pasta) specific varieties to meet the requirement of food industries. Decision support system for the management of wheat crop will be developed in near future. Regional Research Station at Flowerdale, Shimla is keeping strong vigil on spread of diseases and maintaining repository of 126 wheat rust pathotypes in pure form. Directorate is strengthening the production of double haploid facilities in Dalang Maidan. In barley, major emphasis has been given on improving the malt quality and understanding its biochemical basis.

The year 2012-13 has been an eventful year, wherein four wheat varieties including one durum and one triticale variety were released by the Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) for different production conditions of the country. Similarly, 10 wheat and 4 barley varieties were identified for release under different production conditions in various zones. Use of improved crop varieties coupled with better soil, water and fertilizer management practices and technologies have been responsible for attaining highest ever production of wheat. Timely management of stripe rust in high production zone was also instrumental for achieving highest ever production in wheat. However, some head-way has been made in gene pyramiding and gene deployment for combating stripe rust. In resource management, results of seed priming were encouraging. To reduce the cost of cultivation, application of phosphorus can be skipped, when 300% cropping intensity is maintained with inclusion of legume crops. In the area of quality and basic sciences, Indian wheat varieties were characterized for low molecular weight glutenin alleles using PCR. Similarly, very good progress has been made in social sciences, wherein various constraints in wheat and barley production have been identified, which will form the base of future research programme. At Regional Station Flowerdale, Shimla, rust resistance genes namely *Lr1, Lr3, Lr10, Lr13, Lr18, Lr23, Lr24, Lr26, Lr28, Lr 34, Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr12, Sr13, Sr24, Sr30, Sr31, Yr2, YrA, Yr9, Yr18* and *Yr27* characterized in more than 170 lines on the basis of gene matching technique. At Dalang –Maidan, a record number of 36,000 lines of wheat and 900 lines of barley were grown for generation advancement by 19 co-operators during 2012. In barley, a two row malt barley DWRB91 was developed and released by the directorate and good synergy has been developed with malt industry. Overall conduct and reporting of wheat and barley coordinated trials have improved during the year. An important milestone during the year was the allotment of 200 acre land by the council at Hisar for experiment and seed multiplication purposes.

Recognising the overall contribution, prestigious Chaudhary Devilal outstanding All India Coordinated Research Project Award 2011 was conferred to AICW&BIP led by the Directorate on July 16, 2012 for playing key role in enhancing the wheat and barley productivity.

I hope new research initiatives undertaken during last year in frontier areas of research will pay rich dividend in the years to come.

(Indu Sharma)

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EXECUTIVE SUMMARY

Crop Improvement

- Four new wheat varieties namely MP3288, UAS428, PBW644 and TL2969 were released by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) for different production conditions of the country.
- Nine new wheat varieties namely; HPW349, WH1105, DBW71, HD3059, RAJ4229, RAJ4238, HI8713(durum), MP3336 and WHD948 (durum) were identified for release by the varietal identification committee during the 51st All India Wheat and Barley Research Workers' Meet held at Jaipur in August 2012.
- Seven genetic stocks of wheat viz., WCF12-7, WCF 12-9, WCF 12-61, WCF 12-208, DWRL-1 DDK 1037 (dic) and UAS320 were registered for specific traits at NBPGR, New Delhi.
- Wheat variety DBW71 developed by the Directorate has been identified for irrigated late sown conditions of NWPZ by the Varietal Identification Committee during 51st Wheat workshop at Durgapura, Jaipur in August 2012.
- A total of 87 wheat varieties have been registered with PPV&FRA under extant category so far.
- Under coordination, 476 entries along with 60 check varieties were evaluated for yield, diseases, quality and agronomic characteristics in 37 series of 438 trial sets at 129 centres spread over six wheat growing zones of the country.
- Under coordination, a total of 255 entries in different NIVTs and 39 in IVTs were evaluated and 69 entries were found promising for yielding ability and disease resistance
- Among the 164 genotypes evaluated in various AVTs conducted in different zones, 38 genotypes were found superior to the check varieties on the basis of yield and response to incidence of rusts.
- A total of 35893.02 q breeder seed involving 157 wheat varieties was produced by 30 seed production centres against DAC indent of 28619.55q. In addition, 1958.35 q nucleus seed of 154 varieties was also produced.
- Sixteen nurseries/trials from CIMMYT and 10 trials (8 bread and 2 durum wheat) from ICARDA, Syria were planted at different co-operating centres for the identification of suitable genotypes for different production conditions.
- In germplasm exchange, sixty germplasm accessions were received from USA(58) and Canada (2), while 2652 wheat accessions were supplied to various indentors within country.
- In an exploration undertaken in higher altitude areas of Ladakh district of Jammu and Kashmir, fourteen divergent types wheat were collected.
- Seven hundred fifteen indigenous and exotic accessions of wheat comprising 669 of *T. aestivum*, 40 of *T. durum* and 2 each of *T. polonicum*, *T. compactum* and Triticale were characterized for 44 characters and promising accessions identified for various yield contributing characters:
- 11,500 germplasm accessions are being conserved in medium term storage module (4°C and RH 30-35%) at Directorate and a duplicate set comprising of 8697 accessions is being conserved under natural condition at DWR Regional Station, Dalang Maidan.
- To transfer the *ph1b* mutant gene in background of Indian wheat varieties, Chinese Spring wheat genotype with *ph1b* was crossed with bread wheat cultivars (PBW502 and DBW16) and tetraploid durum wheat cultivar (HI8498).
- Back cross program was taken up involving the resistant stocks *Sumai#3* and *Frontana* to incorporate *Fusarium blight* resistance in Indian wheat varieties.
- For incorporating resistance to Ug99 in advanced genotypes, 50 cross combinations were made involving 10 FLW lines and 16 STEMRRSN lines as donor parents.
- Crosses were attempted involving *Kharchia-65* (multiple stress tolerance) as one of the parent in order to study the genetics of biotic and abiotic stresses traits.
- QTL analysis was conducted using phenotypic and marker genotyping data from 330 diverse double haploid lines derived from *Excalibur/Kukri* cross.
- Mapping population (total 728 lines) of three sets of RILs (*Sonalika/BH1146, Kanchan/Chirya1* and *HUW234/Yangmai6*) phenotyped as well as screened with microsatellite markers for tagging of major

QTLs associated with spot blotch resistance in wheat.

- A set of RIL population (HD2808/HUW510) consisting of 475 lines was phenotyped alongwith parents under normal (timely sown) and stress (late sown) environments for terminal heat tolerance.
- Phenotypic evaluation of double haploid populations derived from *Ducula 4/2*Brookton* and *Camm/HD2329* for yield and disease resistance (stripe rust, leaf rust and KB) indicated the variation in resistance level in both the populations
- Six national nurseries comprising of 426 germplasm lines and 87 F_2s and F_3s in segregating stock nursery and 50 F_2s in Spring x Winter segregating stock nursery were shared with cooperating centres for utilization in wheat improvement.
- More than 1200 crosses under various projects were successfully attempted during the year in addition to specific crosses at DWR, Karnal.
- A total of 345 spring and winter wheat crosses were made which include 231 three-way crosses; and 114 single crosses and 50 F_2 crosses were shared with seven cooperating centres.
- Among 10 genotypes of durum wheat evaluated at 24 centers for three years in the Yield Component Nursery, 3 (DBPY-08-01, DBPY-08-06, DBPY-08-10), 3 (DBPY-08-04, DBPY-08-7, DBPY-08-09), and 4 (DBPY-08-02, DBPY-08-03, DBPY-08-05, DBPY-08-08) genotypes were identified as the genetic stocks for tillers/m, grains per spike and thousand-grains weight, respectively
- Among 12 wheat genotypes evaluated for genotype-tillage interaction by conducting surface seeding, NW1014 was the best performer (59.39 q/ha) followed by Raj3765 (56.60 q/ha) and HUW234 (56.12 q/ha).
- Out of 250 germplasm lines phenotyped for pre-harvest sprouting (PHS), 6 lines namely EC383445, PI376842, AC Domain, EC362087 (durum), EC201931(durum) and CITR4926 (*compactum*) were found moderately dormant to PHS.
- Around 200 elite lines including bread wheat and triticale were evaluated for quality traits and selected 10 genotypes for further use in hybridization programme.
- Among 28 genotypes evaluated for drought (rainfed conditions) and terminal heat tolerance (late sown conditions), 9 genotypes were found tolerant to both the stresses, while 5 genotypes to heat stress and 9 genotypes to drought stress.
- Genotypes DBW88 and DBW74 were in final year of evaluation in AVT-IR-TS and AVT-RF-TS trial of NWPZ and DBW93 in AVT-RF/RI-TS trial of PZ.
- Genotypes DBW101 and DBW102 promoted to AVT-IR-TS of NWPZ and DBW110 promoted to AVT-RF in all the four zones.
- Durum genotype DDW23 showing yield superiority over checks has been promoted to Advance Varietal Trial in Central Zone.
- A total of 75 accessions of hexaploid synthetics were evaluated for heat tolerance under polyhouse and field conditions and lines exhibited lesser reduction for 1000-grains weight and grains number/ spike under stress condition were identified.
- Sixty-three indigenous germplasm accessions were evaluated for heat tolerance under both field as well as temperature controlled glasshouse conditions. Thirteen genotypes had lesser reduction in grain weight/spike, while 16 had lesser reduction in thousand grains weight.
- *Bipolaris sorokiniana* isolates viz., B-1 (most virulent), B-2 and B-3 exhibited a significant variability in their virulence and pathogenesis along with cultural characteristics.
- Molecular characterization of 300 genotypes by *Lr34* co-dominant gene marker revealed that 60 genotypes possess *Lr34* gene and majority (33%) of them from NWPZ.
- Dosage of 0.7 to 0.8 % EMS for 16 hrs having survival rate of 50-60% plants was used to mutagenize the seeds of DPW621-50 for developing a mutant population for TILLING (Targeting Induced Local Lesions IN Genomes).
- Partial DREB gene sequences for drought tolerance were isolated from 15 drought tolerant Indian bread wheat cultivars and

submitted to NCBI with HQ804651-55 and FC556845-53 accession numbers.

- Sixty-one wheat genotypes were haplotyped for stem rust resistance genes *Sr2, Sr6, Sr22, Sr24, Sr25, Sr26, Sr31, Sr36, Sr40* and 1A.1R using linked microsatellite (SSR) and sequence tagged site (STS) markers.

Crop Protection

- The sources of resistance (multiple disease/ pest resistant sources) were identified through multilocation hot spot evaluation. These were made available to the breeders through NGSN, which had helped in diversification and enhancement of resistance level.
- Indian wheat advance lines (189) were evaluated at Kenya and Ethiopia for resistance against Ug99. Slow ruster lines were identified for leaf rust and stripe rust resistance at Karnal.
- Fifty eight entries possessing multiple disease and insect pests resistance were contributed in the NGSN, 2011-12 which was planted at 20 breeding centers across different agro climatic zones of country for their utilization in breeding for resistance to biotic stresses. The entries utilized most (20% or more) at centres were VL 907, DBW 50, DBW 54, NW 3087, DBW 49, HD 3007, WH 1021, VL 920, UAS 305, HD 2987, MACS 6273, PBW 612, WH 1061, WH 1062, PBW 610, VL 926, DBW 39, HD 2998, HUW 626, WH 1076, WH 1078, K 0716, MACS 6222 and MP 4080.
- The overall crop health was good except sporadic occurrences of yellow rust in Punjab, Haryana, HP, Uttarakhand and J&K.
- Karnal bunt (KB) incidence analysed in 9280 samples was lower than the preceding year. Samples received from central and peninsular India were found free from KB.
- Out of 4133 grain samples analyzed for black point from different zones in the country, 72.33 % samples showed its incidence.
- Compatibility among monosporidial lines of *Tilletia indica* isolates was studied on susceptible host cultivars HD 2009 and WL 711. Genetic variation *Tilletia indica* isolates / monosporidial lines was studied through RAPD and ISSR markers.
- Pathogenic variation among *Fusarium graminearum* isolates was studied on a set of wheat varieties under artificially inoculated conditions.
- The diseases and pests like powdery mildew, root aphid and termites were more under FIRBS, whereas powdery mildew, Karnal bunt and termites showed low incidence under zero tillage. IPM module was promoted at the farmers fields on large scale in parts of Haryana and registered more than 10.00 % yield gain in comparison to the non-IPM.

Resource Management

- No-till transplanting of rice gave significantly lower yield compared to transplanting under dry and wet tillage conditions.
- Tillage either in rice or wheat had non-significant effect on wheat productivity. However, rotary tillage had the yield gain over zero tillage and conventional tillage.
- In a long term residue management study, retention of residue load of 4 to 6 t/ha was found beneficial in improving wheat productivity and soil organic carbon. The surface retention of residue can also help in saving one to two irrigations.
- Direct seeded rice had lower productivity compared to transplanted rice.
- Skipping of P application in rice or wheat or in both the crops at alternate year produced similar rice and wheat yield. This showed that continuous applications of P containing fertilizers can be skipped particularly when 300% cropping intensity is maintained with inclusion of legume crops.
- Response of FYM was observed at recommended NPK level. Increasing the dose of NPK up to 150% decreased the effect of FYM. This shows that there is scope for increasing the wheat yield if 150% NPK is added or 10 t/ha FYM is applied in combination with recommended fertiliser.
- Intercropping options like 6 rows of wheat and one row of canola/ mustard produced additional mustard or canola yield without loosing wheat yield. Equivalent wheat yield

was maximum in case of 6:1 wheat: canola/mustard intercrop.

- It was recorded that irrigation scheduling at 60, 68, 75 and 82 kPa (centibars) produced statistically similar yield of wheat crop with genotype DBW 17.
- Seed priming by water and sprouted seeds were produced significantly higher grain yield of wheat over unprimed seed (61.68 & 59.67 q/ha over 56.08 q/ha).
- Under limited irrigation conditions (two irrigations at CRI and Late tillering), wheat variety NI 5439 produced highest grain yield (51.89 q/ha).
- In organic wheat production, use of FYM @ 30 t/ha in rice-wheat-moong produced the wheat yield of cultivar C 306 similar to inorganic control (Recommended NPK).
- Application of recommended NPK + 15 t FYM/ha produced the highest yield which was better than farmer's practice (N and P only).
- Application of nitrogen (urea) just before irrigation was found better than its application after irrigation.
- Pyroxasulfone at 63.75 g a.i./ha applied in combination with metsulfuron, carfentrazone, triasulfuron and pyroxsulam provided better yield compared to alone application of pyroxasulfone due to broad-spectrum weed control.
- Tank mix combination of topramezone with clodinafop and pinoxaden was better compared to alone application of topramezone due to effectiveness in controlling complex weed flora. Topramezone application without surfactant had high level of phytotoxicity and addition of safener or grass herbicide clodinafop or pinoxaden drastically reduced the crop phytotoxicity.

Quality and Basic Sciences

- Wheat genotypes namely Raj4238, MP3336, PBW175, C306, HI1563, K8027, HD2888, HI1500 and NIAW1415 were found promising for chapati quality scoring >8.0/10.0.
- Several *T.aestivum* wheat genotypes namely, WH1097, K0906, NW2036, NIAW34, Raj4083, HD2932, HI5439 and NIAW1415 were found suitable for bread quality recording >575 ml loaf volume.
- Only one genotype namely HS490 was found good for biscuit recording ~10.0 spread factor.
- Some of the *durum* wheat genotypes, HI8713, WHD948, PDW314 and HI8627 were rated good for pasta products scoring >7.0/9.0 on hedonic scale.
- Apart from identifying promising genotypes for individual quality traits including nutritional parameters, their variability in the country was also ascertained.
- Promising genotypes were selected from NIVTs namely HI1588 for CZ and MP1270 for PZ.
- Quality Component Screening Nursery comprising of 52 genotypes was evaluated at 15 locations and consistent & stable performing genotypes were identified.
- To improve the chapati, biscuit and bread quality, superior combinations were identified in an attempt to improve protein content, grain hardness, gluten strength and grain size. Generations were advanced based on yield attributes, disease resistance and quality traits using summer nursery facilities. Promising lines have been identified.
- More than 600 crosses were attempted to combine prominent quality traits related to *chapati*, bread and biscuit with yield and disease resistance.
- Evaluation of 75 fixed lines was done for yield and quality traits in preliminary yield trial. Four entries were promoted to NIVT 1A and NIVT 1B.
- Promising lines were identified from various nurseries viz. NGSN (97 lines), EIGN-I (119 lines) and EIGN-II (60 lines) grown at DWR Research Farm, Karnal and analysed for processing & nutritional quality parameters and also molecular characterization.
- Low molecular weight (LMW) glutenin genes have been characterized. Full length Glu-B3 gene was cloned and sequenced from 2 varieties to develop Glu-B3b allele specific markers.

- Nap Hal and other soft germplasm lines have been utilized for the improvement of biscuit quality, using back crossing and molecular marker assisted selection (MAS).
- For the improvement of nutritional quality, purification and kinetic analysis of phytase has been carried out. Synthetic hexaploids showed higher Zn content and can be utilized to improve Zn content in Indian wheat.
- Twenty three Indian wheat varieties were evaluated for free, bound and total phenolic acid content in the bran. On an average, bound phenolic content was found to be 4-fold higher compared to free phenolics.

Social Sciences

- During the wheat crop season 2011-12, 210 Wheat Front Line Demonstrations (WFLDs) of one hectare each were allotted to 80 coordinating centres of which 204 were conducted through 78 coordinating centers.
- The maximum number of WFLDs were conducted in UP (31) followed by Haryana (20), Bihar (18), Maharashtra (17), Rajasthan (13), Gujarat (13), Jharkhand (12), J&K (12), Punjab (10), HP (10) and Chhattisgarh (9).
- The maximum yield gain was observed in MP (34.47%) followed by Chhattisgarh (32.52%), Uttarakhand (29.09%), HP (23.45%), Jharkhand (22.97%), J&K (17.98%), Rajasthan (17.74%), West Bengal (15.12%), Karnataka (14.91%), Bihar (14.73%), Maharashtra (14.05%), UP (13.82%), Gujarat (13.32%), Punjab (09.81%), Delhi (07.86%) and Haryana (06.90%).
- FLDs on Bio-fertilizer (Azotobactor & PSB) alongwith 100 % inorganic fertilizer as compared to check (100% recommended dose of Inorganic fertilizer) showed that the yield gain was significant at West Singhbhum centre (33.13 %) in NEPZ followed by Vijapur center (09.09 %) in CZ and DWR-Karnal (04.41 %) in NWPZ.
- Zero tillage gave positive but non-significant yield gain of 19.70%, 19.51%, 14.68%, 05.95% and 05.72% at Faizabad, Shillongani, Kathua-Jammu, Varanasi and Ambala centers, respectively.
- *Phalaris minor*, *Rumex dentatus* (Jangali Palak), *Chenopodium album* (Bathua), yellow rust, leaf blight and water stress were the important constraints across the zones in wheat production in India.
- During the rabi crop season 2011-12, 40 Barley Front Line Demonstrations (BFLDs) were allotted to 13 different Barley Network centers all over India in six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP of which 33 were conducted by 10 network centers, covering 33.00 hectares area of 57 farmers.
- The highest yield gain in barley was recorded in MP (41.44 %) followed by HP (19.62%), Rajasthan (16.03 %), Punjab (14.40 %), UP (12.88 %) and Haryana (06.89 %).
- Infestation of *Phalaris minor* in barley field, aphid attack, high cost of custom hiring, small holdings, high cost of inputs their quality and non-availability were observed as most serious constraints impeding barley production in the country.
- Timely sowing (Last week of October to 20th November), adoption of zero tillage technique, growing latest recommended varieties, seed treatment, maximum usage of certified/quality seeds, nutrient usage as per soil testing, timely control of weeds with uniform spray using flat fan nozzle, rotation of herbicides and crop rotations are effective strategies to control weeds.
- In Saharanpur district of Western UP, the major factors affecting wheat yield were yellow rust, termite, *Phalaris minor* (mandusi), declining water table, non availability of labour, high cost of inputs, imbalanced use of fertilizer, lack of knowledge among farmers about recent technologies and non availability of electricity.
- The positive impact of adoption zero tillage was on cost saving, time saving, management of *Phalaris minor,* fuel saving, organic carbon in soil, improves water retention capacity, decreases lodging and avoid terminal heat. The farmers perceived that laser land leveller saves water, increases area under cultivation and gives more yield.
- Social science section organized Foundation Day, four training programmes, Innovator-cum-Seed Day, three awareness programmes on "Protection of Plant Varieties and Farmers' Rights Act 2001" related to wheat and barley crops, one Kisan mela, one

workshop, seven exhibitions, delivered four lectures and coordinated 38 visits of 1507 students/farmers/entrepreneurs and five foreign delegates. SMS service was also started to send wheat and barley crop messages.

Regional Station, Flowerdale, Shimla

- The year was comparatively a dry season, therefore, development of rusts occurred almost one month late than the previous two years due to scanty rainfall. Except for yellow rust, incidence of other rusts was minimal. In some localities in Northern India, high severity of yellow rust of wheat was observed. Chemical intervention in the initial stages checkmated the yellow rust.

- Aecial collections from at least six *Berberis* species drawn from four districts of Himachal Pradesh, Uttrakhand and Nepal could not infect wheat, barley and oat. It indicated that the aecial cups in these areas do not relate to wheat rust. Similarly grass samples did not infect wheat, however, one sample infected oat and was recorded as leaf rust of oat.

- National repository of 126 pathotypes of different rust pathogens of wheat, barley, oat and linseed was maintained as live cultures and stored for long term also. To enable rust research elsewhere and creation of artificial epiphytotics, nucleus inocula of rust pathotypes was supplied to 49 Scientists/centers.

- 1655 samples of wheat and barley rusts were collected and 1006 were analyzed. There was no occurrence of new pathotype. Pathotype 46S119 of yellow rust was most predominant followed by 78S84 in Northern India. In Nilgiri hills pathotype I(38S102) was common. In Ladakh pathotype CI, followed by CII and CIII were observed. These pathotypes do not occur anywhere in India.

- In black rust, pathotype 40A followed by 40-1 were common in Nilgiri hills. In Ladakh area, pathotype 34-1 was identified in all the samples. This pathotype is very primitive and does not occur in other parts of India.

- In brown rust, pathotype 77-5 was observed in most of the samples from India, Nepal, Pakistan and Bangladesh. Proportion of pathotype 93R57(104-4) identified two years ago, has increased over Northern India.

- 1625 wheat and barley lines were evaluated at seedling stage against different pathotypes of three rusts. None of the wheat AVT lines showed resistance to all the rusts however, three lines of barley were resistant to three rusts. Ten *Lr* genes were characterized in 151 lines, 5 *Yr* genes in 117 and 13 *Sr* genes in 159 lines.

- To know the movement of wheat rusts in South Asia and within India, SAARC wheat disease monitoring nursery at 23 locations in six SAARC nations and National Wheat Disease Monitoring Nursery at 38 locations in all the wheat growing areas of India were organized and coordinated. Yellow rust was more prevalent in Northern India, Pakistan and Afghanistan whereas, blight was common in Eastern India, Bangladesh and Nepal. Incidence of yellow rust was more in Northern India than Pakistan and Bangladesh, indicating a different racial pattern of *P. striiformis*.

Regional Station, Dalang Maidan, Lahaul & Spiti

- Around 36,000 lines of wheat and 900 lines of barley from 19 co-operators were planted at regional station for generation advancement disease screening and seed multiplication during the year 2012.

- About 1000 corrective crosses were attempted by the researchers across the institutes.

- Approximately 15,000 lines were screened for yellow rust and powdery mildew.

- Wheat X Maize system of doubled haploid production in wheat was initiated at Dalang Maidan.

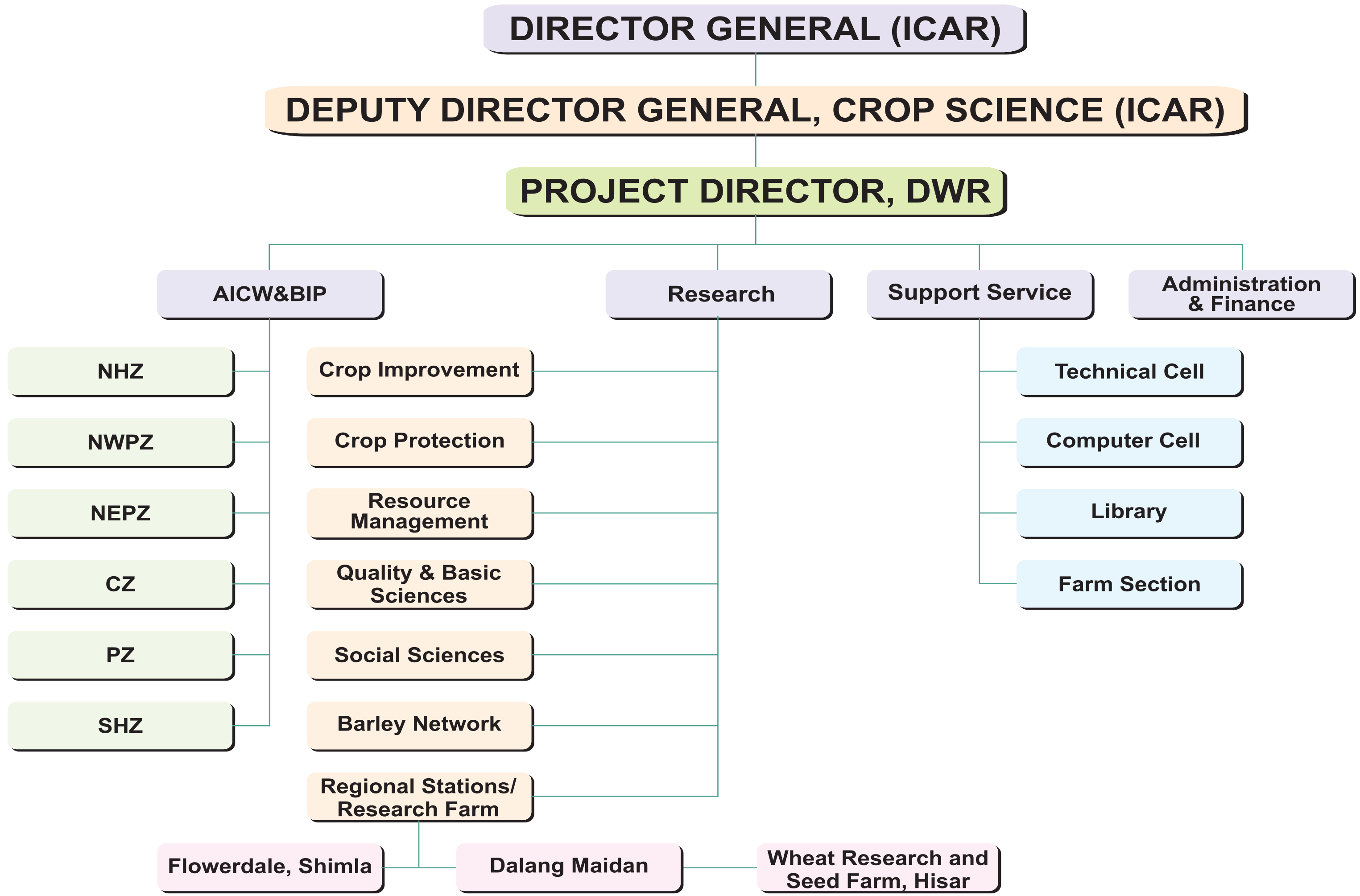
Barley Network

- A new two-row malt barley variety DWRB91 has been released for commercial cultivation in NWPZ by CVRC. The new variety is suitable for late sown cultivation under rotation with cotton, pearl millet and sugarcane where sowing get delayed in rabi season in north western India.

- Under the AICW & BIP varietal evaluation programme, out of 120 new entries, 18 were found promising, in which four (DWRB92, HUB113, RD2811, BHS400) have qualified for final years testing in AVT.

- Zonal monitoring was organized in three zones during the crop season covering a large number of locations in three zones in plains and one in hills.
- Against the DAC indents of 1841.6 q breeder seed for 28 barley varieties, a production of 1905.80 q was achieved under AICW&BIP.
- In all, 848 new genotypes received as five yield trials and seven nurseries from ICARDA, Syria were evaluated at Karnal and other locations. A set of 45 genotypes was selected for constitution of EIBGN, which was supplied to eleven centres for further utilization.
- Under the malt barley improvement programme at DWR, 13 entries (9 in malt barley and 4 in feed barley) were contributed for network trials. More than 696 families involving 465 crosses were evaluated, out of which 30 new bulks were made for PYT, while 676 families (382 crosses) were selected in field evaluation under artificial inoculations of rusts, leaf blight and foliar aphid for next season.
- A set of 46 SSR markers was screened with the final year test entries (VLB118, BH933, RD2784, RD2786, RD2787, BH932 and DWR91) and check varieties (HBL113, UPB1008, BHS352, PL751, BH902, RD2035, RD2552, K551, DWRUB64 and DWRB73) to develop DNA fingerprinting data and 68 marker alleles were scored and approximately 1156 data points were considered. The dendrogram generated clearly indicates that the final year test entries do not cluster at one place and are quite diverse except for VLB118 and HBL113.
- In cross DWR49/RD2503, parents were screened with 270 SSR markers for leaf blight resistance and 50 SSR markers segregated co-dominantly. The 142 RILs when screened with these 50 polymorphic SSR markers indicated that markers *Bmac213*, *ABG059* and *Bmag211* on chromosome 1H were found to be closely linked with leaf blight resistance in barley during single marker analysis.
- More than 392 grain samples were evaluated for grain and malt traits from coordinated trials, through micro malting process. The entries DWRB102, DWRB103, DWRB104, RD2848, RD2849 were having better overall malting quality score under timely sown conditions. In late sown trials, BH968 was found promising.
- A total of 760 samples were analysed under feed barley programme for grain physical parameters and protein content. From these 15 entries were identified as promising from different experiments.
- In the Barley Quality Screening Nursery (BQSN) the entries BK306, BCU4966, BCU5070, BCU5474 and DWR49 have been found to contain higher protein content coupled with good grain development.
- Seventy Six barley varieties grown at DWR, Karnal were screened for grain beta glucan content and varieties with >5% beta glucan (dry weight basis) were BHS352, Dolma, HBL276, NB-2 and NB-3.
- Twenty two trials for varietal evaluation and 26 special trials for fine tuning package of practices were conducted in different zones during the year 2012-13.
- A row spacing of 18 cm with 100 kg seed/ha is recommended for two-row malt barley after three years of experimentation.
- The feed barley responded up to two irrigations because of lodging at higher irrigation levels, while for two-row malt barley the response was observed up to three irrigations.
- Minimum tillage is found profitable over conventional tillage and sustainable in barley, for saving precious input cost by reducing cost on tillage, energy, labour and improved soil health on long term basis.
- In crop protection programme, 598 barley entries (358 entries in IBDSN, 194 in NBDSN and 46 in EBDSN) were evaluated under artificial inoculations of rusts, leaf blight, CCN, aphid etc. at hot spot locations. Entries RD2715, RD2786, RD2787, RD2809, RD2816 and RD2828 for stripe rust and BH932, BH942 and PL860 (for leaf blights) were observed promising.

ORGANOGRAM


DIRECTOR GENERAL (ICAR)
DEPUTY DIRECTOR GENERAL, CROP SCIENCE (ICAR)
PROJECT DIRECTOR, DWR
AICW&BIP
Research
Support Service
Administration & Finance
NHZ
NWPZ
NEPZ
CZ
PZ
SHZ
Crop Improvement
Crop Protection
Resource Management
Quality & Basic Sciences
Social Sciences
Barley Network
Regional Stations/ Research Farm
Flowerdale, Shimla
Dalang Maidan
Wheat Research and Seed Farm, Hisar
Technical Cell
Computer Cell
Library
Farm Section

1 CROP IMPROVEMENT

Wheat production in India recorded an all time highest production of 94.88 million tonnes during 2011-12 crop season. Crop Improvement entails basic, strategic and applied research in bread, durum and dicoccum wheat and the progress made during 2012-13 is presented below.

Release of new wheat varieties

The All India Coordinated Wheat & Barley Improvement Project (AICW&BIP) organizes large number of wheat varietal evaluation trials under various cultural conditions in the six wheat growing mega-zones spread across the country. During the All India Wheat and Barley Research Workers' Meet, varietal release proposals from various wheat breeding centres are considered and varieties for release are recommended by the Varietal Identification Committee (VIC). On the basis of VIC recommendations, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) finally recommended the varieties MP3288, UAS428, PBW644 and TL2969 for notification and release during the year 2011-12 (Table 1.1). During the 51st All India Wheat & Barley Research Workers' Meet held at Jaipur in August 2012, the VIC identified 10 new varieties namely; HPW349, WH1105, DBW71, HD3059, RAJ4229, RAJ4238, HI8713(durum), MP3336, WHD948 and HW5216 for release under different production conditions in various zones.

Table 1.1. Wheat varieties released by CVRC

SN	Name and parentage	Developed by (University/ Institute)	Area of adoption	Production condition	Grain yield (q/ha)	
					Average	Potential
1.	MP 3288 *DOVE/BUC/DL788-2*	JNKVV, Jabalpur	CZ	Timely sown, RF & RI	23.2 (RF) 35.1 (RI)	42.1 (RF) 43.9 (RI)
2.	UAS 428 (Durum) *Green-14/YAV-10//AUK/ UAS402*	UAS, Dharwad	PZ	Timely sown, Irrigated	47.9	58.8
3.	PBW 644 *PBW175/HD2643*	PAU, Ludhiana	NWPZ	Timely sown, Rainfed	31.4	44.8
4.	TL 2969 (Triticale) *JNIT/TL1210//JNIT141*	PAU, Ludhiana	NHZ	Timely sown, Rainfed	29.3	53.8

Registration of new genetic stocks

The various national nurseries constituted from DWR are evaluated through multilocation and multi-year screening of wheat germplasm for different yield traits, resistance against various diseases, abiotic stresses and quality attributes. The good and consistently performing germplasm lines are then considered for registration as genetic stock. The Plant Germplasm Registration Committee examines the proposals and approves their registration. The registered genetic stocks are then utilized for creation of new variability in wheat breeding programmes at different centres across the country. The germplasm resource unit of DWR, Karnal multiplies the seeds of these genetic stocks and makes them available to wheat breeding centres in the country. The registered genetic stocks are also included in the National Genetic Stock Nursery (NGSN) from time to time for ensuring their availability to large number of wheat centres for further use in wheat improvement activities. During the year under report, seven genetic stocks of wheat viz. WCF12-7, WCF12-9, WCF12-61, WCF12-208, DWRL1, DDK1037 (dic.) and UAS320 were registered (Table 1.2).

Table 1.2. New genetic stocks registered

SN	Name and parentage	Registration number	ID No.	Developed by	Trait
1.	WCF12-7 *RIL component line of WL711/C306*	INGR11037	IC0594376	IARI, New Delhi	Drought tolerance
2.	WCF12-9 *RIL component line of WL711/C306*	INGR11039	IC0594378	IARI, New Delhi	Drought tolerance
3.	WCF12-61 *RIL component line of WL711/C306*	INGR11038	IC0594377	IARI, New Delhi	Drought tolerance
4.	WCF12-208 *RIL component line of WL711/C306*	INGR11040	IC0594379	IARI, New Delhi	Drought tolerance
5.	DWRL1 *NIAW34/ RL6010 (Lr19)//CMH81A-575*	INGR12019	IC0590878	IARI, New Delhi	Triple dwarf, resistance to rust (*Lr19*) and high protein content
6.	DDK1037 *(dic.)* *HW1092/DDK1006//SHIVANI KHAPLI// DDK1001*	INGR 12001	IC 0590877	UAS, Dharwad	Resistance to loose smut and flag smut
7.	UAS320 *UAS257//GW322/DWR195*	INGR 13001	IC0590875	UAS, Dharwad	Resistance to flag smut

Evaluation of genotypes in coordinated yield trials

Conduction of coordinated trials

During the crop season 2011-12, 37 series of trials comprising 476 test entries along with 60 check varieties were constituted. In all, 438 trial sets were supplied to 129 centres spread across six wheat zones in the country out of which 431 trials were actually conducted (Table 1.3). The conduction of trials was 100% in NEPZ and CZ, while it was over 96% in NHZ, 98% in NWPZ and PZ.

Table 1.3. Breakup of yield trials during 2011-12

Zone	Prop.	Cond.	Not Cond.	Rep.	Not Rep.
NHZ	53	51	2	34	17
NWPZ	130	127	3	116	11
NEPZ	75	75	0	59	16
CZ	99	99	0	77	22
PZ	70	69	1	57	12
SHZ	11	10	1	4	6
Total	**438**	**431**	**7**	**347**	**84**

It was over 90 % in SHZ. The percent conduction of the coordinated trials during 2011-12 (98.4%) was higher than the last two previous years (Table 1.4). Out of the 431 trials which were conducted during 2011-12, the data on 347 trials were found qualifying for reporting based on set norms. Out of the 84 trials which were not reported, as many as 16 trials were rejected by the monitoring teams in various zones.

Table 1.4. Percent success in trial conduction and reporting during three seasons

Zone	% conduction of proposed trials			% reporting of conducted trials		
	2009-10	2010-11	2011-12	2009-10	2010-11	2011-12
NHZ	84.6	93.5	96.2	68.2	81.4	66.7
NWPZ	90.7	95.1	97.7	90.5	94.0	81.3
NEPZ	95.9	100	100	91.4	83.1	78.7
CZ	90.6	91.8	100	80.5	89.9	77.8
PZ	94.5	95.1	98.6	66.2	75.9	82.6
SHZ	100	77.8	90.9	41.7	42.9	40.0
Spl trials	88.9	92.6	100	66.7	80.0	72.0
Total	**94.5**	**94.5**	**98.4**	**80.8**	**85.6**	**80.5**

The rest of the unreported trials were not considered for reporting due to low site mean (LSM), high coefficient of variation (HCV) and other anomalies like unrealistic yield (UY), early sowing (ES), incomplete data (ID) or improper layout (IL). The maximum trial reporting (82.6%) was in PZ with similar percentage in NWPZ, NEPZ and CZ.

On perusal of the three years data on conduction and reporting of trials, it was observed that there was low percentage of reporting of trials in SHZ which is a matter of concern. In this zone the trial conducting centres are quite less and that too at voluntary centres; therefore, there is a need for better management of the trials conducted at all the centres in this zone. Similarly, there is a need for improving the trial conduction in NHZ.

Promising varieties in Advanced Varietal Trials

Among the 164 genotypes evaluated in various AVTs conducted in different zones during the year 2011-12, 38 genotypes were identified to be superior on the basis of their yield performance with respect to the check varieties and their response to the incidence of rusts (Table 1.5). As many as 15 entries were found promising under timely sown irrigated condition. Among these 15 entries, 5 were durum entries and two entries were from final year testing. The 7 promising entries under late sown condition were all from NWPZ out of which 4 were from final year of testing. Under rainfed/restricted irrigation condition, 16 entries were promising out of which 7 were final year entries.

Table 1.5. Most promising entries in AVTs

Zone	Timely sown irrigated	Late sown irrigated	Rainfed/ Restricted irrigation
NHZ	HPW349*	-	HS536, HS542*, HPW376, HS557
NWPZ	HD3086, DBW88, HI8728 (d)	HD3065*, WH1100*, DBW71*, HD3059*, DBW90, WH1124, HD3091	WH1126, PBW674, DBW74*, PBW675*, PBW660*, WH1127, WH1098*, NIAW1594*, HI1579*
NEPZ	NW5054, K1006, WH1120, HD3076, PBW661	-	-
CZ	HI8713*(d), HI8727(d), HI8725(d), HI8724(d)	-	HI8731(d)
PZ	UAS334, MACS6478	-	DBW93
SHZ	-	-	HW5216

* Final year entry; d: durum wheat

Promising varieties in Initial Varietal and Special Trials

Among the total of 255 entries evaluated for their performance in different NIVTs and 39 in IVTs, 69 entries were found promising for high yielding ability and disease resistance (Table 1.6).

Table 1.6. Most promising entries in NIVTs, IVTs and Special Trials

Zone	Timely sown irrigated	Late sown irrigated	Rainfed/ Restricted irrigation
NHZ	VL969	-	HPW381
NWPZ	UP2841, WH1139, PBW683, DBW101, HUW666, WH1138, DBW102, HD3109, PBW681, HI8738(d), UPD94(d), HI8735(d)	UP2843, HUW668, K1114	HD3122, HD3121, HD3123, JAUW598, PBW689, UP2847, DBW110, UP2848, HUW669
NEPZ	K1105, WH1138, HD3111, HD3110, WH1137, WH1136	DBW107, HD3118, UP2844, HD3117, PBW688, HUW667, K1114, HUW668	DBW110, UAS347, BRW3723
CZ	HI1588, HI8735(d), HI8736(d), DDW23, HI8737(d)	MP3379, Raj4295	K1116, HD3123, UAS446(d)
PZ	HI8735(d)	NW5064, NIAW1994, MP3379, HD3116, DBW107, UP2845, K1114, HD3118, Raj4295	UAS347, DBW110, NIAW1994, UAS446(d), UAS447(d)
SHZ	-	-	HW1900
Special Trials			
Triticale	-	-	TL2990
Dicoccum	DDK1042	-	-

d: Durum wheat

Out of the 69 promising entries, 59 were of bread wheat and 10 of durum wheat. Twenty-five entries were observed to be promising for timely sown irrigated condition, 22 for late sown irrigated condition and 22 for rainfed/restricted irrigation. Only two genotypes, one each from dicoccum and triticale, were found promising among the 18 genotypes evaluated in three special trials on salinity/alkalinity, dicoccum and triticale.

Organization of national and international nurseries and trials

National nurseries

New germplasm in six national nurseries and two segregating stock nurseries were supplied to different cooperating centres for utilization in wheat improvement (Table 1.7). Breeders from various centres also contribute entries in these nurseries which are included after tests and seed multiplication. The germplasm in the nurseries are generally utilized in hybridization. Some of the promising germplasm based on multilocation evaluation data in the different national nurseries for various yield contributing traits have also been listed. The promising germplasm lines (Table 1.8) for different attributes are tested for 2-3 years to confirm their performance and are later proposed for registration as genetic stock by the germplasm contributing centres.

Table 1.7. National nurseries shared with co-operators

Nursery	Genotypes	Centres
National Genetic Stock Nursery (NGSN)	98+3 (C)	28
Yield Components Screening Nursery (YCSN)	130+3 (C)	24
Salinity/Alkalinity Tolerance Screening Nursery (SATSN)	60+5 (C)	9
Short Duration-cum-Late Heat Tolerance Screening Nursery (SDSN)	40+5 (C)	15
Drought and Heat Tolerance Screening Nursery (DHTSN)	46+3 (C)	12
Quality Component Screening Nursery (QCSN)	52+3 (C)	15
Segregating Stock Nursery (SSN)	87 F_2 & F_3	15
Spring x Winter Segregating Stock Nursery (WSSN)	50 F_2	7

Table 1.8. Promising germplasm identified from national nurseries

Characteristics	Promising genotypes
Early heading (< 75 days)	PHS1107, PHS1108, PHS1109
Tillers/ metre (>72)	AKDW4537, VW0826 , KYP853 , WSM2479 , DBPY08-1(d), LBPY08-6, LBPY08-11, HPW324, HPW327 , DBPY08-6, LBPY08-8, NWL 8-7, LBPY08-7, DBPY08-10(d)
Dwarf plant height (75 cm)	K0716
Grains /spike (>60)	VW0764, HD2967, TL2966, MP4080, UAS305, PBW621, HI1552
1000-gr weight (> 55 g)	PHS1109, PHS1101, PHS1103, PHS1108, PHS1102, PHS 1104
Spike length (> 11 cm)	PHS1101, PHS1103, HPW309, HPW308, PHS1102, PHS1105, PHS1106, PHS1108, PHS1109
Salt tolerance	KRS1104, KRS1102, KRS1118, KRS1112, KRS1108, KLP1006, KRS1114, KRS1109, WH1145, KRS1106, KRS1103, KRS1113, KRS1117,RAJ4324, WS1101, KRS1120
High grain protein (> 13%)	KLM1005 (d), QLD11, WSM24(d), KLM1008, UP2672
High sedimentation (>50 ml)	BW5872, QLD31, 3rdSTEMRRSAN6071, QLD49, HI977(C), WH1088
Drought sensitivity index (<0.5)	KLP1042, HI1564, K0624, GW-09-264, HI1581, AKAW4705, KLP1043, GW-09-270, RAJ4128, AKAW4730, NWL-9-15, HI1580, RS1017, KLP3077, KYP0826 and RAJ4258

Elite International Germplasm Nurseries (EIGN)

The DWR constitutes two germplasm nurseries i.e., for bread and durum wheat, from the promising lines indentified from the international germplasm nurseries and trials received from CIMMYT for the benefit of breeders at the cooperating centres. During 2011 -12 crop season, 24 sets of EIGN-I (bread wheat) and 20 sets of EIGN-II (durum wheat) were supplied to cooperating centres for evaluation and utilization. On the basis of multi-location evaluation, the promising entries were identified in the EIGN for 1000–grains weight and grain yield/plot (Table 1.9). Similarly, the promising durum entries were also identified for days to maturity, 1000-grains weight and number of tillers/plant (Table 1.10). A total of 308 and 44 selections were made by the cooperators in EIGN-I and EIGN-II, respectively, for utilization in hybridization and yield evaluation in their breeding programmes.

Table 1.9. Promising entries identified from EIGN-I

Trait	Entry number
1000-grains weight (≥ 43 g)	43rd IBWSN-1141, 43rd IBWSN-1095, 21st HRWSN-2091, 21st HRWSN-2118, 10th HLWSN-5056, 43rd IBWSN-1119, 43rd IBWSN-1213, 43rd IBWSN-1201, 43rd IBWSN-1077, 43rd IBWSN-1091, 21st HRWSN-2066, 21st HRWSN-2086, 18th HRWYT-208
Grain yield /plot (≥ 720 g)	43rd IBWSN-1153, 10th HLWSN-5078, 18th HRWYT-227, 43rd IBWSN-1095, 43rd IBWSN-1141, 18th SAWYT-342, 21st HRWSN-2059, 43rd IBWSN-1121, 43rd IBWSN-1068, 21st HRWSN-2056, 43rd IBWSN-1077, 43rd IBWSN-1025, 18th HRWYT-230, 18th HRWYT-239

Table 1.10. Promising entries identified from EIGN-II

Trait	Entry number
Days to maturity (≤ 125 days)	42ndIDSN-2, 42ndIDSN-3, 42ndIDSN-7, 42ndIDSN-9, 42ndIDSN-123, 42ndIDSN-138, 42ndIDSN-154, 42ndIDYN-6, 42ndIDYN-7, 42ndIDYN-17, 42ndIDYN-20, 42ndIDYN-21, 42ndIDYN-25, 42ndIDYN-27, 42ndIDYN-46, 42ndIDYN-47, 42ndIDYN-50
1000-grains weight (≥ 43 g)	42ndIDSN-2, 42ndIDSN-103, 42ndIDSN-117, 42ndIDSN-130, 42ndIDSN-187, 42ndIDYN-18, 42ndIDYN-45
Number of tillers/plant (≥ 10 g)	42ndIDYN-18, 42ndIDYN-22, 42ndIDYN-26, 42ndIDYN-34

International nurseries and trials

CIMMYT, Mexico has been the chief source of the exotic germplasm supplied through various nurseries and trials. During 2011-12 crop season, germplasm lines from 16 nurseries and trials of bread wheat, durum wheat and triticale were received from CIMMYT and evaluated at 34 centres in the country. Besides these nurseries/ trials, 4 CSISA and CIMCOG trial was also evaluated at different centres.

One set of each nursery/ trial was planted at DWR, Karnal in order to expose the exotic germplasm to large number of wheat breeders/ pathologist of the country for exercising *in-situ* selection as per their requirement. The Wheat Field Day was organized at Karnal to facilitate wheat breeders to make selections in the international germplasm. The best performing lines from these nurseries were also utilized to constitute the EIGN-I and EIGN-II and supplied to cooperating centres for evaluation and utilization in wheat improvement. The promising genotypes for high grain yield in different trials/nurseries of bread and durum wheat were identified at various centres evaluating the international germplasm (Tables 1.11 and 1.12).

Table 1.11. Promising genotypes for grain yield in CIMMYT nurseries/trials

Trial/Nursery	Entry number
Bread wheat	
19th SAWYT (> 49 q/ha)	321, 327, 330, 331, 337
32nd ESWYT (> 50 q/ha)	117, 125, 132, 133, 141
6th EBWYT (> 55 q/ha)	506, 518, 520, 530
19th HRWYT (> 53 q/ha)	215, 219, 228, 235, 236
32nd ESWYT-H (> 49 q/ha)	120, 125, 126, 127, 128, 139, 141, 144, 150
Durum wheat	
43rd IDYN (> 45 q/ha)	707, 722, 733, 736, 745, 748
43rd IDSN (> 55 q/ha)	7065, 7110, 7111
Triticale	
42nd ITYN (> 50 q/ha)	807, 809, 816

Table 1.12. Promising genotypes for 1000-grains weight in CIMMYT nurseries/trials

Trial/Nursery	Entry number
Bread wheat (> 40 g)	
42nd IBWSN	1014, 1062, 1064, 1065, 1066, 1166, 1189, 1197, 1213, 1235
29th SAWSN	3027, 3038, 3041, 3047, 3055, 3091, 3102, 3115, 3123
6th HTWSN	30, 36, 39, 83, 116, 123, 138, 167
19th SAWYT	303, 304, 305, 317, 319, 320, 321, 322
32nd ESWYT	108, 112, 115,122, 123, 124, 125, 128, 130, 133
6th EBWYT	507, 508, 527
3rd CSISAHT-EM	10212, 10213, 10214, 10215
CIMCOG	28, 29, 36, 50, 54, 58
19th HRWYT	5, 18, 19, 28, 35, 36
32nd ESWYT-H	1, 2, 16
11th HLWSN	5010, 5014, 5015, 5018, 5041, 5082, 5089, 5101, 5107, 5135, 5215
6thSTEMRRSN	6035, 6059, 6082, 6113, 6117, 6128
Durum wheat (> 43 g)	
43rd IDYN	713, 715, 733
43rd IDSN	2, 13, 78, 91, 104, 113, 125
Triticale (≥ 41 g)	
42nd ITYN	803, 810, 816

During the crop season 2011-12, a total of 10 trials (8 bread and 2 durum wheat) were also received from ICARDA, Syria which was planted at different centres in the country. The promising entries were identified for further utilization in wheat improvement (Table 1.13).

Table 1.13. Promising lines for grain yield in ICARDA trials/nurseries

Trial/Nursery	Entry number
Bread wheat	
12th DSBWYT-CA (>33 q/ha)	418, 419, 420, 423
4th SRR –SBWYT (FA/IR) (>51 q/ha)	101, 106, 122
4th SRR –DSBWYT (>44 q/ha)	210, 217
12th IRSBWYT-CA (>60 q/ha)	306, 307, 319
12th SBW-ON (>60 q/ha)	39, 47, 48, 49, 84, 79, 105, 132
HTSBW-ON (>49 q/ha)	7, 68, 76, 77, 112
Durum wheat	
35th IDYT-MD	1, 3, 4, 5
35th IDON-MD	41, 42, 91, 141, 142, 192

Breeder and nucleus seed production

A total breeder seed requirement of 29159.55q was received for production during 2011-12 crop season. This included 28959.55q breeder seed of 167 wheat varieties indented through the Department of Agricultural and Cooperation, MoA, New Delhi and an additional 200q of variety DPW621-50 from ADG (Seed). Among all the varieties in seed production chain, the highest indent was for the variety PBW550 (1931.05q). The breeder seed indent of major varieties in the respective zones is given in Table 1.14.

Table 1.14. Breeder seed indent of major varieties in each zone

Variety	Indent (q)		
	2010-11	2011-12	2012-13
NWPZ			
PBW550	1430.8	1931.05	1182.4
PBW502	2047.4	1274.9	686.1
PBW343	1170.4	1086.7	562.2
WH711	970.4	890.0	593.4
CZ			
GW322	1124.0	1126.2	1126.2
GW273	1247.0	1095.0	1154.0
Lok1	1297.8	847.0	937.6
HD2932	350.0	622.8	447.7
NHZ			
VL892	27.0	57.0	55.0
VL616	40.0	50.0	41.0
VL804	38.0	37.0	45.0
VL907	-	36.0	37.0
HS507	-	35.0	21.0
NEPZ			
HD2733	700.0	1686.4	877.4
K9423 (Unnat Halna)	377.0	416.0	51.2
Raj4120	115.0	351.2	208.4
HD2643	320.0	340.0	10.0
CBW38	359.2	297.2	115.2
PZ			
Raj4037	780.8	1101.2	545.2
HD2932	350.0	622.8	447.7
HD2189	273.3	291.0	370.7
HUW510	415.0	215.8	113.0
MACS2496	45.0	115.0	100.0

A perusal of the indents of breeder seed requirement revealed that PBW550 was the highest indented variety during the production year 2011-12 and it was also the top indented variety for 2012-13 production year as well although its total indent decreased. Another significant development was the high demand for varieties suitable for CZ, viz. GW273, GW322 and GW366 which together occupied 2nd to 4th positions among the top indented varieties; however the indent of old variety Lok1 has gone up for 2012-13 crop season (Table 1.15).

Table 1.15. Most popular indented varieties for breeder seed production

SN	2011-12		2012-13	
	Variety	Indent (q)	Variety	Indent (q)
1	PBW550	1931.05	PBW550	1182.40
2	HD2733	1686.40	GW273	1154.00
3	DBW17	1586.00	GW322	1129.20
4	PBW502	1274.90	GW366	947.05
5	GW322	1126.20	Lok1	937.60
6	Raj4037	1101.20	HD2733	862.40
7	GW273	1095.00	DBW17	787.80
8	PBW343	1086.70	PBW502	686.10
9	Raj3765	921.40	Raj3765	651.00
10	WH711	890.00	WH711	619.40

Against an allocation of 28619.55q breeder seed of 157 varieties made for production at 30 seed production centres, a total production of 35893.02q breeder seed was reported during 2011-12 crop season. This production was 7273.47q higher by the allocated quantity of breeder seed.

The maximum breeder seed was produced at JNKVV-Jabalpur (7139.65q) followed by MPUA&T-Kota (4965q), RVSKVV-Gwalior (3350q), GBPUAT-Pantnagar (3097.70q), CSAUAT-Kanpur (2804.22q), PAU-Ludhiana (2492.50q), SKRAU-Bikaner (1940q), IARI-Indore (1265q), and SDAU-Vijapur (1215.60q). The breeder seed production report was not received from BAU, Sabour. A deficient breeder seed production was also observed for 48 varieties. The breeder seed production for 20 allocated varieties, viz. DL788-2, HD4672, HW2004 and HI1563 at IARI-Indore; HPW89, HPW184 and HPW251 at HPKVV-Palampur; NIAW301, NIAW917 and NIDW34 at MPKV-Niphad; PBW299 & PDW314 at PAU-Ludhiana; WH1080 at CCS HAU Hisar; K9465 at CSAUA&T-Kanpur; HS277 at IARI-Karnal; HD2428 at IARI-New Delhi; HDR77 at JNKVV-Jabalpur; NW1067 at NDUA&T-Faizabad and UAS415 at UAS-Dharwad was not taken up at the concerned centres (Table 1.16).

Table 1.16. Deficient seed production in latest varieties

SN	Variety	Year of release	DAC indent (q)	Prod. (q)	Deficient prod. (q)
1	DBW17	2007	1586.00	1095.53	-490.47
2	HD2932	2008	622.80	322.00	-300.80
3	PBW550	2008	1931.05	1662.00	-269.05
4	K0307	2007	246.00	142.00	-104.00
5	PBW590	2009	120.20	72.00	-48.20
6	DBW39	2010	51.60	20.00	-31.60
7	Raj4120	2009	351.20	324.00	-27.40
8	WHD943	2011	24.00	10.00	-14.00
9	NIAW1415	2011	25.00	15.06	-9.94

Inspite of the emphasis on replacement of old varieties with newly released varieties in different zones, a surplus seed production was observed in the case of some old varieties. Such surplus production is becoming a limiting factor in promoting the new varieties for commercial cultivation (Table 1.17).

Table 1.17. Surplus seed production of old varieties

SN	Variety	Year of release	DAC indent (q)	Prod. (q)	Surplus prod. (q)
1	Lok1	1982	847.00	1205.00	358.00
2	WH147	1978	86.40	260.00	173.60
3	PBW154	1988	172.60	255.00	80.40
4	Raj3077	1989	354.00	931.00	577.00
5	GW496	1990	584.60	683.20	98.60
6	MACS 2496	1991	115.00	184.00	69.00
7	DWR162	1993	84.50	137.00	52.50
8	GW173	1994	100.20	156.40	56.20
9	UP2338	1995	98.20	237.00	138.80

Nucleus seed production and test stock multiplication

A total of 1958.35q nucleus seed comprising 154 varieties was reported to be produced against a production target of 1388.50q for 155 varieties. The maximum nucleus seed was produced for the varieties GW273 (122.12q), W366 (117.81q), HI8498 (85.96q), MP3211 (77.27q), GW496 (76.73q), HD2932 (74.54q), GW322 (67.53q), PBW343 (59.76q), PBW502 (58.68), DPW621-50 (50q), MP3288 (46.41q), Lok1 (45.50q), DBW17 (45q) and PBW550 (43.03q). The maximum nucleus seed quantity was reported to be produced at JNKVV-Jabalpur (849.81q) followed by MPUA&T-Kota (207.15q), PAU-Ludhiana (198.70q), SDAU-Vijapur (133.93q), IARI-Indore (88.50q), GBPUAT-Pantnagar (83q), UAS-Dharwad (75.50q), CSAUAT-Kanpur (47.60q) and CCSHAU-Hisar (47.50q).

The test stock multiplication of two newly identified bread wheat varieties (PBW644 and HD3043) and one each durum wheat (UAS428) and triticale (TL2969) was allocated at SFCI farms. Due to non-supply of basic seed by the concerned breeders, test stock of these varieties could not be multiplied, except in variety HD3043 where 40q seed was produced.

At DWR, a quantity of 1381.75q breeder and 34.25q nucleus seed of nine wheat varieties namely DPW621-50, DBW17, DBW16, CBW38, DBW39, DBW71, DBW74, PBW550 and HD2967 was produced as per allocation during 2011-12. An '**Innovator-cum-Seed Day**' was also organized on 31st Oct., 2012 for the benefit of farmers.

Evaluation, characterization, conservation and documentation of germplasm

Collection

An exploration was conducted during 20-24 September, 2012 to collect the local/ primitive cultivars of wheat from the higher altitude areas of Khardung, Diskit, Thicksay and Tangtse mandals of Ladakh District of Jammu and Kashmir. The local land races namely *Toh, Tro, Tokarmo, Toril, Trochin* and *Trochen* of wheat were collected by adopting random sampling strategy. A total of 14 divergent wheat collections were made from Ladakh.

Germplasm exchange

Sixty exotic germplasm accessions were received from USA and Canada, while 2652 wheat accessions were supplied to various indenters within country. Multiplied seed of 207 accessions were supplied to NBPGR for long term conservation in National Gene Bank.

Characterisation

A total of 715 indigenous and exotic accessions of wheat comprising 669 of *T. aestivum*, 40 of *T. durum* and 2 each of *T. polonicum*, *T. compactum* and Triticale were characterized for 44 characters. The promising accessions were identified for various yield contributing characters:

Days to heading and maturity: Thirty one accessions flowered in less than 89 days and matured in less than 150 days (145 -149 days). These accessions were D4-27, WR1202, PI430048, EC378785, PI383909A, IC57586, EC378791, EC378797 (d), PI430035, WR1201, KBRL10, EC378776, PUSA 5-3, EC362074, JOB2029, EC378796, PI430037, KRL402, PI430064, EC378771, EC378774, EC378778, EC362136, EC378779, EC407763, EC378780, HW2065, IC405238, KBRL13, JOB203020, WR1204 and EC380615.

Plant height: Accessions EC721319, EC407740, EC407731, PI376842, EC407761, EC407736 and EC407725 were very short (≤ 75cm), 65 accessions had plant height ranged between 76 - 90cm. Accessions namely CITR7327, PI182078, EC407732 and EC556477 were very tall (>150cm).

Spike length: Twelve accessions namely EC542529, DWR246, EC542449, EC407755, EC407727, EC407752, EC407756, EC383449, EC407754, EC407759, EC407700, EC407757 had more than 17cm spike length.

Spikelets/ spike: Six accessions namely EC582649, EC407754, EC407757, EC405393, EC407700 and EC582655 had recorded more than or equal to 26 spikelets per spike.

Grain number/ spike: Twelve accessions namely EC455051, EC378769, EC407761, EC380904, D5-27, EC407666, EC455053, EC407620, EC407644, EC407627, EC407750 and EC407622 had more than 90 grains in one spike and three accessions viz. EC407604, 407765 and EC407764 had more than 100 grains per spike.

Grain weight/ spike: Eighteen accessions namely EC407614 (4.02), DCB/GW-2 (4.11) (d), EC407666 (4.12), EC407662 (4.17), EC407604 (4.20), EC407764 (4.31), EC407754 (4.34), EC407765 (4.36), IC296433 (4.52), IC407622 (4.63) and Todia (4.73) had more than 4.0 g seed per spike.

Thousand-grains weight: Thirty accessions had test weight ranging between 45-50 g, whereas accessions WR1201 (50.2), Somai 12 (50.5), UNL 39 B (50.8), DBPY2000-2 (51) (durum), KP402 (51), IWP-532 (51.8), EC362038 (52), EC362099 (52.2), DBP-01-4 (53) (durum), PI360867 (54.1), WR1202 (54.7), Todia (55.1), PI360865 (56.1) and Sel. III (60.7) had more than 50g 1000 grains weight.

Protein content: Grain protein content was estimated at 14% grain moisture using NMR. Majority of accessions were having 13-14% protein. Accessions viz. EC556446, EC407644, EC407756, EC407765, EC407627, EC556441, EC381994, EC380880, EC378750, EC407700, EC514403, EC519484, EC3804904, EC407618, EC380896, EC383447 and EC407755 had more than 16% protein.

Conservation

The germplasm repository at DWR constitutes 11,500 germplasm accessions of wheat that includes released varieties, AVT-II lines, registered genetic stocks, exotic and indigenous collection being conserved in medium term storage module (4°C and RH 30-35%). A duplicate set of 8697 germplasm accessions is being conserved in a repository maintained under natural condition at DWR Regional Station, Dalang Maidan. The viability of seeds stored at Lahaul was monitored by germination test and more than 80% viability was observed after ten years of storage.

DUS testing in wheat

During 2011-12, 4 DUS trials were sown as per DUS guidelines, in which 9 candidate varieties (Ajay (NW72), Vinay (NW404), KRL210, KRL213, DBW39, HPW249 (Asmi), HD2967, HD2985, HD2987) were tested against reference varieties. One set of trial was also sown at IARI Regional Station, Indore and PAU, Ludhiana. Data of all the locations were compiled and submitted to PPV&FRA.

Out of a total of 102 applications of bread wheat which were submitted by the DWR for registration under PPV&FR Act, 2001, 87 varieties have been registered under extant category, while another 15 varieties are under consideration of the Authority for registration.

Prebreeding

The wild relatives (alien species) of wheat provide a vast and largely untapped reservoir of genetic variation for traits such as tolerance to abiotic and biotic stresses, biomass, yield and photosynthetic potential. Although a number of genes have been introgressed from wild *Triticum* and *Aegilops* species, but very few have been commercially exploited due to substantial linkage drag. Prebreeding is a requisite to transfer the desired genes from primary and tertiary gene pool to well adapted varieties.

Wide crossing program

The wild progenitors or related species were evaluated for biotic and abiotic stress tolerance. The selected accessions were crossed with good agronomic base varieties to transfer the desired traits. A number of synthetics showing the drought and heat tolerance were crossed (Table 1.18)

Table 1.18. F_1s involving wild species and synthetics produced

Cross name	Cross name
T. urartu / PDW 291	SYN 176/ GW 322
Agropyron / UP 2425 // PBW 343	SYN 187/ HD 2967
PBW 175 / *Ae. ovata*	DBW 17 / *Ae. kotchyii*
PBW 175 / *Ae. ventricosa*	DBW 17 / *Ae. triaristata*
T. dicoccum / PBW 502	DBW 17 / *Ae. culinaris*
HI 8743/ *Ae. geniculata*	SYN 166/PBW 343
HI 8744/ *Ae. kotschii*	SYN 228/ K 8027
HI 8744/ *Ae. speltoides*	SYN 236/ PBW 550
PDW 291 / *T. ventricosa*	SYN 242/ HD 3010
PDW 291 / *T. umbellulata*	SYN 432/ DBW 14
SYN 143/ DPW 621-50	SYN 233/ Dharwad dry

Evaluation and selection of lines for better quality traits

Around 200 elite lines including bread wheat and triticale were evaluated for quality traits. Many lines were found better for test weight, higher protein content, softness or hardness and sedimentation value. Soft wheats are good for biscuit spread factor while hard wheats are good for *chapati* making quality. Test weight is related to floor recovery etc. Some lines have been developed which showed sedimentation value from 9.5 to 13 cc. These lines are under evaluation for quality parameters at DWR, Karnal. On the basis of these assumptions, the following 10 genotypes were selected for further use (Table 1.19).

Table 1.19. Quality traits in selected lines

Pedigree	Hect. weight	Protein %	Grain hardness index	Sed. value (cc)
ITYN 846	69.4	8.5	23	3.5
ITYN 848	70.8	9.9	22	5.8
ITYN 850	72.7	9.2	28	4.5
PBS-11-01	73.0	12.6	64	9.0
PBS-11-01	73.5	10.1	85	7.0
Sel 67	81.3	9.5	84	7.0
Sel 70	74.8	12.6	73	13.0
Sel 80	74.6	12.3	73	10.0
Sel 81	75.6	12.0	80	10.5
Sel 2061	81.1	8.3	67	7.1

* 14% grain moisture

Using *ph* mutant for increasing the recombination frequencies

In order to transfer the *ph1b* mutant gene into bread and durum wheat background of Indian wheat varieties, Chinese Spring wheat genotype with *ph1b* was crossed with bread wheat cultivars (PBW502 and DBW16) and tetraploid durum wheat cultivar (HI8498). In the preliminary studies, F_2 populations were screened with PCR based SCAR molecular marker linked to *ph1* locus. Through cytological analysis *ph1b* genotypes were identified by checking multivalent chromosome pairs at meiotic MI. A series of backcrosses with promising wheat cultivars accompanied by selection for multivalent will follow to recover the wheat genetic background of *ph/ph* in well adapted varieties. This will help in crossing wild sources and transferring stress resistant genes into desirable agronomic background.

Using irradiation to produce new variability

To induce variability *de-novo*, interstitial translocations and amphidiploids, a total of 30 F_2s seed involving crosses with synthetic hexaploid wheat and promising elite genotypes were irradiated with 20Kr doses of gamma rays. The M_2 population is under evaluation.

Developing head scab resistance in bread and durum wheats

To develop *Fusarium blight* resistance in Indian wheat varieties, the back cross program was taken up involving the resistant stocks Sumai#3 and Frontana. The crosses available are Sumai 3/ DBW16, Sumai 3/PBW502, Sumai 3/PDW274, Sumai3/PDW291, Frontana/DBW16, PBW502/ Frontana and Sumai3/Frontana.

Breeding for drought tolerance

A breeding program to understand genetics of drought tolerance and development of varieties requiring less water was initiated at DWR, Karnal (Fig 1.1). Initially two DH mapping populations derived from the crosses Excalibur/Kukri and RAC875/Kukri developed in Australia were evaluated at three locations viz. DWR, Karnal, Haryana; CCS Haryana Agricultural University, Hisar, Haryana and Agharkar Research Institute, Pune. The 330 diverse DH lines of cross Excalibur/Kukri were raised in an augmented block design under 2 treatments, one in well irrigated, and the other in rainfed condition. Data were recorded on traits namely days to flowering, days to anthesis, days

Fig. 1.1. Crop grown under rain shelter for evaluating genotypes for drought tolerance

to maturity, grain filling duration, height, grain number/ear, grain weight/ear and thousand-grains weight.

Phenotypic data and the marker genotyping data collected earlier in Australia was used for QTL analysis. QTL interval mapping will be conducted. Similarly, for association mapping, 330 diverse genotypes were grown under rainfed conditions at Meerut (India) and relevant phenotyping data was recorded. Using this phenotyping data along with the genotyping data being collected and association mapping will be completed.

Five new crosses namely HD2967/C 306, DBW17/NP846, HUW234/NP846, HUW468/Dharwar Dry and HUW468/NP846 were attempted to develop new populations and to improve the already existing agronomic base varieties.

Wheat improvement for high productive environments of Northern India

Hybridization programme

257 cross combinations were made during *rabi* 2011-12 at Karnal involving parents selected from national and international nurseries and trials, short duration nursery, zero tillage trial, reactions to different diseases, heat tolerance sources and other attributes. In addition, 40 new cross combinations were attempted at the Dalang Maidan, during summer 2012. In 2012-13, 222 cross combinations were attempted.

Yield trials

DWR Station Trial : A total of 15 entries were contributed to DWR Station trial (06 for timely, 07 for late sown and 02 for A+D) which were conducted at 2 locations of NWPZ (Karnal and Ludhiana), 2 locations of NEPZ (Faizabad and Coochbehar) and 3 locations for A+D trials (Vijapur, Junagarh and Pune).

From the station trial, four promising genotypes namely DBW113, DBW118 (NIVT-1A), DBW120 (NIVT-1B), DBW125 (NIVT-2) and DBW127, DBW128 (NIVT 3), DBW130 (NIVT 5A) were promoted to respective NIVTs.

National Initial Varietal Trial : Based on the performance of the entries in DWR Station Trial for timely sown and late sown conditions (2010-11), the four entries were promoted to the NIVTs. The performance of these entries in different NIVTs is given in Table 1.20.

Table 1.20. Performance of genotypes promoted to NIVTs

Entry	Pedigree	Yield (q/ha)			
		NWPZ	NEPZ	CZ	PZ
DBW95 (NIVT-1A)	K9908/PBW534	53.3	50.0	-	-
DBW112 (NIVT-1A)	INQUALAB/30th BWSN116// HUW593	51.4	50.6	-	-
DBW106 (NIVT-2)	MPOO29/ HUW558	-	-	54.4	45.0
DBW108 (NIVT-3)	DBW14/ NIAW34	37.8	44.3	42.7	39.3

Advance Varietal Trial: Based on the performance of the entries in National Initial Varietal Trial for rainfed and restricted irrigation conditions conducted over zones during 2011-12, DBW74 was promoted to second year of testing. The performance of DBW74 and DBW90 in AVTs is shown in the Table 1.21.

Table 1.21. Performance of DBW 74 and DBW 90 in AVTs

Entry	Pedigree	AVT	Yield (q/ha)
DBW74	WBLLI*2/ BRAMBLING	AVT-RF-TS-NWPZ	34.9
DBW74	WBLLI*2/ BRAMBLING	AVT-RI-TS-TAS-NWPZ	44.6
DBW90	HUW468/WH730	AVT-IR-LS-NWPZ	42.1

Evaluation of breeding material

During the crop season, the breeding materials were evaluated and selections made on the basis of disease response and other desirable attributes (Table 1.22). During summer 2012, the breeding material evaluated at DWR Regional Station, Dalang Maidan included 130 F_1s, 12 F_5 and DH lines.

Table 1.22. Selections made in different generations at DWR, Karnal

Generation	Cross combination	Selections made
F_1	117	100
F_2	198	1000 single spikes
F_3	186	550 single spikes
F_4	49	220 single spikes

Targeted programme for resistance against Ug99

During the crop season, 50 cross combinations were made with 10 FLW lines and 16 STEMRRSN lines as donor parents for incorporating resistance to Ug99 in advanced genotypes. The breeding material generated in previous crop seasons was evaluated and the single spike selections were made based on plant type, maturity etc. (Table 1.23).

Table 1.23. Breeding material for resistance against Ug99

Generation	Cross combination	Selections made
F_1	5	5
F_2	26	110 single spikes
F_3	37	60 single spikes
F_4	9	40 single spikes
F_5	5	15 single spikes
F_6	6	15 single spikes + 3 Bulks
F_7	5	20 single spikes + 5 Bulks

Evaluation of advance generation bulks in Preliminary Yield Trial

During the crop year 2011-12, 104 advance generation bulks were tested under timely sown conditions along with four checks namely CBW38, DBW17, DBW16 and DPW621-50. The material was artificially inoculated for different rusts and leaf blight. Out of 104 advance bulks, 72 showed field resistance to both yellow and brown rust. Quality analysis for protein, sedimentation and hardness index was also carried out for the 104 bulks, wherein 25 genotypes including two checks (CBW38 & DPW621-50) performed better. On the basis of yield performance and other desirable traits, 15 bulks were selected for further evaluation in the DWR Station Trial (Table 1.24).

Table 1.24. Elite material selected from PYT in 2011-12 for DWR station trial

Entry	Pedigree
RWP 2012-1	NW3033/WH786
RWP 2012-2	HP1761/PBW343//DBW15
RWP 2012-3*	MEX94.27.1.20/3/SOKOLL//ATTILA/3*BCN(CIMCOG 79)
RWP 2012-4	NW1014/RAJ3777//K 406
RWP 2012-5	PBW343/DBW15
RWP 2012-6	DBW18/NW3079
RWP 2012-7*	SERI.1B*2/3/KAUZ*2/BOW//KAUZ/4/PFAU/WEAVER (IBWSN 09-10) 1136
RWP 2012-8	RAJ3765/PBW443
RWP 2012-9	PBW343/DBW16//RAJ 3765
RWP 2012-10	HD2733/DBW49
RWP 2012-11	PBN142//PBW343/K9901
RWP 2012-12	NW1014/RAJ3777//UP 2655
RWP 2012-13	PBW373/DBW30
RWP 2012-14	PBN142/DBW30
RWP 2012-15	PBW343/DBW16//RAJ3765

Wheat improvement for eastern and far-eastern parts of the country

New germplasm identified

As a regular breeding activity, 550 new lines were tested for identification of new sources that were utilized for hybridization programme. Besides, a set of 99 field tested lines was planted in poly house under controlled epiphytotic conditions to confirm the field score of promising donors. The poly house screening indicated similar trend for HLB scores but with slightly higher reactions. A total of 23 lines that showed high degree of resistance to spot blotch disease under polyhouse conditions were identified, utilized and also shared with centres for widening genetic base.

Hybridization programme and evaluation of breeding material

New and back cross combinations for improving yield, abiotic stress tolerance and spot blotch resistance was attempted and 68 cross-combinations were made. In addition, new crosses (Kharchia-65/HD2967, Kharchia-65/DBW 17, Kharchia-65/DBW 39, Kharchia-

65/K-307, HD2985/Kharchia-65, GW322/Kharchia-65) were attempted to study genetics of biotic and abiotic stresses related traits in Kharchia-65 for multiple stress tolerance from one genotype. Complete set of breeding material was evaluated at DWR, Karnal and selections were made for advancing the generations and identifying the promising ones.

17 segregating bulks were contributed to Segregating Stocks Nursery (SSN) supplied to different centres for evaluation and also for making site specific selection during the crop season 2011-12.

Introgression of desirable traits for improving yield, adaptation and resistance

During the crop season, a total of 28 new cross combinations were made primarily for improving yield, adaptation and spot blotch resistance. About 9-10 spikes were attempted for each combination and half of the F_1 seed was planted at summer nursery Dalang Maidan during summer 2012 for generation advancement. During this season, part of segregating material in F_2 generation has been shared with three centers under shuttle breeding approach to identify potential combinations for high yield and adaptation and also to make site specific selections.

Sharing of DSBL lines for evaluation and utilization at six centres in NEPZ

A set of 148 genotypes that constituted DSBL (Directorate shuttle breeding lines) material was shared with six centres (Shillongani, Coochbehar, Kalyani, Ranchi, Faizabad and Varanasi) in NEPZ. This material was planted and data were recorded on plant height, thousand-grains weight, grain yield, grain per spike, spike length, leaf blight and leaf rust reaction. The promising genotypes based on mean performance and range of thousand-grains weight were DBW104 (48g, 36-58), RIL130 (48g, 40-52), HUW234/YM#6 (46g, 34-94), LBP2010-11 (45g, 32-52), RIL585 (44g, 35-51), RIL128 (43g, 32-53), LBP2010-23 (43g, 39-45), LBP2010-25 (43g, 28-51), RIL178 (43g, 35-49), 12thEGPSN-125 (43g, 34-47), DBW105 (43g, 34-49) and DBW109 (43g, 40-47), LBP2010-1 (42g, 30-50), LBP2009-4 (42g, 34-45). The high grain yield mean and range were reported in LBP2010-16 (791g, 210-1119), PBW550/CHIRYA7 (771g, 300-882), LBP2011-25 (751g, 400-960), DBW16/BH1146 (712g, 350-950), 12thEGPSN -23 (707g, 200-925) and 12thEGPSN -72 (701g, 220-940). Similarly, grains per spike reported by Coochbehar location only and promising genotypes were LBP-2011-29 (75), NW2036 (74), LBP-2011-23 (68), LBP-2009-12 (67), 12thEGPSN -102 (67) and GW322 (67). Spike length was recorded by Coochbehar location only and promising genotypes showed maximum (13cm) in LBP-2011-3, LBP-2010-17, LBP-2010-18, 18th HRWYT-53, 12th EGPSN-47 and DBW51.

Leaf blight data were recorded by Varanasi, Faizabad and Coochbehar locations and maximum scoring was recorded at Coochbehar location which shows that this is the hot spot for screening of wheat material for leaf blight. Leaf rust was reported at Varanasi and Sabour locations and most of the genotypes were found resistant for leaf rust disease in this zone.

Contribution to AVT and NIVTs

Entry DBW 101 was promoted to AVT level, while two entries namely DBW 117 and DBW 122 have been contributed to NIVT-1A and NIVT-1B respectively (Table 1.25). Besides, 15 entries were contributed to DWR Station Trials (for timely, late and A+D) for testing 2012-13.

Table 1.25. Entries promoted to NIVTs during 2012-13

SN	Entry	Plant height	1000-gr. wt	Heading (days)	Yield (q/ha)	Remarks
1	LBP2011-25	110	43	103	59.84	DBW 117 (NIVT-1A)
2	LBP2011-6	100	37	109	60.86	DBW 122 (NIVT-1B)
3	DBW17 (Check)	91	33	109	54.8	
4	HD2733 (Check)	103	35	111	50.0	

Contribution to national nurseries

Six entries identified as genetic stocks through yield component screening nursery (YCSN), were contributed to NGSN for respective yield component trait (Table 1.26).

Table 1.26. Genetic stocks confirmed through YCSN and contributed to NGSN during 2012-13

Entry	Pedigree	Trait	Passport data	
			Range	Mean
LBPY-08-4	CROC-1/ AE.SQ(224) OPATA	Grains/spike	38-63	51
LBPY-08-6	MUNIA//FGO// YAV 79	Tillers /meter	49-137	86
LBPY-08-7	GAA/KEA// GAA/BL 1887	Tillers /meter	33-117	67
LBPY-08-11	KAMBI*2/ BRAMBING	Tillers/meter	48-112	76
LBPY-08-9	BL 2017/NL 297	1000-gr. wt.	40-56	48
LBPY-08-13	GA/KEA// GAA/BL 1887	1000-gr. wt.	32-59	47

Phenotyping of mapping population at hot spot and tagging of major QTLs associated with spot blotch resistance in wheat

Three sets of RILs (total 728 lines) in their F_8 generation were planted at three hot spot locations for spot blotch disease namely Kalyani, Coochbehar as well as at Karnal under natural condition. The comparative distribution of RILs based on disease response and severity at these three locations is given in Table 1.27.

The distribution of RILs at three locations and under polyhouse condition was normal but disease severity varied under different environments. This is obvious as the disease pressure and environmental conditions have influence on disease scores. The parental lines of three mapping populations were screened with microsatellite markers. Out of 326 SSR

Table 1.27. Distribution pattern of three sets of RILs during 2011-12

Scale	Disease response	Coochbehar (# RILs)	Karnal (# RILs)	Kalyani (#RILs)	Poly house condition (#RILs)
SET1- SONALIKA/BH1146					
00-01	Immune (I)	2	2	6	2
12-24	Resistant (R)	32	66	35	48
34-46	Moderately resistant (MR)	61	67	48	51
56-68	Moderately susceptible (MS)	92	63	102	69
78-79	Susceptible (S)	19	10	9	15
99	Highly susceptible (HS)	4	2	2	7
	Total	**210**	**210**	**202**	**192**
SET2-KANCHAN/CHIRYA					
00-01	Immune (I)	1	1	2	2
12-24	Resistant (R)	26	70	10	50
34-46	Moderately resistant (MR)	57	68	42	63
56-68	Moderately susceptible (MS)	100	70	80	54
78-79	Susceptible (S)	19	2	66	21
99	Highly susceptible (HS)	5	1	1	10
	Total	**208**	**212**	**201**	**200**
SET3-HUW234/YANGMAI#6					
00-01	Immune (I)	1	1	6	4
12-24	Resistant (R)	22	90	15	64
34-46	Moderately resistant (MR)	90	80	43	75
56-68	Moderately susceptible (MS)	134	66	99	69
78-79	Susceptible (S)	5	1	85	10
99	Highly susceptible (HS)	2	2	2	12
	Total	**254**	**260**	**250**	**234**

markers surveyed, 86 were found polymorphic in Sonalika/BH1146, 64 in Kanchan/ Chirya1 and 49 in HUW 234/Yangmai6 populations, respectively.

Analysis of selected lines for quality traits

Data of 194 genotypes were analysed for quality traits. Grain hardness index (SKCS) revealed that most of the genotypes were hard in texture except a very few genotypes which had soft grain characteristics suitable for biscuit making quality. The grain protein content varied from 8.0% to 14.9% at 14%mb. Sedimentation value (1g test) also quite variable, ranging from 5.7 to 15.5 cc. The genotypes need further validation for subsequent utilization.

Phenotyping against pre-harvest sprouting (PHS) tolerance

Based on germination index (GI), 280 germplasm were phenotyped for pre-harvest sprouting (PHS) resistance. Majority of genotypes were susceptible to PHS based on GI. Only 6 germplasm lines were found to be moderately resistant to PHS. Three bread wheat genotypes (EC383445, PI376842 and AC Domain), two durum wheat (EC362087 and EC201931) and *compactum* wheat (CITR4926) were found to be moderately dormant with Germination Index in the range of 0.25-0.5.

Genotype x tillage interactions

An experiment on tillage aspect i.e. surface seeding was conducted with 12 wheat genotypes including recently released varieties for NEPZ, advance lines and checks suitable for genotype-tillage interaction. The results indicated that genotype NW1014 was the best performer (59.39 q/ha) under surface seeding tillage conditions followed by Raj3765 (56.60 q/ha) and HUW234 (56.12 q/ha). Two genotypes Sonalika and Raj3765 had comparatively high 1000-grains weight (47.57 and 44.82) showing their potential under surface seeding tillage conditions. For ear head length trait genotypes K307 (13.32 cm) and HW2045 (13.23) recorded higher than other genotypes. Similarly, NW1014, HUW234, K9017 and HUW468 genotypes were recorded higher plant height and produce of biomass.

Isolation of toxin from spot blotch pathogen

The three isolates of *Bipolaris sorokiniana* were designated as B-1, B-2 and B-3 for their characterization. It was observed that the three isolates exhibited a significant variability in their virulence and pathogenesis along with the considerable variability in their cultural characteristics. The B-1 isolate was most virulent followed by B-2 and B-3. Variability among the isolates of *B. sorokiniana* was further studied by characterizing the toxin secretion of the isolates and observations were recorded.

Wheat improvement for water logging, salinity and element toxicities

The three wheat breeding experiments included bi-plot analysis, development of three combinations for SSD populations for high yield potential and disease resistance in wheat under neutral soils and evaluation of two double haploid population lines for yield and resistance, were conducted and results are summarized below.

Based on two years results of biplot analysis experiment at DWR location, it may be summarized; i) good extent of genetic variability, high heritability coupled with high genetic advance was observed for most of the traits studied, ii) significant correlation between plant height, 1000-grains weight, grains per spike and spike weight with grain yield was observed.

Three crosses namely; PBW550/Chirya1, DBW17/BH1146 and DBW16/BH1146 having a total of 1140 individual spike in F_4 lines have been planted at DWR, Karnal for generation advancement. However, for remaining optional crosses, 30 lines each have been planted. Since SSD combinations involve very diverse gene pool (high yielding lines – DBW17, resistant stocks BH1146, potential donors for salinity, water logging etc.) and thus might give useful segregants in the coming generations.

Population (Camm/HD 2329) was in general better than other population under neutral soils. High estimates of heritability were recorded in population (Camm/HD 2329) than other populations for grain yield per meter (99.67%), tillers/meter (98.12%), plant height (97.08%), days to maturity (96.71%) and 1000-grains weight (96.71%). Some lines showed good level of resistance to leaf rust while others were found moderately resistant to susceptible. Analysis for KB score indicated that some lines possess good level of Karnal bunt resistance.

Phenotypic evaluation of double haploid (Ducula 4/2*Brookton and Camm/HD2329) populations for yield and disease resistance (stripe rust, leaf rust and KB) indicated the variation in resistance level in both the populations.

Wheat improvement for warmer areas

Identification of new wheat variety

Wheat variety DBW71 (Fig. 1.2) was identified for irrigated late sown conditions of NWPZ by the Varietal Identification Committee during 51st Wheat workshop at Durgapura, Jaipur in August 2012. It showed significant yield advantage over the check varieties ranging from 5.12% (over PBW590) to 17.56% (over PBW373). In agronomical trials, significantly higher yield advantage over checks (8.9 to 18.73 %) under very late sown conditions indicated its plasticity for sowing even upto mid January. It showed resistance to the virulent yellow rust pathotype 78S84 and possesses high level of protein content (13.4%), perfect 10/10 Glu-1 score, better grain appearance (score 6.2) and hectoliter weight (78.4 kg).

Fig. 1.2. Wheat variety DBW 71

New cross combinations and their evaluation for parental diversification

472 cross combinations were attempted during 2011-12 that included diverse genotypes as parents with the objective to broaden the parental diversity for hybrid development programme. These crosses involved synthetics, Chinese germplasm, elite material from national and international nurseries/trials 201 F_1s made in 2010-11 season were evaluated for yield and component traits along 8 checks namely, DBW17, DBW16, K0307, CBW38, DBW14, GW322, NIAW917 and NIAW34 during 2011-12 and wide range of heterosis for various traits was observed.

Evaluation of advanced bulks in PYT

80 advanced bulks were evaluated for various yield traits along with 08 checks namely DBW17, DBW16, DBW14, CBW38, K307, GW322, NIAW34 and NIAW917. Based on the yield and disease reactions, promising bulks were promoted to station trials of the DWR.

Contribution to coordinated trial

During 2011-12, three genotypes namely DBW102 (NIVT-1B), DBW107 (NIVT-3) and DBW110 (NIVT-5A) were contributed in the coordinated trials and all these entries have been promoted to AVT trials in different zones during 2012-13 (Table 1.28). DBW93 was evaluated in AVT-RF-TS-NEPZ and AVT-RF / RI-TS-PZ which showed significant superiority over the best check. It was promoted to final year of evaluation in PZ during 2012-13. From the 16 entries tested in DWR station trials, three entries viz. DBW126, DBW132 and DBW129 were promoted to NIVT-3, NIVT-2 and NIVT-5A, respectively for evaluation during 2012-13.

Table 1.28. Performance of genotypes contributed through warmer areas project in coordinated trial

Entry	Trial	Zone	Yield (q/ha)	Promotion
DBW102	NIVT 1B	NWPZ	56.6	AVT-TS-IR-NWPZ
DBW107	NIVT 3	NEPZ	50.7	AVT-LS-IR-NEPZ
		PZ	42.0	AVT-LS-IR-PZ
DBW110	NIVT 5A	NWPZ-RF	41.6	AVT- TS- RF -NWPZ
		NEPZ-RF	26.7	AVT- TS- RF-NEPZ
		CZ-RF	30.7	AVT- TS- RF/ RI-CZ
		CZ-RI	45.0	
		PZ-RF	18.2	AVT- TS- RF/ RI-PZ
		PZ-RI	24.4	

Sharing and multilocational evaluation of genetic stocks

During 2011-12, a total of 8 genetic stocks were contributed in NGSN and shared with 28 cooperating centres. The data from 25 centres were pooled which indicated the better performance of some genetic stocks for various traits compared to checks (Table 1.29). These lines showed 27.2% utilization. Based on the pooled mean, the promising genotypes that showed better performance than the best check were identified. PHS1108 and PHS1109 showed excellent performance for more than two traits in combination compared to the respective best checks.

Table 1.29. Superior genetic stocks for yield component traits

Characteristics	Criteria	Promising genotypes
Days to heading	<75	PHS1107(73 days), PHS1108, PHS1109 (74 days)
Days to maturity	<125	PHS1108, PHS1109 (123 days), PHS1107(124 days)
1000-gr weight (g)	>55	PHS1109 (60g), PHS1101(58g), PHS1103, PHS1108 (57g), PHS1102 , PHS1104 (55g)
Spike length (cm)	>11	PHS1101, PHS1103 (13cm), PHS1102, PHS1105, PHS1106, PHS1108, PHS1109 (12 cm)

Value in parenthesis indicates the values of the traits.

Sharing of the segregating populations with cooperating centres

During rabi 2011-12, a total of 30 segregating populations of F_2 generation have been contributed in the Segregating Stock Nursery (SSN) and shared with 15 wheat breeding centers. This material has utilization of 70.3% with maximum number of plants selected (1496) compared to other wheat programmes. Besides these, 109 segregating populations of F_2 generation was shared with shuttle breeding centres in CZ (Jabalpur and Vijapur centres) and PZ (Niphad and Dharwad centres) zone and target specific selections were made by the centres (Table 1.30). In addition, 30 cross combinations were contributed to national hybridization programme which were advanced to F_2 in DWR-RS, Dalang Maidan and sent to the cooperating centres this year for further utilization.

Table 1.30. Selection in F_2s generation

Centres	F_2s	Plants /ears selected
Dharwad	50	3036 ear heads
Jabalpur	50	164 single plants
Vijapur	59	42 single plants
Niphad	59	165 single plants

Durum breeding

Hybridization and evaluation of breeding material

About 300 lines including exotic as well as indigenous advance bulks were evaluated for yield and contributing traits, besides quality characteristics like beta carotene, protein content, test weight and for brown & yellow rusts. The number of crosses and their progenies available in different filial generations are given in Table 1.31.

Table 1.31. Crosses and their progenies evaluated and advanced

Generation	No. of Crosses/Progenies
F_1	60
F_2	60
F_3	35 (200)
F_4	35 (180)
F_5	40 (200)
F_6	40 (185)
F_7	30 (120)

Evaluation of genotypes under national coordinated trials

Four advance durum lines were evaluated in national coordinated trials. Two genotypes DDW23 and DDW24 in NIVT-4 while other two DDW25 and DDW26 were evaluated in rainfed durum trial NIVT-5B.

On the basis of yield, genotype DDW23 has been promoted to Advance Varietal Trial in CZ. These genotypes were better for yellow pigment and comparable in respect to test weight, with the check varieties PDW291 & HI8498 for quality traits (Table 1.32).

Table 1.32. Genotypes tested evaluated under national coordinated trials

Genotype	Trial name	Yellow pigment (ppm)	Test wt.
DDW 23 Promoted to AVT in CZ	NIVT-4	5.1	80
DDW24	NIVT-5B	5.6	81
DDW25	-do-	6.0	81
DDW26	Checks	7.0	82
HI8498	-do-	4.6	81
PDW291	-do-	4.2	80

The genotype DDW26 was found better for yellow pigment content and grain size. This genotype will be registered as the genetic stock for these traits.

In the Yield Component Nursery which was evaluated at 24 centers for three years, 10 genotypes of durum wheat were shared. Three genotypes DBPY-08-01, DBPY-08-06, DBPY-08-10 were identified as the genetic stocks for tillers / meter; three genotypes DBPY-08-04, DBPY-08-7, DBPY-08-09, for grains per spike and four genotypes DBPY-08-02, DBPY-08-03, DBPY-08-05, and DBPY-08-08 for thousand grains weight (Table 1.33). Many of these are having more than one yield component traits. The feedback reports suggested that breeders are using them extensively in the hybridization program.

Table 1.33. Durum promising lines identified through YCSN and shared

Trait	Genotype
Tillers/ meter	DBPY-08-01, DBPY-08-06, DBPY-08-10
Grains/ Spike	DBPY-08-04, DBPY-08-7, DBPY-08-09
TGW (g)	DBPY 08-02, DBPY-08-03, DBPY-08-05, DBPY-08-08

Sharing of segregating material with centers for quality traits

Every year a number of segregating populations of specific crosses involving parents with high quality, are distributed to cooperating centers.

Last year ten populations were shared with 15 centers through segregating stock nursery (Table 1.34), while another set of ten populations was shared with Wheat Research Station, Niphad.

Table 1.34. Population shared with wheat Research Station Niphad

Fixed material to Niphad	Traits
DSP4/Raj1555	TKW
PDW245/WH896	Virtuousness, Resistance
DBP01-11/Raj 1555	Yellow pigment
PDW251/UPD52	TKW
T. turgidum/DCB15	Long spikes
HI8381/DCB93	Shorter duration
Bawaji/HI8498	TKW
EDUYT17/GW 2	Drought tolerant
DBP01-11/HI8498	Yellow pigment
Raj1555/MACS2846	TKW, Short duration

Spring x Winter wheat hybridization

The spring x winter wheat hybridization programme is aimed at enhancing the genetic variability to raise the yield potential of spring wheat cultivars alongwith improving resistance to various biotic and abiotic stresses. One of the objectives of the project is also to develop genotypes suitable for early planting in NWPZ wherein the derivatives from spring x winter wheat hybridization are naturally endowed with the required characteristics for longer vegetative growth period and accumulation of high biomass together with tolerance to early and terminal heat.

The number of progenies screened and evaluated in different filial generations included 210 F_1 and 200 F_2 crosses, and 315 F_3, 124 F_4, 54 F_5, 36 F_6 and 44 F_7 families. The promising lines in advance generations (F_6/F_7) are presented in Table 1.35. Suitable plants were selected for advancement of the filial generations and superior families in advance generations were bulked for yield evaluation in PYT. In the off-season of 2012 year, 1255 breeding lines were evaluated at the summer nursery facility at DWR RS Dalang Maidan for generation advancement and disease reaction.

Table 1.35. Promising SxW cross-combinations in F_6/F_7 generations

Cross combination	Characteristics
UP2425/ Centruk// PHR1010	High tillering, medium late maturity, longer spikes
China84-400022/ WH542//PHR 1010	High tillering, medium late maturity and bold grains with good appearance
90Zhong65/UP2572// HRWYT-28	High tillering, medium late maturity and longer spikes
90Zhong65/UP2572// UP2556 /Wugeng8025	High tillering, medium late maturity, longer spikes and bold grains with good appearance
UP2572/ F35.70/3// HRWYT-23	High tillering, medium late maturity, longer spikes and bold grains
KYZ9712/Wugeng8025// EGPSN 149	High tillering, longer spikes and bold grains with good appearance
UP2556/Mv 231-98	High tillering, medium late maturity and longer spikes

New hybridizations and sharing of segregating material

During the current crop season, F_1s of 60 single crosses of spring x winter wheat were raised for producing three-way crosses. This approach helps to effectively tailor the F_1 derivatives of spring x winter wheat hybridization to attain the required maturity duration along with desired diversity for agronomic traits and disease resistance. New hybridizations were attempted during Feb. – March, 2013 and a total of 345 crosses were made which included 231 three-way crosses and 114 single crosses between spring and winter wheat parents.

The material generated in the programme in collaboration with VPKAS, Almora was also provided to seven centres in the form of a segregating nursery for selection under diverse agro-ecological conditions. The Spring x Winter wheat Segregating Stock Nursery (SWSSN) comprising 50 crosses in F_2 generation was shared with seven cooperating centres, namely GBPUA&T-Pantnagar, NDUAT-Faizabad, RAU-Sabour, JNKV-ZARC-Powarkheda, SDAU-Vijapur, JAU-Junagadh and UAS-Dharwad. The utilization report from Dharwad centre was not received. The segregating material was subjected to natural biotic and abiotic stresses at different centres. There was occurrence of yellow and brown rust and powdery mildew at Pantnagar; stem and leaf rust at Vijapur and leaf blight at Sabour and Faizabd. Regarding abiotic stresses the material was subjected to early heat at Vijapur and terminal heat and sodicity at Faizabad. The utilization report from cooperating centres showed that the percent utilization of the spring x winter crosses varied from 22% (GBPUA&T-Pantnagar) to 100% (NDUAT- Faizabad). The maximum 390 single plants were selected at Powarkheda followed by RAU-Sabour (278) and NDUAT-Faizabad (251). The major selections across the cooperating centres were done in the crosses with pedigree VL900/SKUZ/HATUSHA//RAJ4083; VL895/ KOTUNG#81//VL832; VL905/LUMAI// VL907 and PHS0623/VORONA/KAUZ// LBPY04-2. The utilization of the SWSSN from the cooperating centres was very encouraging and it reflected the usefulness of winter wheats in spring wheat improvement.

Entries contributed in national trials

During the period under report, two genotypes from the project which were tested in the DWR-ST during the previous year were evaluated at the national level in the coordinated trial viz. DBW99 (HD2618/HJA70581//HD2590) in NIVT-1A and DBW111 (JARU//SHA4/CHIL) in Salinity/Alkalinity Trial. Further, eight advance lines developed in the project were evaluated in DWR-ST and 5 genotypes were tested in Salinity/Alkalinity nursery of the coordinated programme. Some of the promising cross combinations in yield evaluation trials is given in Table 1.36. From the 8 lines tested in DWR Station Trial, 4 lines were promoted for national evaluation in NIVTs (DBW115, DBW121, DBW124, DBW133) and one genotype was promoted from the Salinity/Alkalinity Nursery and included in Salinity/Alkalinity Trial (DBW 131) of the coordinated programme for the 2012-13 crop season.

A set of two PYTs was conducted to evaluate 68 advance lines along with 4 checks during the crop season. Out of these, ten superior lines were selected for evaluation in DWR-ST and 5 in Salinity and Alkalinity Nursery conducted during 2012-13. During the crop season 2012-13, two PYTs with 46 advance lines alongwith 4 checks was conducted.

Table 1.36. Promising SxW cross-combinations in yield trials

Cross Combination	Characteristics
UP2572/Wugeng8025	Resistant to leaf (score-0) and stripe rust (20S; ACI=5.7)
90Zhong65/UP2572	Long ears and dwarf plant type (60cm)
HUW 548/Mv231-98	Resistant to stem (10MR; ACI=1.3), leaf (score-0) and stripe rust (10MR; ACI=0.7); high tillering and high thousand grains weight (48g)
Lucero/Tirchmir-2// Hunza/3/VW 9676	High tillering and bold seeds
UP2425/Spartanka-Kak-Hori-Doli // PHR1010	Resistant to leaf (score-0) and stripe rust (20MR; ACI=1.2); medium late, long ears and broad leaves

Genetic studies on abiotic stress tolerance in wheat

Phenotyping RIL population

The RIL population (HD2808/HUW510) consisting of 475 lines was phenotyped alongwith parents under normal (timely sown) and stress (late sown) environments for terminal heat tolerance. The parents differed significantly in grain weight under stress conditions. Sixty-four lines had less reduction in grain weight/spike than tolerant parent HD2808 and 230 lines had more reduction than susceptible parent HUW510. One hundred and six lines had less reduction in 1000-grains weight than HD2808 and 212 lines had more reduction than HUW 510.

Evaluating genotypes under drought and heat stress conditions

Twenty-eight genotypes including 3 checks were evaluated for drought (rainfed conditions) and terminal heat tolerance (late sown conditions). Genotypes RAJ 4311, RAJ4313, AKAW4692, AKAW3717, HI8743(d), RAJ4310, HI8731(d), HI8744(d), WSM103, HI8742(d), RAJ4312, C306, GW2010-408, GW2010-407, GW2010-409, NIAW2248 and HI8741(d) gave higher or at par yield than check under late sown conditions, whereas genotypes RAJ4310, HI8730(d), GW2010-409 and RAJ4313 gave higher yield under rainfed conditions. However, on the basis of stress indices, 9 genotypes were tolerant to both stresses (GW 2010-408 and HI 8743), 5 genotypes to heat stress (HI 8745 and RAJ 4313) and 9 genotypes to drought stress (GW2010-410 and HI 8730) (Fig. 1.3).

Evaluation of synthetic wheats for heat tolerance

75 synthetic wheat lines were evaluated for heat tolerance under timely and late sown field conditions during the crop season 2011-12. The post heading average maximum temperatures under late sown field conditions were approximately 3.2°C higher than the normal temperature, whereas minimum temperatures were higher by 2.8^{0}C. Synthetic lines 466, 186, 222, 153, 145, 210, 223, 188, 136, 209 and 206 had marginal

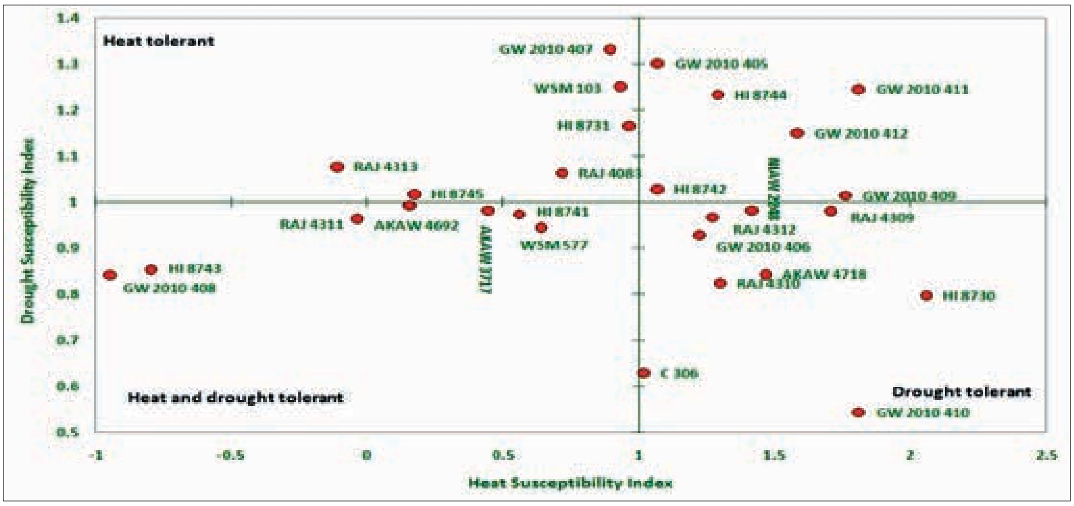


Fig. 1.3. Categorization of advanced breeding lines into heat and drought tolerant and susceptible categories

reduction in grain filling duration; synthetic lines 175,145,139, 186, 206, 168, 136, 222 and 153 had less than 10% reduction in grain number/ spike; synthetic lines 186, 175, 206, 139, 145, 136, 153 and 168 had lesser reduction in 1000 grains weight than their counterparts under non stress conditions (Fig. 1.4). Based on heat sensitivity index for thousand grains weight, synthetic lines 206, 186, 175, 139, 145, 136, 153 and 168 were less sensitive under stress conditions. The synthetic lines 212 and 237 had significantly higher reduction in grain filling duration under stress conditions; lines 453, 210, 188 and 466 had more than 25% reduction in grain weight/spike and lines 210, 453, 209, 223, 241, 188 and 182 had more than 25% reduction in 1000 grains weight.

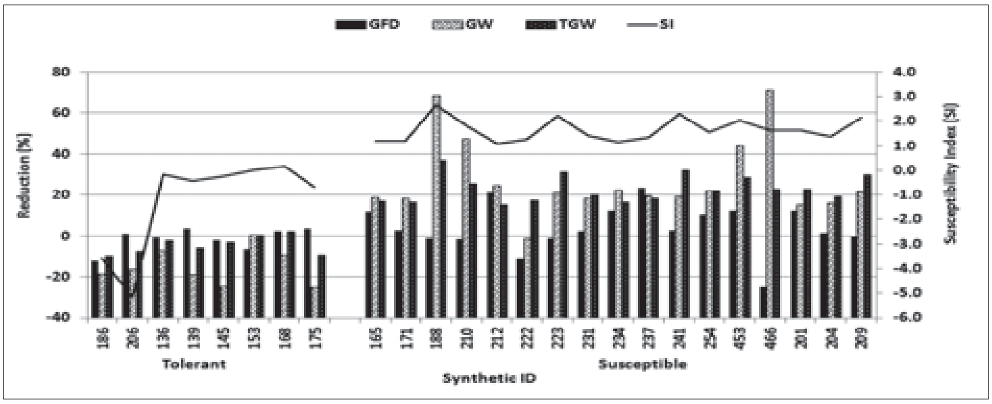


Fig. 1.4. Reduction (%) in grain filling duration (GFD), grain weight/spike (GW), thousand grain weight (TGW) and susceptibility index of synthetic lines under stress conditions

Evaluation of indigenous germplasm accessions for heat and drought tolerance

Sixty-three indigenous germplasm accessions were evaluated for heat tolerance under both field as well as temperature controlled glasshouse conditions during 2011-12 crop season. The temperatures inside glasshouse were adjusted 2^0C above normal. The maximum and minimum temperature under both conditions was recorded daily. The post heading average maximum temperatures under glass house and late sown field conditions were approximately 2.3^0 and 4.4^0C higher than the normal temperature whereas minimum temperatures were higher by 2.1^0 and 3.5^0C under polyhouse and latesown conditions respectively. These genotypes were also evaluated under rainfed conditions in field for drought tolerance. There was 18mm rainfall during the crop season; 8.3mm during grain growth period.

Based on the data recorded under both stress conditions, it was found that genotypes IC32198, IC31405B, IC55707B, IC57983B, IC55701A, NEPAL6, IC128342, NEPAL8, IC128335, NEPAL39, IC78762B, IC28658 and IC28692A had lesser reduction in grain weight/spike, genotypes IC 321987, IC55701A, IC28904B, IC 28661, NEPAL9, IC41504, IC 322005, IC 30290B, NEPAL 8, IC321921, IC28938B, IC 59575A, IC128342, NEPAL 38, IC 57586 and IC 30276A had lesser reduction in thousand grains weight (Fig. 1.5). Thirty-two genotypes were sensitive

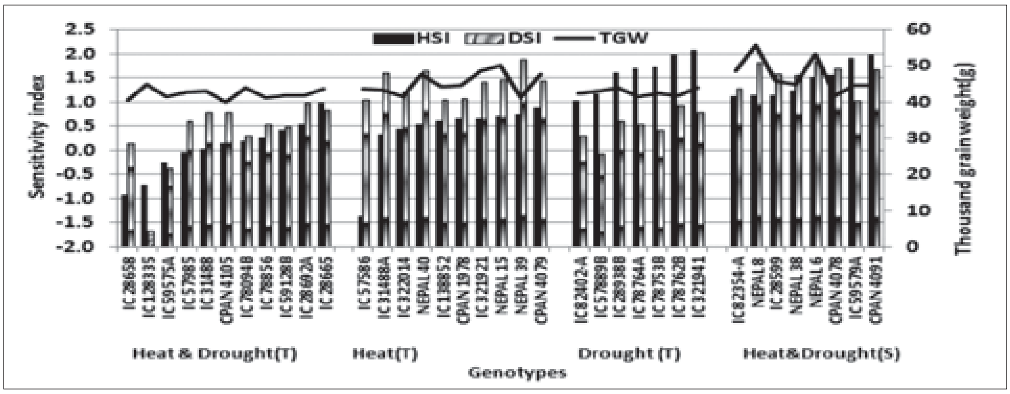


Fig.1.5. Heat and drought susceptibility indices in genotypes having thousand grain weight more than 40g

to high temperature stress under late sown conditions and thirty were sensitive to drought conditions under rainfed conditions. Eleven genotypes were tolerant under both stress conditions, ten were tolerant for heat stress and seven under drought conditions only. Forty accessions had 1000 grains weight more than 40g. Eleven of these accessions were tolerant to both the stresses, 10 to heat stress only, 7 to drought stress only and 12 to none of the stress.

Of 24 accessions with 1000-grains weight less than 40g; 9 were tolerant to both the stresses, 2 to heat stress only, 8 to drought stress only and 5 to none of the stress.

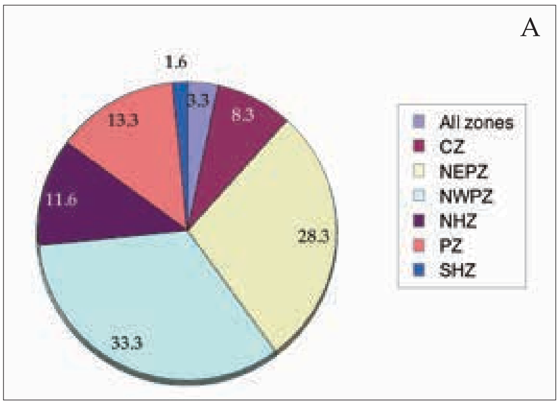
Evaluation of wild species for cell membrane stability

Cell membrane stability was determined in 96 wild species accessions; 8% of accessions with A genome, 18% with B genome, 12% with D genome, 1005 with UM genome, 17% with US and AB genome and 20% with ABD genome had CMS more than 40%. Sixteen accessions with high CMS values were used in crosses with advanced breeding lines and F_1 seed harvested.

Biotechnological interventions

Occurrence of durable adult plant resistance gene *Lr34* in Indian wheat varieties

Lr34 gene is non-hypersensitive Adult Plant Resistance gene which has been characterized at molecular level for which a diagnostic, co-dominant marker is available. About 300 genotypes were screened with the marker showing presence of the gene in 60 genotypes. Amongst the wheat agroclimatic zones, NWPZ was credited with maximum number of genotypes possessing *Lr34* (33.3%) while SHZ had the lowest frequency (Fig. 1.6a). Genotypes characterized possessing *Lr34* gene have also been presented on the basis of wheat breeding center amongst which PAU, Ludhiana had maximum number of genotypes positives (16.6%) followed by IARI, New Delhi having (11.6%) and rest others contributed jointly 71% (Fig. 1.6b). The proportion of Area Under Disease Progress Curve (AUDPC) recorded in these genotypes *vis-a-vis* the AUDPC of the most susceptible check genotype is presented in Fig. 1.7. This clearly shows that majority of the genotypes show resistance (green bar) towards pathotypes of both northern and southern wheat belts.



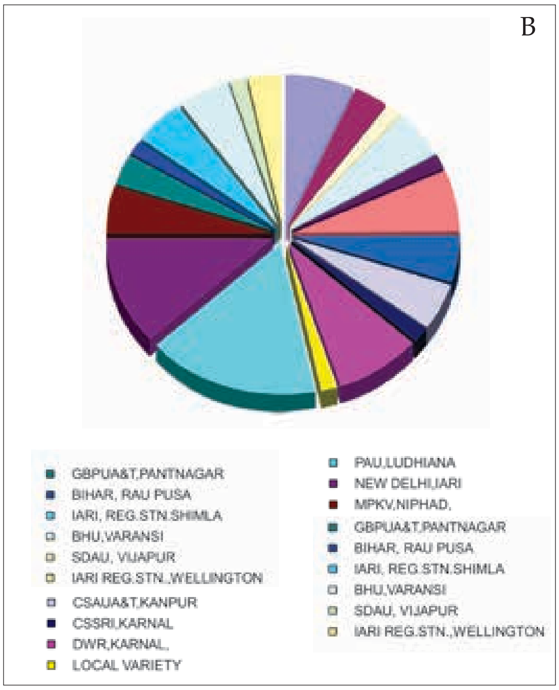


Fig.1.6. Distribution of *Lr34* gene carrying wheat genotypes based on (a) agro-ecological zone and (b) wheat breeding centres

Development of mutant genetic resource for wheat improvement by TILLING technology

TILLING (Targeting Induced Local Lesions IN Genomes) represents the use of induced mutants in plant breeding which allows the direct identification of beneficial genetic changes in genes with known functions. The range of alleles that can be developed via TILLING in a short time is unlikely to be found elsewhere in the pool of germplasm accessible to plant breeders. Because TILLING identifies single base changes

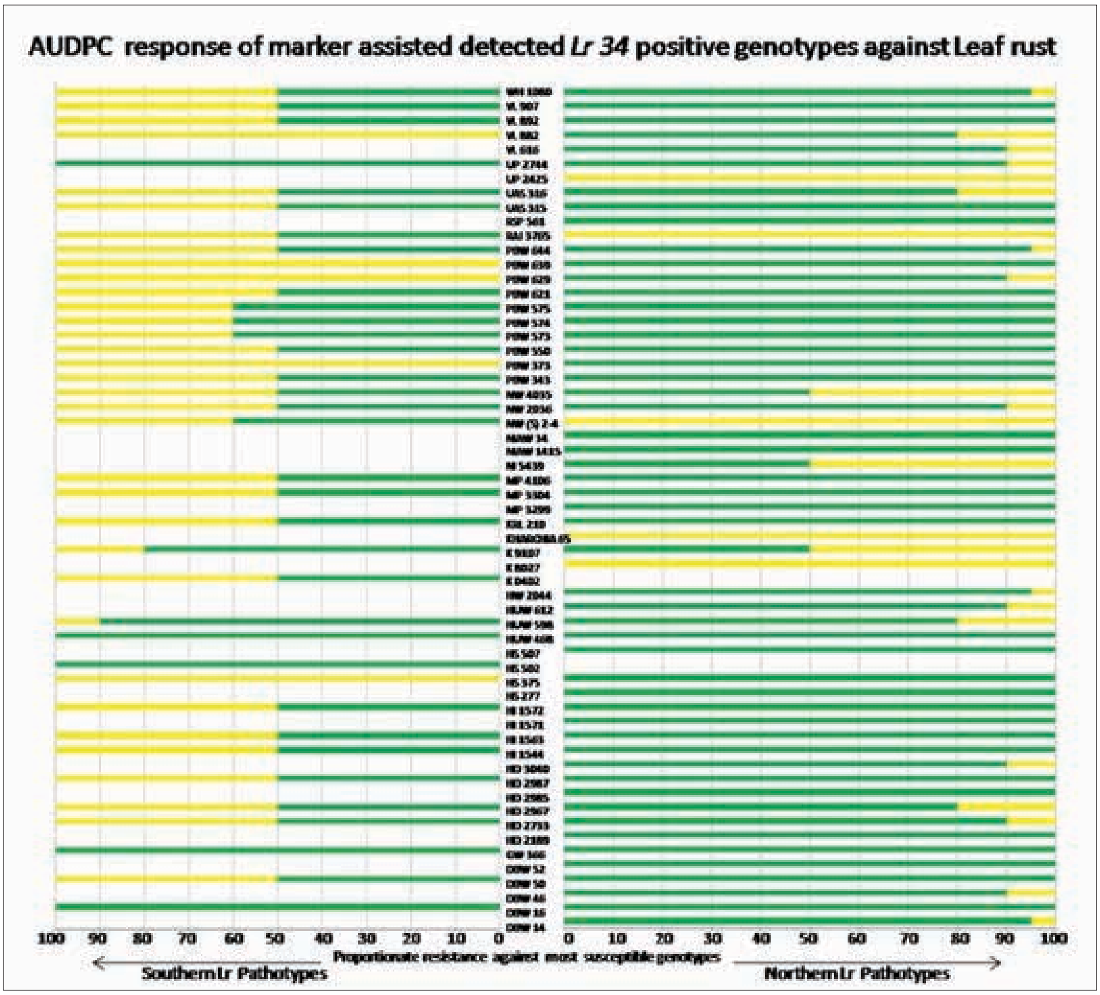


Fig. 1.7. Response of *Lr34* (Marker assisted) possessing genotypes in terms of their proportionate AUDPC score vis-a-vis susceptible corresponding check genotype

or mutations in a given gene, it is important to mutagenize grains that are homozygous and genetically identical to each other. In order to decrease genetic variation in the lines to be mutagenized, we performed the purity test based was performed on SSR and STS markers on the wheat genotype to be utilized for the study. The wheat cultivar DPW621-50 was used to develop a mutant population for TILLING (Fig. 1.8). It was observed that the survival rate of plants with dosage of 0.7 to 0.8 % EMS for 16 hrs treatment were closest to targeted 50-60% survival and was used to mutagenize the seeds of DPW621-50.

Fig.1.8. M_2 generation of TILLING population

Functional analysis of *DREB2* gene isolated from Indian bread wheat genotypes

Partial DREB gene sequences were isolated from 15 drought tolerant Indian bread wheat cultivars and submitted to NCBI with HQ804651-55 and FC556845-53 accession numbers. Nucleotide alignment of 15 wheat cultivars DNA sequences by multalin software indicated that sequences showed 99 % homology to each other but has differences in some nucleotides that might be critical for amino acid changes. Their protein alignment showed conserved N-terminal nuclear localization signal, AP2 domain (57 amino acids) from 56 to 113 amino acid (Fig. 1.9). Alignment of protein sequences revealed three conserved features; an AP2- DNA binding domain of 57 amino acids based on the conserved 14th valine and 19th glutamic acid residues, an N-terminal nuclear localization signal and Ser/Thr-rich region adjacent to the binding domain. In addition, more similarities were established between AP2/EREBP protein of *A. thaliana* and *T. aestivum* by conducting protein docking with the DNA containing GCC-box. Both proteins seem to interact through their â-sheet with the major DNA groove by hydrogen and hydrophobic bond.

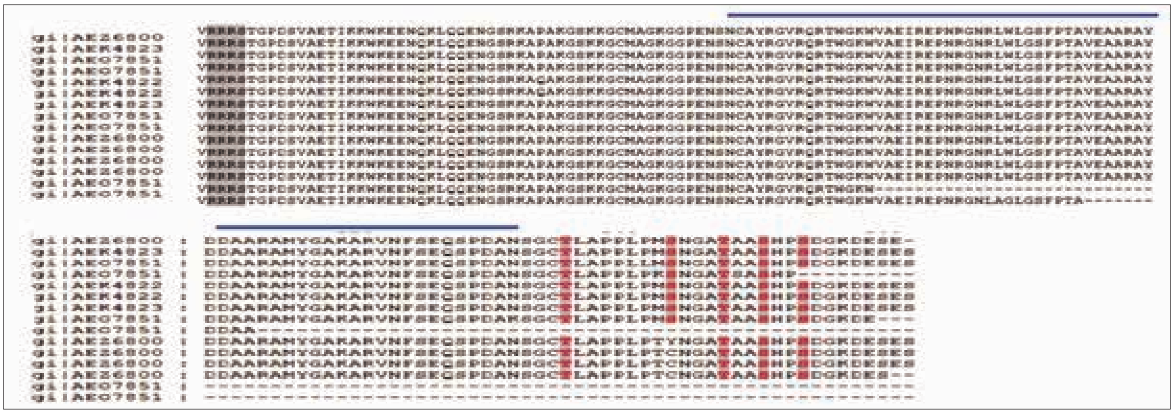


Fig.1.9. Sequence analysis of the deduced amino acid sequence of the isolated TaDREB2 protein. The nuclear localization signal in the N-terminus is shaded in bold. The serine/threonine-rich regions are shaded in red. The AP2/ERF conserved domains of TaDREB2 are underlined

Molecular characterization of wheat varieties for stem rust resistance

Sixty-one wheat genotypes were haplotyped for stem rust resistance genes *Sr2, Sr6, Sr22, Sr24, Sr25, Sr26, Sr31, Sr36, Sr40* and 1A.1R using linked microsatellite (SSR) and sequence tagged site (STS) markers. 21 markers were screened for 10 major *Sr* genes of that 19 markers gave amplification for Indian wheat. Total 29 alleles were amplified for nineteen molecular markers for 61 varieties. Haplotype analysis indicated that 44 and 18 out of 61 lines likely carry *Sr2* and *Sr31* genes respectively. The polymorphism information content (PIC) ranges from 0.0171 (GWM319) to 0.9868 (SCM9) for given data. A genotype by trait biplot is constructed by plotting the PC 1 scores against the PC 2 scores for each genotype (61) and each trait (10 *Sr* genes and 29 alleles). The variance due to two PCA values was 45% and 7%, respectively and cumulative variance of first two PCA was

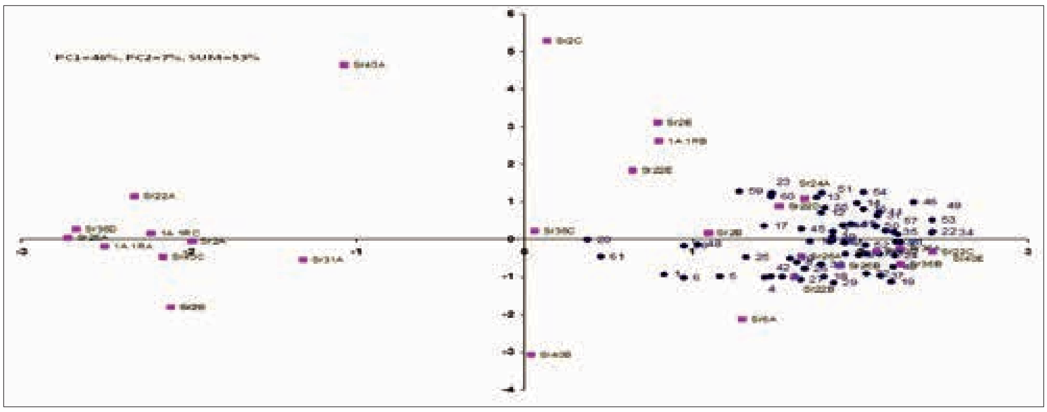
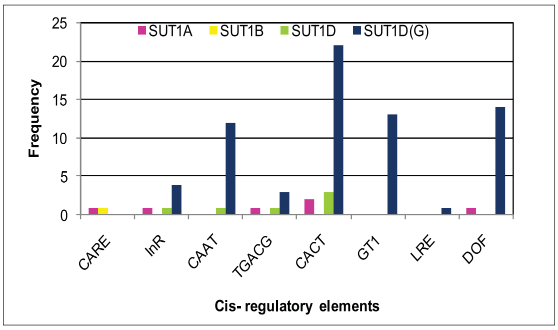


Fig.1.10. The wheat genotype by trait biplot based on 61 genotypes x 10 stem rust resistance genes. 1.AKAW 1071, 2. DL788-2, 3. DL803-3, 4. Durgapura 65, 5. GW 10, 6. GW18, 7. GW 40, 8. GW 89, 9. GW173, 10. GW190, 11. GW273, 12. GW 496, 13. GW 503, 14. HD 2236, 15. HD 2278, 16. HD2327, 17. HI 385, 18. HI617, 19. HI 784, 20. HI 1077, 21. HI 1418, 22. HI 1454, 23. HW 2004, 24. HYB 65, 25. HYB 633, 26. J 24, 27. J 405, 28. Lerma Rajo , 29. Lok 1, 30. MP 4010, 31. Narbada 4, 32. Narbada 112, 33. Ajanta, 34. AKAW 3722, 35. DWR 39, 36. DWR 16, 37. DWR 162, 38. DWR 195, 39. HD 1925, 40. HD2189, 41. HD2501, 42. HD2781, 43. HD 2833, 44. HUW 510, 45. HW 657, 46. K 9644, 47. NI 747-19, 48. NI 917, 49. NI 5439, 50. NI 5643, 51. NIAW 34, 52. NIAW 301, 53. PBN 51, 54. PBN 142, 55. PBW 533, 56. Raj 4037, 57. Sarbati Sonara, 568., 58. Vinata, 59. HD2135, 60. Malviya 318, 61. HW74

observed 53%. Marker for alleles and genotypes were classified in four quadrants (Fig.1.10). Alleles associated with their corresponding genotypes are more close as compare to other related genotypes. Genotypes grouped in first quadrant are positively correlated among themselves whereas genotypes from first and fourth quadrants expressed negative correlations. Determining the presence of different *Sr* gene with a combination of SRT/ACI may necessarily deliver a comprehensive assessment at molecular level and is expected to enhance the accuracy even further by which *Sr* gene can be transferred into future wheat breeding program for stem rust resistance.

Analysis of cis-acting regulatory elements in 5' regulatory regions of sucrose transporter gene families in wheat

Sucrose is a major osmoprotectant molecule in plants; it helps in maintaining cell hydration and subsequently providing resistance against cellular dehydration. Identification of regulatory motifs and their organization is an important step to improve understanding of gene expression and regulation. Bioinformatic tools were used to identify putative *cis*-acting regulatory elements that may be involved in the regulation of wheat sucrose transporters. The possible *cis*-acting regulatory elements were predicted by scanning the sequences upstream of the sucrose transporter genes translational start sites, using Plant CARE, PLACE and Genomatix Matinspector professional data bases. Several *cis*-acting regulatory elements that are associated with plant development, plant hormonal regulation and stress response were identified, and present in varying frequencies within the 5′ regulatory region (Fig. 1.11) as : A-box, ABRE, ARF, ERE, GARE, Me-JA, ARE, DRE, RY, CAT, Pyrimidine-box, Sucrose-box, GA-motif, GATA, GT-1, MYC, MYB, W-box, and I-box. This analysis indicates cis regulatory elements that possibly involved in the expression and regulation of sucrose transporter gene families in wheat during cellular development or environmental stress conditions.



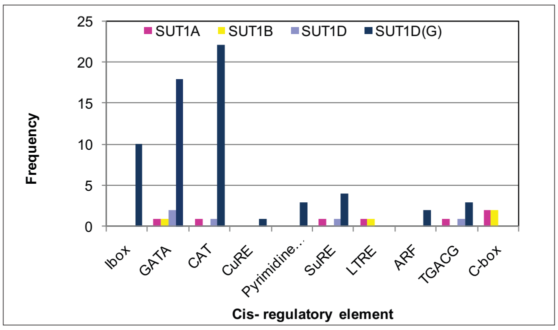


Fig.1.11. Illustration of frequencies of the cis-acting elements identified in the 5'regulatory sequences of wheat sucrose transporter gene family

2 CROP PROTECTION

Crop Protection Programme covers three disciplines, namely Pathology, Entomology and Nematology. The major thrust areas are: crop health monitoring (including grain health), distribution of rust pathotypes, host resistance, rust resistance gene postulation, pest management (host resistance, tillage options, chemical control and IPM modules). The highlights of the programme are given hereunder:

Host resistance

For providing support to the wheat breeding programe, evaluation of disease/pest screening nurseries was undertaken under artificially inoculated conditions at various hot spot locations. The major nurseries were: IPPSN, PPSN, EPPSN, MDSN, MPSN and disease/pest specific nurseries.

The Initial Plant Pathological Nursery (IPPSN), with 1380 entries and Plant Pathological Screening Nursery (PPSN) with 530 genotypes including checks, are the main nurseries which are the major components of the Decision Support System in promotion of entries from one stage to the other, and finally the identification of genotypes for release. The other nurseries that are evaluated at hot spot multilocations are LBSN, KBSN, LSSN, PMSN, nurseries for diseases of limited importance (FHB, foot rot, hill bunt and flag smut) EPPSN, MDSN, MPSN and the evaluation against nematodes and insect pests.

Based on rigorous multilocation evaluation, following genotypes having multiple disease/pest resistance were identified.

Multiple disease resistance

I. Resistant to three rusts +

MR to Leaf blight (LB) + R to Karnal bunt (KB) + Powdery mildew (Pm): HPW 347, VL 930

MR to LB + R to FS+ Pm: HPW 317VL 931, VL 943, VL 944

MR to LB+Pm: HUW 635

R to FS: DBW 60

MR to LB: GW 1255

R to KB+FS: NIAW 1395, PDW 313, AKDW 4021 (d)

R to Pm+FS+KB: HI 8692 (d), HI 8702 (d), HI 8709 (d), MACS 3742 (d)

R to FS+KB+PM+ MR to LB: PBW 615, DBW 62, HS 522, HUW 629, KRL 250, TL 2963 (T), MACS 3744 (d), NIDW 577(d), NW 4091, PBW 635, HI 8708 (d), HS 533, UAS 327, UAS 432(d), PDW 315 (d), PDW 317 (d)

MR to LB+KB: HS 525

R to FS: HPW 289, HD 3002, HD 2982

R to KB: PBW 628, HUW 638, NW 4081

R to PM: DBW 58, HI 1653, HI 1569

R to Pm+FS: RSP 561, HS 534

II. Resistant to leaf and stem rusts +

R Pm+FS+ MR to LB: HD 3013

R to FS+ Pm+KB: DDK 1037(dic.), DDK 1039(dic.), HD 3048, HD 3052

III. Resistant to leaf and stripe rusts+

R to KB+FS+MR to LB+MR to head scab: VL 934

R to KB+Pm+FS and MR to LB: DBW 52

Karnal bunt

Resistant (Av. incidence upto 5 %): KRL 238, HS 514, HI 8704, TL 2969, PBW 639, PDW 322, WHD 946, UAS 320

Fusarium head blight (FHB) or head scab

Free: UP 2825

Moderately Resistant: HP 1940

Identification of slow ruster lines in AVT

The delay in progress of epiphytotic development is attributed to several factors including latent period, number of uredosori per unit area, size of uredosori, rate of sporulation, etc. Chances of new variants or pathotypes are minimized due to reduced selection pressure. A convenient option of identifying slow ruster lines is the estimation of the Area Under Disease Progress Curve (AUDPC) which takes into account all the factors collectively leading to manifestation of slow rusting in a genotype. AVT entries were sown in single rows, each of 1 meter length with an interception of the spreader row after every 20th line for identifying the slow ruster lines at Karnal. For creating a load of inoculum pressure, four rows of mixture of susceptible genotypes were sown as border rows (infector/ spreader). The infector/spreader rows were syringe inoculated at growth stage 37 (Zadoks growth scale for cereals) when flag leaf was just emerging out of boot. On appearance of rust pustules on flag leaf, the high humidity was maintained for rust development. The data of leaf rust and stripe rust intensities recorded at different dates of equal intervals were subjected to AUDPC analysis. Coefficient of Infection (CI) was calculated. The AUDPC values ranged between 0 and 1800 for leaf rust (Table 2.1) and 0-3000 (Table 2.2) for stripe rust at Karnal. Entries were grouped according to their AUDPC values and are described below:

Table 2.1. Grouping of AVT Ist year and AVT IInd year (2011-12) entries according to AUDPC values for brown rust

AUDPC value	AVT Ist year	AVT IInd year
0	AKDW 4749, DBW 88, DBW 93, DBW 111, DDK 1042, GW 428Q, HD 3077, HD 3078, HD 3079, HD 3080, HD 3081Q, HD 3090, HD 3091, HD 3095, HD 4725, HI 1584, HP 1940, HPW 377, HPW 387, HS 536, HS 557, HS 560, HS 561, HW 5224, KRL 327, KRL 330, MACS 5008, MACS 5012, MACS 5022, MACS 6478, MP 1259, MP 3353, MPO 1255 (d), MPO 1256 (d), NIAW 1689, NIAW 1773Q, NIAW 1846, NW 5038, PBW 661, PBW 662, PBW 665, PBW 674, PBW 675, Raj 4245, Raj 4246Q, Raj 4250, Raj 4270,RW 3705, TL 2978, UAS 334, UAS 336, UAS 442 (d), UP 2822, UP 2824, UP 2825, UP 2828, UP 2852, VL 950, VL 971, VL 972, VL 975, WH 1112, WH 1124 and WH 1127	A-9-30-1 (C), CoW (W) 1 (C), DBW 17 (C), DBW 74, DDK 1009 (C), DPW 621-50 (C), GW 322 (C), HD 2864 (C), HD 2888 (C), HD 2932 (C), HD 2932 (C), HD 3065, HI 1500 (C), HI 1544 (C), HI 1563 (C), HPW 251 (C), HPW 349, HPW 360, HS 277 (C), HS 295 (C), HS 507 (C), HS 526, HS 541, HS 542, HW 1098, HW 5216, K 0911, KRL 210 (C), KRL 283, MP 3336, MP 4010 (C), NIAW 1415 (C), NIAW 34 (C), PBW 343 (C), PBW 373 (C), PBW 590 (C), PBW 658, PBW 660, Raj 4083 (C), Raj 4229, Raj 4238, VL 892 (C), VL 907 (C), WH 1098 and WH 1105
1-100	DBW 90, GW 1276 (d), GW 1277 (d), GW 433, HD 3075, HD 3076, HI 8724 (d), HI 8725 (d), HI 8726 (d), HI 8727 (d), HI 8728 (d), HI 8730 (d), HI 8731 (d), HPW 368, HPW 376, K 1006, K 1016, KRL 331, MACS 3817 (d), MPO 1262 (d), PBW 670, PDW 329 (d), Raj 4240, RKD 219, UAS 439 (d), UP 2851, UPD 93 (d), WH 1126 and WHD 950	AKDW 2997-16 (d) (C), DBW 14 (C), DBW 39 (C), HD 3043 (I) (C), HI 8498 (d) (C), HI 8627 (d) (C), HS 490 (C), HW 2044 (C), MACS 2496 (C), MACS 2971 (C), MACS 3828, MACS 6222 (C), MPO 1215 (d) (C), NIDW 295 (d) (C), PBW 644 (I) (C), PDW 291 (C), PDW 314 (C), VL 829 (C), WH 1021 (C), WH 1080 (C) and WHD 948
101-200	HPW 385, HS 556, HUW 652, WH 1120, GW 1280 (d), HD 3086, HD 3096, HP 1939, HPW 386, HS 559, KLP 402, VL 973, WH 1123, AKAW 4731 and PDW 327 (d)	HD 2733 (C), HD 3059, K 0307 (C), K 0906, NW 2036 (C), UAS 428 (I) (C) and VL 804 (C)
201-500	CG 1006, GW 432, HD 3093, HD 3098 and VL 974	HI 1579, HD 3070, HI 8713 (d), NIAW 1594, PBW 175 (C), WH 1097 and WH 1100.
501-1000	GW 431, NW 5054 and NW 5055	DBW 71 and NI 5439 (C)
1001-2000	-	C - 306 (C), K 8027 (C) and Kharchia 65 (C)

d: durum wheat; C: check

Table 2.2. Grouping of AVT Ist year and AVT IInd year (2011-12) entries according to AUDPC values for yellow rust

AUDPC Value	AVT Ist year	AVT IInd year
0	DBW 88, GW 431, GW 433, HD 3075, HD 3076, HD 3077, HD 3078, HD 3079, HD 3080, HD 3081Q, HD 3090, HD 3093, HD 3096, HI 8724 (d), HI 8727, HPW 387, HS 557, HUW 652, K 1006, K 1016, KRL 327, MP 3353, MPO 1256 (d), NW 5054 and NW 5055	C - 306 (C), DPW 621-50 (C), HD 2888 (C), HD 3059, HD 3065, HI 1500 (C), HI 1563(C), HI 8498 (d) (C), HPW 349, HPW 360, HS 542, K 0906, K 0911, K 8027 (C), KRL 210 (C), MPO 1215 (d) (C), NIAW 34 (C), NIDW 295 (d) (C), PBW 644 (I) (C), PBW 658, PBW 660, PDW 314 (C), Raj 4083 (C), Raj 4229, UAS 428 (I) (C), VL 892 (C), VL 907 (C), WH 1080 (C), WH 1097, WH 1098 and WH 1105

1-100	AKAW 4731, AKDW 4749, CG 1006, DBW 111, GW 1277 (d), HD 3086, HD 3098, HD 4725, HI 8724, HI 8725 (d), HI 8726 (d), HI 8728, HI 8730 (d), HI 8731 (d), HPW 368, HPW 376, HPW 385, HPW 386, HS 556, HS 560, HS 561, HW 5224, KLP 402, KRL 330, KRL 331, MP 1259, MPO 1262 (d), NIAW 1846, NW 5038, PBW 662, Raj 4240, Raj 4245, Raj 4250, UP 2822, UP 2825, UP 2828, VL 973, VL 974, WH 1120, WH 1123 and WHD 950	HS 541, AKDW 2997-16 (d) (C), DBW 74, DBW 14 (C),DBW 39 (C), HD 3043 (I) (C), HD 3070, HI 1579, HI 8713 (d),HPW 251 (C),HS 490 (C),HS 507 (C),HW 2044 (C),K 0307 (C), KRL 283, MACS 3828, MACS 6222 (C), NIAW 1594, NW 2036 (C), PBW 175 (C), PDW 291 (C), VL 829 (C) and WHD 948
101-200	DBW 90, DBW 93, HP 1939, HP 1940, HS 536, HS 559, MACS 6478, MPO 1255 (d), PBW 675, UAS 442 (d), WH 1124 and WH 1127	DBW 71, HD 2733 (C), HI 8627 (d) (C), HS 526, HW 5216, PBW 590 (C), VL 804 (C) and WH 1021 (C)
201-500	DDK 1042, GW 1276 (d), GW 1280 (d), GW 432, HD 3091, HD 3095, HI 1584, HPW 377, MACS 3817 (d), NIAW 1773Q, UAS 334, UP 2851 and UP 2852	GW 322 (C), HD 2864 (C), HI 1544 (C), HS 295 (C), NI 5439 (C), NIAW 1415 (C), PBW 373 (C), Raj 4238 and WH 1100
501-1000	GW 428Q, MACS 5008, MACS 5012, MACS 5022, and NIAW 1689	A-9-30-1 (C), CoW (W) 1 (C), DBW 17 (C), DDK 1009 (C), HD 2932 (C), HW 1098, Kharchia 65 (C), MACS 2496 (C), MACS 2971 (C), MP 3336, MP 4010 (C) and PBW 343 (C)
>1000		HS 277 (C)

d: durum wheat; C: check

Utilization of resistance sources through NGSN

The confirmed sources of multiple disease and insect pests resistance were contributed in the NGSN, 2011-12 and were planted at 20 breeding centers across different agro climatic zones of country for their utilization in breeding for resistance to biotic stresses. All the 58 entries were utilized in the range of 5-45%. The entries utilized most (20% or more) at centres (Fig. 2.1) were VL 907, DBW 50, DBW 54, NW 3087, DBW 49, HD 3007, WH 1021, VL 920, UAS 305, HD 2987, MACS 6273, PBW 612, WH 1061, WH 1062, PBW 610, VL 926, DBW 39, HD 2998, HUW 626, WH 1076, WH 1078, K 0716, MACS 6222 and MP 4080. The utilization of resistant entries to biotic stresses in NGSN indicates increasing trend over years by breeders which proves worthiness of programme in providing multiple resistance in pipe line varieties of wheat.

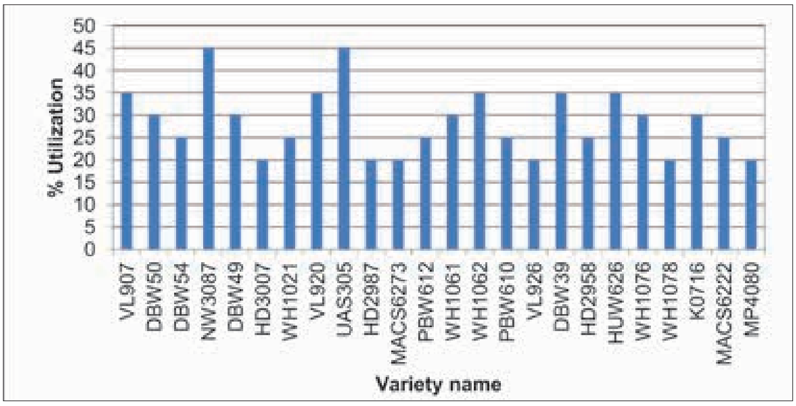


Fig. 2.1. Per cent utilization of promising resistant genotypes at different breeding centres in NGSN, 2011-12

Preparedness to combat Ug99

Indian wheat advance lines (189) were evaluated at Kenya and Ethiopia for resistance against Ug99, as a part of strategy to meet the threat in case this pathotype enters India. The genotypes found resistant against Ug99 and its pathotypes in Kenya, Ethiopia and both the locations, are enlisted below:

Following genotypes showed resistance to Ug 99 at Ethiopia and Kenya:

AVT-I & II

Those resistant in Ethiopia

TR: TL 2942, TL 2969, TL 2975, COW (W) 1

Upto 20 MR: MP 4010, HI 8714, WHD 948, GW 418, HI 8722, HD 3075, DDK 1040, MACS 5013, RAJ 4211, MP 3288, LOK 62, PDW 233, HI 8704, MACS 3828, LOK 1, MPO 1215, HD 3040, DDK 1045, MACS 3815, AKDW 2997-16, MACS 6222, NI 5439, NIDW 295, RAJ 4230, UP 2797, HW 1098, HI 8663, JWS 134, MACS 1967, HW 2044, HS 545, HI 8713, HI 8715, WHD 943, DL 788-2, HI 1500, HI 1544, HI 8498, HI 8677, HI 1571, RAJ 4228, RAJ 4229, HD 2888, HI 1563, MACS 2971, VL 941, VL 946, HUW 648, AKDW 2997-16, DDK 1009, HD 3071, HPW 360, UAS 428, NIAW 1415 and RAJ 4238.

Those resistant in Kenya

Free: TL 2942, TL 2969, TL 2975 and VL 957

Upto 20 MR: LOK-1, MP 1246, DDK 1009, C 306, HI 8704, MACS 2971, PDW 322, HS 545, HI 8498, HI 8627, MPO 1215, WHD 948, HI 8715, MACS 3815, MACS 2997, MACS 5012, HI 8703, HPW 360 and HI 8722.

Those resistant at Kenya and Ethiopia

TL 2942, TL 2969, TL 2975, LOK-1, DDK 1009, HI 8704, MACS 2971, HS 545, HI 8498, MPO 1215, HI 8715, MACS 3815 and HPW 360.

Survey and surveillance

Pre- harvest crop health monitoring

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) and J&K (Ladakh). Major focus was on the occurrence of yellow rust and surveillance for the stem rust pathotype, Ug99. Status of other diseases, including leaf rust was also monitored during these survey trips. The extensive surveys were also conducted by the crop protection scientists of different cooperating centers including DWR Karnal and by special teams of scientists constituted during the 50th All India Wheat Workers' Meet. Information on wheat crop health was disseminated through the "Wheat Crop Health Newsletter", which was issued on monthly basis during the crop season. This can be access on DWR website (http://www.dwr.in). Except for the yellow rust in NHZ and NWPZ, the overall crop health status was satisfactory in the country. Disease situation in other zones of the country was very comfortable with no report of any serious out break from anywhere. No natural occurrence of stem rust was observed anywhere in the country. Leaf rust or brown rust was at low level in all the wheat growing zones of the country. Leaf blight or spot blotch was also not serious in the main Indo-Gangetic plains of northern and eastern parts of India.

North Western Plains Zone

In Punjab, on January 4, 2012, at village Patti near Nangal, (A: 253 m, N-30.92719°, E-076.20995°), few foci of yellow rust (60 S) were observed in variety WH 711 in half bigha sown on October 15, 2011. Brown rust was also observed in WH 711 (few foci upto 60S). Yellow rust (80S) was spotted in five acres in village Majiri Jata Di (Gurdaspur Distt., Punjab), WH 711 was severely affected with yellow rust on Feb. 9, 2012, even PBW 550 was also affected with rust. High incidence of yellow rust on variety DBW17 was also noticed in one field of Rampur village in Ropar district on 13th Feb, 2012. Another variety HD 2932 grown at Rurkikalan village (Nawasahar) had yellow rust incidence upto 60S in patches. On 14th Feb 2012, heavy incidence of yellow rust was observed on different varieties viz. PBW 550, HD 2967 and DBW 621-50. In farmer's fields of Kahnuwan block of Gurdaspur district, severe incidences of yellow rust were observed (60-80S) on different cultivars grown in the area.

In Haryana, on Feb. 4, 2012, yellow rust was observed in Larpur village in Sadora block of Bilaspur and in Ranjitpur village near Bilaspur (Yamunanagar). On Feb. 6, 2012, yellow rust was observed in Yamunanagar district in various villages, like, Bhamnoli, Rattuwala, Safeelpur, Nijampur, Rajpur, Kaloudi, Rathali, Thaska, Mirzapur, Baroulimajra, Sadhoura and Bilaspur. The fields were limited and the varieties affected were, PBW 343, WH 711, HD 2851, DBW 17, PBW 550, Raj 3765, Super–172 and HD 2894. The disease was having more incidence in PBW 343, WH 711 and Super 172. On Feb. 9, 2012, yellow rust was observed in villages Larpur and Ranjitpur in Sadhoura block. On February 14, 2012 yellow rust was spotted in a farmers' field (2 acre) on variety DBW 17 in village Dabkoli Khurd (Indri Block of Karnal).

In HP, at Sunhera village (Una, HP, A: 360 m, N-31.35602°, E-076.09498°) yellow rust was observed in variety PBW 550 in a few plants (10S). Yellow rust was recorded in Indora and Nagrota Surian blocks during Feb. 3-4, 2012. It was recorded in severe form on HS 240 with severity touching 40-80S and incidence more than 75% at Karol in Pragpur block. Isolated reports about the appearance of yellow rust in other blocks viz. Kangra, Bhavarna and Panchrukhi in Dhauladhar valley have been received through KVK Kangra and officials of the Department of Agriculture on Feb. 8, 2012. YR has been reported on HPW 184 (Chandrika) at Ichhi (Kangra block) and on UP 2338 at Ghad (Panchrukhi block) with severity touching 60S.

In Jammu, first natural incidence of yellow rust was spotted on 5th January in the field of Sh. Bahadur Singh (Village-Kalayna, Jammu) on PBW343 (30S) and then on RAJ 3765 (5S) on 6th January. Yellow rust was also observed in Kathua and Samba districts on 25-27 January 2012 on varieties, PBW 343, PBW 550, Shalimar and some unknown varieties. Yellow rust was found in every surveyed area with few foci or in patches (1-4 meter diameter) with 5 to 80S severity in susceptible varieties (PBW 343, PBW 502) and mixed varieties in Samba and Kathua districts of J&K from 9th & 10th February, 2012. In Chatha, yellow rust was found in Shalimar wheat -1 and PBW 343 with 10-80S severity in 3-4 meter patches. In RS Pura area, disease was only found on PBW 343 or varietals mixture sown by farmers. RAJ 3765 and RAJ 3077 were free from the yellow rust in every surveyed area. Powdery mildew was also observed in 2-3 ha. area of PBW 175 with higher severity and intensity (50-80%) in Marh block.

In Uttarakhand, on 17th February 2012, , yellow rust was found in Busbheeda village, Chaukhutia block, Almora District with up to 10S severity with very low incidence. But in the same village one field of UP 2338 as informed by the owner of Krishi Nivesh Selling Centre about 10.0 m^2 area had severe yellow rust with 80 – 90S and almost 50% prevalence was observed. Yellow rust was found in many fields with 10-30S infection in the villages Busbheeda, Chaukhutia, Chinoni. Brown rust was also observed in one field with about 10S infection in Chaukhutia.

Yellow rust appeared later in different parts of HP, Uttarakhand, Punjab and Haryana With the timely advisory issued by DWR and with the support of ICAR, DAC, State Departments of Agriculture, yellow rust spread was not much as chemical sprays were given by the farmers well in time. This combined efforts resulted in record breaking wheat production during 2011-12.

North Eastern Plains Zone

In eastern U.P., wheat crop health was good and moderate incidence of leaf blight was observed in timely sown crop and initiation started in late sown also. Brown rust was observed on 18-2-2011 in trap nursery on the cultivar Agra Local. Shoot fly infestation was also observed in some of the fields. At Ranchi, leaf rust was recorded on variety Lal Bahadur with severity below 5S on 22nd March 2012. Foliar blight incidence was moderate to high. In Kanpur area no rust was observed.

Central Zone

No rust was found in the route of CZ monitoring tour in Chhatisgarh and M. P. (Raipur, Bilaspur, Ambikapur, Jabalpur, Sagar and Bhopal). Only traces of brown rust was observed in Agra Local, Lalbahadur, C 306 and Lok 1 in TPN. Black rust was not observed in any of the entries as well as susceptible infectors.

Peninsular Zone

The crop was free from leaf and stem rust at farmer's field in Pune. Plants were free from leaf and stem rust in trap plot nursery. Incidence of foliar blight was recorded in many varieties viz. Balaram, Hybrid wheat, Lok 1, Bijaga Yellow, MACS 2846 and also in breeding material at ARI, with severity ranging from 00 to 25. First natural incidence of leaf rust was observed in farmer's field in Satara on 11-03-2012 (Lok-1). Natural incidence of leaf rust was observed on HD 2189, Trimbak, Lok-1 and farmers local varieties. The rust severity was from 20S to 60S. No natural incidence of black rust was noticed in any of the locations. Stem borer and rodent damage was observed in a few of the farmers' fields with low severity. In Niphad, incidence of rust diseases (stem and leaf) was not observed in any field and on any variety in the surveyed districts. Leaf blight was noticed on lower leaves in the month of March 2012. The population of aphids was low to medium and in some fields, it was severe. As per report received from Niphad, cereal leaf beetle (Coleoptera) was observed on 27/12/2011 in restricted irrigation breeding trial.

Off season surveys

Wheat crop health in Leh region was surveyed in a stretch of nearly 80 Km x 8 Km where wheat was grown near the Indus river as well as away from the Indus river from September 5-7, 2011. In the Indus river basin all the wheat rusts, i.e., stem, leaf and stripe, were observed with severity of 60S, 40S and 60S, respectively. At Nemo, stripe rust severity was 80S and one club wheat was also showing 40S stripe rust infection. A total of 35 samples of three rusts (17 of stripe, 7 of brown and 11 of black) of wheat representative of varieties and localities were collected for pathotype (race) analysis.

Wheat rusts survey in Nepal

A team surveyed off-season wheat in the hills of Nepal during October 17-18, 2011 to understand the epidemiology of wheat rusts. The team surveyed rusts in the off season wheat, self sown wheat and alternate/collateral hosts. No rust was observed in any of the fields in the village. Yellow rust in traces was observed only in a field at village Khari Dunga (farmer, Naina Bahadur Shrestha) in variety Pasang Lamu. Black rust was not observed at any of the fields. Berberis was observed almost regularly for around 100 km along the roadside in the Dhaulaka region. However, no rust was observed. One leaf rust focus (8-10 plants, severity upto 20 S) was observed in the field of Kaila Shrestha in variety Sonalika.

Karnal bunt status

A total of 9280 grain samples collected from various mandies in different zones, were analyzed by DWR as well as other cooperating centers (Table 2.3). The number of samples analyzed by various centres were: DWR-2210, Ludhiana-1903, Hisar-512, Pantnagar-3244, Vijapur-251, Durgapura-783, Junagarh-377. From CZ and PZ, 961 and 182 samples, respectively, were analyzed to know the distribution and disease situation in these zones. The highest Karnal bunt incidence (87.66 %) was recorded from Uttarakhand. In Haryana, out of 1286 samples analyzed, 1.94% were found infected with Karnal bunt. In Punjab, 2.95 % samples showed Karnal bunt infection. From Rajasthan, out of 855 samples analyzed, 8.77% were found infected with Karnal bunt with infection range upto 1.30%. In Uttarakhand, out of 3322 samples analyzed, 87.66% were infected. Based on the overall Karnal bunt occurrence, it emerged that the Karnal bunt incidence this year was less except the *tarai* region of Uttarakhand.

In the CZ, none of the samples from Gujarat (Vijapur & Junagarh), MP (Sagar, Indore, Powarkheda) were found infected with Karnal bunt. Only one sample from Hoshangabad was found infected with Karnal bunt. All the samples received from Maharashtra were free from Karnal bunt.

Table 2.3. Karnal bunt situation in the country during 2011-12 crop season

State	Total samples	Infected samples	% infected samples	Range of infection
Punjab	2165	64	2.95	0-003
Haryana	1286	25	1.94	0-0.35
Rajasthan	855	75	8.77	0-1.3
Uttarakhand	3322	2919	87.86	0-1.0
Himachal Pradesh	60	7	11.67	0-0.1
UP	449	10	2.22	0-0.25
MP	333	1	0.30	0-0.05
Gujarat	628	0	-	-
Maharashtra	182	0	0	-
Total	**9280**	**3101**	**33.41**	**0-1.3**

In addition to 2210 samples analyzed by DWR, Karnal, more than 1100 samples received from different FCI's stores were also analyzed for KB at the Directorate.

Black point

Out of 4133 grain samples analyzed for black point from different zones in the country, 72.73% samples showed black point. (Table 2.4)

Table 2.4. Spectrum of black point in the country during 2011-12 crop season

State	Total samples	Infected samples	% infected samples	Range of infection
Punjab	262	201	79.00	0-1.90
Haryana	1286	1168	90.82	0-1.25
Rajasthan	855	819	95.78	0-13.50
Uttarakhand	78	35	44.87	0-0.55
HP	60	32	53.33	0-0.35
UP	449	324	72.16	0-2.65
MP	333	194	58.25	0-1.05
Gujarat	628	108	17.19	0-15.60
Maharashtra	182	125	68.68	0-2.20
Total	**4133**	**3006**	**72.73**	**0-15.60**

IPM in Wheat: Management of diseases and pests

Management of diseases and pests through chemical control: Chemical control has gained attention under the present scenario due to the wide spread occurrence of yellow rust in most of the varieties in the NWPZ. Similarly chemical control is needed for the management of insect pests, since there is no resistance available in wheat against the insect pests. Through multilocation testing, propiconazole 25EC (Tilt 25EC), tebuconazole (Folicur 250EC) and tridemorph (Bayleton 25 WP) were found very effective against yellow rust disease. The extent of avoidable losses due to yellow rust were upto 40% in NWPZ, hence timely action is required for avoiding the major losses.

Evaluation and promotion of IPM modules: During 2011-12, the validation and promotion of IPM was carried out by Karnal (NWPZ), Faizabad (NEPZ) and Niphad (PZ) centres. The IPM module was evaluated with two varieties Trimbak (NIAW – 301) and NIAW-34 in five locations at farmers fields in Nasik district of Mahrashtra. The module consisted of seed treatment with Azotobactor, PSB and Cruiser spray for the management of aphids. The percentage increase over farmers practice ranged from 6.1 to 12.9%. The population of aphids was comparatively lower than the previous season.

After the adoption of the IPM module in Kaithal District (Vill. Seevan), the IPM module was further promoted in Tikri Village (District Karnal), Haryana. The module was taken up by two farmers (new) during 2011-12 crop season. The varieties taken up were HD2967, HD2851 and WH 544. These were cultivated along with sugarcane.

The module consisted of seed treatment with combination of tebuconazole (Raxil 2DS @ 1.00g) + bio agent fungus Trichoderma viride @ 4 g / kg seed and one spray of Imidacloprid (Confidor 200 SL) @ 100 ml / ha on border rows only resulted in more than 10 % gain in yield as compared to farmers practice.

Pathogenic and genetic variability among the isolates and monosporidial lines of *Tilletia indica* causing Karnal bunt of wheat

Karnal bunt of wheat, caused by *Tilletia indica* (syn. *Neovossia indica*) (Mitra) Mundkur is a destructive disease on wheat as well as an important internationally quarantined disease in many countries. *T. indica* was first found in 1930 at Karnal, Haryana, in northern India. It occurs in the northern part of India in the states of Delhi, Himachal Pradesh, Jammu and Kashmir, Uttar Pradesh, Punjab, Rajasthan and Haryana. *T. indica* survives in the form of teliospores produced within sori on kernels by a teliosporogenous mycelium. The pathogen due to its heterothallic nature shows high variability. Among several approaches advocated for management of KB, deployment of resistant varieties has been the most effective and economical method. For applying efficient strategies in the breeding process, knowledge about the genetic diversity and structure of naturally occurring pathogen populations are indispensable. Therefore, it is important to index all possible pathogenic variants prevailing upon the areas of concern.

Total 34 monoteliosporic isolates of *T.indica* and 62 monosporidial lines were developed and maintained from different geographical regions of the NWPZ of India in crop season 2011-12. To identify variability in *Neovossia indica* pathogenecity tests and genetic analysis based on PCR molecular markers (RAPD/ISSR) were carried out. Out of 34 isolates and 62 Ms lines, ten isolates and 15 monosporidial lines belonged to different locations of North West India were inoculated at Zadok stage 49 on a set of 10 wheat host differentials comprising of resistant, susceptible, moderately susceptible genotypes, during the two successive crop season from 2011-12. Depending upon the pathogenic potential, most virulent and least aggressive isolate was found from Chaksu (Rajasthan) and Tarau (HP), which scored CI 70.98 and 6.22 respectively, on susceptible host genotype HD 2009. Twenty monosporidial lines were inoculated in 40 combinations. Most virulent compatible combination was found Karnal Ms.d X Chaksu Ms.a which resulted co-efficient of infection of 74.91. The self paired monosporidial lines raised from the same isolates caused less infection as well as magnitude of variation based on clustering was also narrow.

Genetic relationships among ten isolates and 15 monosporidial lines were investigated by using 52 RAPD and 32 ISSR primers. Among the two marker systems employed 34 RAPD primers produced 223 total bands whereas 28 ISSR primers produced 193 bands. The level of polymorphism revealed by RAPD (92.8%) is lower than the ISSR (98.43%). In the present investigation the average number of fragments amplified by RAPD and ISSR primers were 6.55 and 6.85 respectively. Such a high variation in the number of fragments produced by these arbitrary primers may be attributed to the differences in the binding sites throughout genome of the isolates included. PIC values for RAPD primer was higher (0.7990) than the ISSR (0.7445). Assay efficiency index (AEI), effective multiplex ratio (EMR), multiplex ratio and percentage polymorphism was higher in the ISSR than RAPD but marker index (MI) and PIC were higher in RAPD. Both the markers RAPD and ISSR used in the present study were found effective to evaluate genetic diversity among different isolates and monosporidial lines of *T.indica* but polymorphism was higher in ISSR, thus indicating the effectiveness of ISSR primers for estimating genetic diversity of *Tilletia indica*. Viewing variability for pathogeneicity even within recombinants derived from a single teliospore and identifying their compatible monosporidial lines with their mating behaviour from north west India would be helpful for effective screening. The study based on pathogenicity and molecular markers confirms the existence of great diversity in the pathogen, also shifting of 'hot spot' areas from one place to another within Karnal bunt prevailing areas. In addition to contributing to the understanding of the diseases caused by this pathogen and improving crop productivity, these results will be useful for developing integrated strategies for disease management and breeding programs.

Pathogenic variation among *Fusarium* spp. isolates causing head scab of wheat

For studying the pathogenic variability in head scab pathogen of wheat, ten wheat varieties viz. TL 2942, PDW 233, VL 892, DBW 17, DBW 14, PDW 291, PBW 550, HD 2967, HPW 251 and DBW 50 sown in poly house in hills were inoculated in March, 2012 at anthesis with nine *F. graminearum* isolates by placing a tiny tuft of cotton soaked with the inoculum in a floret of the middle spikelet in the evening. All *F. graminearum* isolates were from Wellington. Proper temperature and humidity were maintained in the poly house for disease development for 30 days after inoculation. Per cent spike and spikelet infection was calculated. Disease data on per cent spike infection recorded after 21 days is given in Table 2.5. Significant variation in per cent spike and spikelet infection on different wheat varieties with different *F. graminearum* isolates was observed after 21 days of inoculation.

Table 2.5. Pathogenic variation among *F. graminearum* isolates on a set of wheat varieties

F. graminearum isolates	% Spike infection on wheat varieties after 21 days of inoculation									
	TL 2942	PDW 233	VL 892	DBW 17	DBW 14	PDW 291	PBW 550	HD 2967	HPW 251	DBW 50
Fg-W11-9	77.77	68.75	100.00	81.25	75.00	85.00	77.50	77.85	75.00	66.25
Fg-W11-33	72.77	83.33	88.30	66.66	76.18	82.85	75.00	70.00	67.85	78.56
Fg-W11-50	62.5	67.77	95.83	80.00	79.16	80.00	90.00	77.50	66.25	74.99
Fg-W11-56	69.44	66.66	95.83	75.00	85.00	90.00	85.00	93.75	68.75	77.50
Fg-W11-59	87.50	68.33	89.16	75.71	80.00	93.75	85.00	87.50	70.71	83.33
Fg-W11-63	81.25	79.16	85.71	80.71	87.50	82.85	100.0	83.33	75.00	72.50
Fg-W11-65	75.00	77.77	100.00	73.33	77.77	91.66	76.66	72.50	71.66	75.00
Fg-W11-69	74.10	83.33	100.00	87.50	83.33	77.77	90.00	81.25	64.16	66.47
Fg-W11-71	75.71	50.00	100.00	90.00	80.00	71.42	NG	81.25	66.66	64.58
Fg-W11-73	62.50	72.91	95.83	67.50	79.16	80.00	100	70.00	75.00	74.59

Fg-*Fusarium graminearum*; W-Wellington

3 RESOURCE MANAGEMENT

Resource conservation agricultural practices for the sustainability of rice-wheat system

Tillage in rice-wheat system

The effects of the three tillage options in rice i.e. (1) Field preparation by rotary tiller followed by ponding and transplanting (Dry rotary), (2) Puddling with rotary tiller followed by transplanting (Wet rotary), and (3) Transplanting under zero tillage (Zero tillage) and three tillage options in wheat, namely (1) Zero tillage, (2) Conventional, (3) Rotary tillage were evaluated in rice-wheat system. The rice (cv. HKR 47) crop was affected mainly by the tillage options in rice, whereas the tillage in wheat had no effect. The yield attributes except thousand grain weight were adversely affected leading to lower rice yield in zero tillage transplanting whereas similar yield was recorded in dry rotary and wet rotary indicating that puddling (Wet tillage) may not be required and dry field preparation followed by ponding of water and transplanting may be a better option to avoid the destruction of soil structure by wet tillage for puddling (Fig. 3.1).

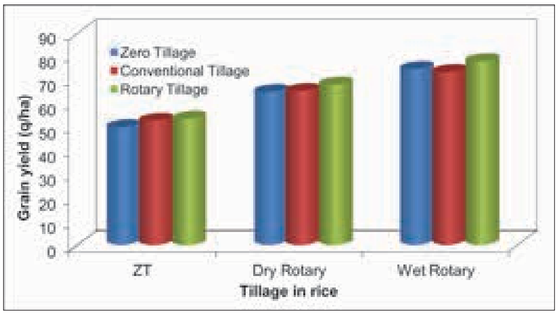


Fig. 3.1. Rice yield under various tillage options

The wheat crop was not affected by tillage in rice but tillage in wheat had some differences in wheat yield recorded under different tillage options. In wheat, the highest yield was recorded in rotary tillage followed by almost similar yield in zero and conventional tillage (Fig. 3.2).

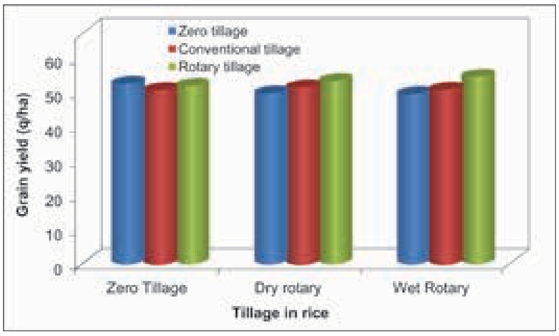


Fig. 3.2. Wheat yield under various tillage options

Effect of residue management on wheat and rice productivity

The differences in yield due to nitrogen were significant but the effect of residue management options was not significant. The yield in residue incorporation treatments was marginally lower than residue removal, retention and residue burning treatments (Fig. 3.3). Among nitrogen levels, the highest yield was recorded with 200 kg N/ha. The mean yield under incorporation treatments was lower compared to removal, burning and retention treatments. The yield of direct seeded rice variety PUSA 1460 was lower than the puddled transplanted by more than 30% under various residue management options.

The soil organic carbon percentage increased with residue retention and incorporation treatments whereas burning of crop residue resulted in decreased soil organic carbon status of the soil.

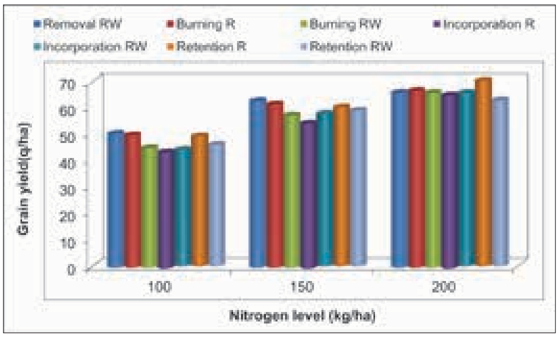


Fig. 3.3. Residue and nitrogen effects on wheat productivity

Residue and irrigation effects on wheat productivity

The effect of residue load from 0 to 6 t/ha was evaluated under different irrigation schedules (2 to 6 irrigations) based on critical growth stages. It was observed that surface residue retention had favourable effect on wheat productivity. The wheat yields recorded in residue free treatment was lower compared to the ones where crop residue was retained on the soil surface (Fig. 3.4). The results showed that 1 to 2 irrigation can be saved by surface residue retention without any deterimental effect on productivity. The water expense efficiency in wheat decreased with increasing irrigation frequency but increased with increasing levels of surface reatined crop residues.

The beneficial effect of conservation agriculture practices on soil microbes, their activities and root architect was observed which may in turn help the Rice-Wheat cropping system to sustain effectively over long period without deteriorating soil health.

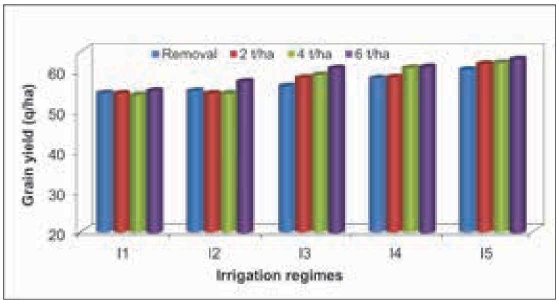


Fig. 3.4. Residue load and irrigation in wheat productivity

Need based nitrogen application using LCC and NDVI sensor

An experiment was conducted to optimise nitrogen application using leaf colour chart (LCC) and NDVI sensor. The agronomic efficiency of applied nitrogen 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).

Micro-irrigation to mitigate the terminal heat

An experiment was conducted under different irrigation practices i.e. conventional, drip irrigation, sprinkler/rainport and a combination of drip and rainport. The water was sprinkled using rainport for about 15 minutes in the afternoon to cool the canopy, whenever the maximum air temperature crossed 30 ^{0}C. It was found that there were yield gains of about 5% when the wheat canopy was cooled by sprinkling water on the day when the ambient temperature was more than 30 ^{0}C. Even drip irrigation also gave slightly higher yield compared to conventional irrigation practice (Fig. 3.5). The results indicate that micro-irrigation can help mitigate the terminal heat leading to higher

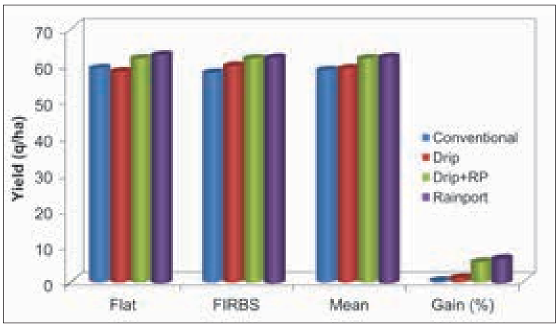


Fig. 3.5. Effect of micro-irrigation on wheat

wheat productivity coupled with more efficient use of scarce water resources.

Effect of P application on rice-wheat productivity

An experiment was conducted with skipping of P application either in rice or wheat or both crops under rice-vegetable pea-wheat, rice-wheat-green gram and rice-wheat-cowpea system. The idea behind this experiment was to skip P application due to shortage of P containing fertilizers during wheat sowing or rice transplanting season. It was observed that skipping of P application in rice or wheat or in both the crops at alternate year produced similar

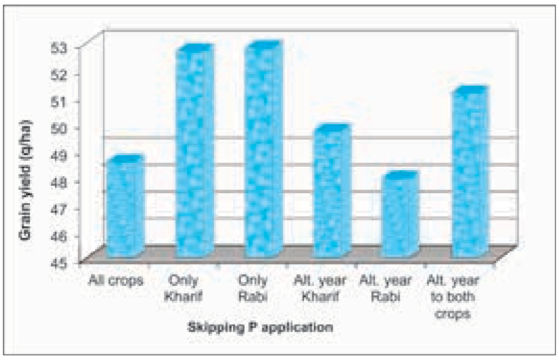


Fig. 3.6. Effect of skipping P application on rice yield

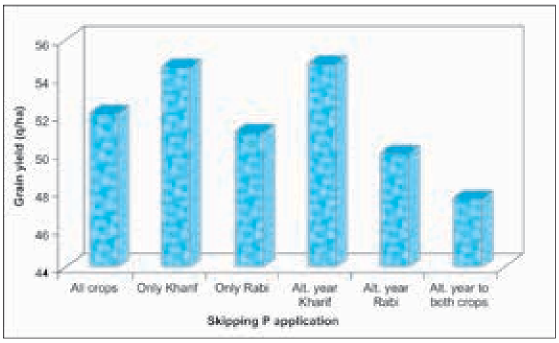


Fig. 3.7. Effect of skipping P application on wheat yield

rice and wheat yield. This shows that continuous applications of P containing fertilizers in all crops can be skipped particularly when 300 % cropping intensity is maintained with inclusion of legume crops (Fig 3.6 and 3.7).

Yield maximisation in wheat

An experiment was conducted with the use of organic and inorganic fertilsers for maximising wheat yield. Two varieties namely DBW 17 and DPW 621-50 were used. Response was observed with increased doses of NPK (125 and 150 %). Increasing the dose of NPK up to 150 % decreased the effect of FYM. This shows that there is scope for increasing the wheat yield if 150% NPK is added or 10 t/ha FYM is applied in combination with recommended fertiliser (Fig 3.8).

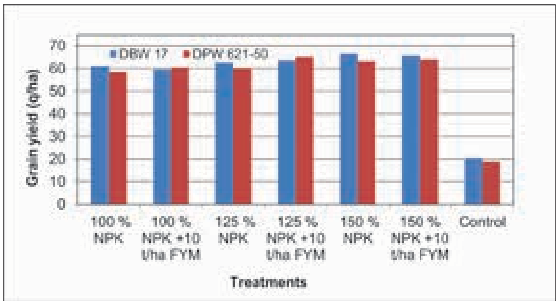


Fig. 3.8. Effect of organic and inorganic fertilizer on wheat yield

Rice straw incorporation

An experiment was started with rice straw removal, incorporation and green manuring in rice-wheat cropping system. Results revealed that wheat productivity decreased significantly when rice straw was incorporated. This showed that rice straw incorporation enhances the immobilsation of available soil nitrogen present in the field (Fig 3.9).

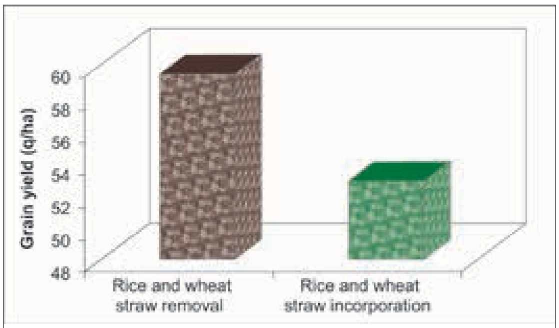


Fig. 3.9. Effect of rice straw management on wheat yield

Intercropping of oilseed with wheat

Earlier intercropping of mustard with wheat was a regular practice. But due to popularisation of combine harvesting its area has decreased. Presently there are many small and marginal farmers, particularly in north eastern plain zone, who perform wheat seeding manually can also sow canola or mustard in 6:1 ratio. This intercropping option produces additional mustard or canola yield without loosing wheat yield. Equivalent wheat yield was maximum in case of 6:1 wheat: canola/mustard intercrop. Higher equivalent wheat yield in intercrop was due to effect of border row. Thus, it confirms that canola or mustard can not replace wheat crop but may be more productive in intercropping situations (Fig. 3.10).

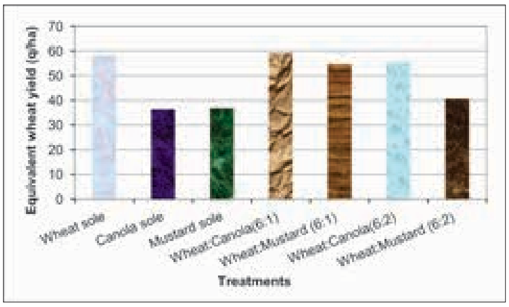


Fig. 3.10. Equivalent wheat yield

Enhancing sustainability and profitability of organic rice-wheat cropping systems

Experiment consisting of four combinations of organic nutrient supply [control, vermicompost 5 t/ha, farm yard manure (FYM) 15 t/ha+ vermicompost 2.5 t/ha and FYM 30 t/ha] and four cropping systems (rice-wheat, rice-wheat-dhaincha, rice-wheat-cowpea and rice-wheat-moong) making thus total 16 combinations and one inorganic control (recommended NPK i.e. 120:60:40 kg/ha) was conducted in Randomized Block Design with three replications. Wheat variety C 306 was grown.

The results presented in Table 3.1 revealed that application of Vermicompost 5 t/ha, farm yard manure (FYM) 15 t/ha+ Vermicompost 2.5 t/ha or FYM 30 t/ha increased the biomass and grain yield significantly as compared to control (no organic or chemical fertilizer) treatment. However, the highest grain yield was recorded in inorganic control treatment and was found significantly better than other treatments except 30 t/ha FYM in rice-wheat-moong treatment, which was at par.

Table 3.1. Effect of organics on crop productivity of wheat

Treatment	Biomass (q/ha)	Grain yield (q/ha)
Rice-Wheat control (no organic or chemical fertilizer)	42.06	20.54
Rice-Wheat with vermicompost 5.0 t/ha	82.54	30.77
Rice-Wheat with FYM 15.0 t/ha+ vermicompost 2.5 t/ha	53.17	23.34
Rice-Wheat with FYM 30.0 t/ha	82.54	32.22
Rice-Wheat-Dhaincha control (no organic or chemical fertilizer)	50.40	22.61
Rice-Wheat-Dhaincha with vermicompost 5.0 t/ha	74.60	28.02
Rice-Wheat-Dhaincha with FYM 15.0 t/ha+ vermicompost 2.5 t/ha	61.11	22.39
Rice-Wheat-Dhaincha with FYM 30.0 t/ha	84.52	32.46
Rice-Wheat-Cowpea control (no organic or chemical fertilizer)	63.10	21.69
Rice-Wheat-Cowpea with vermicompost 5.0 t/ha	107.54	33.74
Rice-Wheat-Cowpea with FYM 15.0 t/ha+ vermicompost 2.5 t/ha	87.30	29.53
Rice-Wheat-Cowpea with FYM 30.0 t/ha	101.59	31.31
Rice-Wheat-Moong control (no organic or chemical fertilizer)	65.08	24.18
Rice-Wheat-Moong with vermicompost 5.0 t/ha	106.35	33.87
Rice-Wheat-Moong with FYM 15.0 t/ha+ vermicompost 2.5 t/ha	90.87	29.34
Rice-Wheat-Moong with FYM 30.0 t/ha	115.87	35.67
Inorganic control (rec. chemical fertilizers NPK 120:60:40)	123.81	39.71
CD (0.05)	12.70	4.69

Integrated nutrient management in rice-wheat system

An experiment consisting of 19 combinations [Recommended NPK (T1), T1+FYM 15t/ha, T1+S, T1+Zn, T1+Mn, T1+Cu, T1+Fe, T1+B, T1+S+Zn+Mn+Cu+Fe+B (T9), Farmer's practice (one bag of DAP at sowing and two bags of urea as top dressing per acre), Rec. N only, Rec. P only, Rec. K only, Rec. NP, Rec. NK, Rec. PK, T1+ GM, T9+FYM 15t/ha and absolute control] of major and micro nutrients as well as FYM and green manuring was conducted in Randomized Block Design with three replications. Wheat variety PBW 502 was grown. Micro nutrients were applied as foliar spray twice at 35 and 55 days after sowing. The results presented in Table 3.2 revealed that biomass and grain yield were significantly lower where only P, K or PK were applied as compared to all other treatments indicating the significance of nitrogen (Table 3.2).

Table 3.2. Integrated nutrient management in wheat

Treatment	Biomass (q/ha)	Grain yield (q/ha)
Rec. NPK (T1)	182.54	66.36
T1+FYM 15t/ha	182.14	68.29
T1+S	177.78	66.16
T1+Zn	173.02	65.53
T1+Mn	174.60	64.25
T1+Cu	170.24	63.48
T1+Fe	18.5.71	67.34
T1+B	177.78	66.02
T1+ S+ Zn+ Mn+ Cu+ Fe+ B (T9)	178.57	66.42
Farmer's practice	182.94	66.94
Rec.N only	173.81	64.00
Rec. P only	48.41	18.07
Rec. K only	45.63	16.80
Rec. NP	176.19	65.67
Rec. NK	167.46	65.06
Rec. PK	46.83	20.78
T1+ GM	175.79	68.19
T9+FYM 15t/ha	181.35	68.37
Absolute control (no Fert)	47.62	17.45
CD (0.05)	7.37	3.13

The highest grain yield (68.37 q/ha) was recorded in treatment where all the major nutrients and micro with FYM 15 t/ha (T18) were applied followed by the treatment in which all the major nutrients as well as FYM 15 t/ha (68.29 q/ha) were applied (T2). These treatments being at par to each other were significantly higher than farmer's practice. The lowest and significantly lower biomass and grain yield were recorded in treatments where no nitrogen was applied i.e. treatments in which only P, K, PK or no NPK (absolute control) were applied showing the importance of this nutrient and its wide spread deficiency.

Improving nitrogen use efficiency with different scheduling in wheat

An experiment of nitrogen scheduling comprising 13 treatments was conducted in RBD with three replications. Wheat variety DBW17 was grown.

Table 3.3. Effect of Nitrogen scheduling on wheat

Treatment	Biomass (q/ha)	Grain yield (q/ha)
90 kg N/ha in 3 equal splits (1/3b,1/3T,1/3J) after irrigation	108.33	46.36
90 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) after irrig.	84.92	36.52
90 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) before irrigation	114.68	48.05
90 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) before irrig.	107.54	44.77
120 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) after irrigation	114.68	45.85
120 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) after irrigation	104.76	42.18
120 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) before irrigation	124.21	52.79
120 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) before irrigation	125.79	50.17
150 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) after irrigation	126.59	53.46
150 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) after irrigation	122.22	50.76
150 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) before irrigation	142.06	60.94
150 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) before irrigation	136.51	58.81
Control (no nitrogen)	45.24	21.38
CD (0.05)	4.90	2.61

B= Basal, T= Tillering, J= Jointing

The results presented in Table 3.3 revealed that significantly higher yield was obtained where nitrogen was applied in three equal splits (1/3b, 1/3T, 1/3J) compared to treatment where nitrogen was applied in four equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf). Moreover significantly higher biomass and grain yield were recorded in treatments where nitrogen was applied just before irrigation as compared to treatments where nitrogen was applied after irrigation at all the three nitrogen levels.

Improving nitrogen use efficiency with natural nitrification inhibitors in rice-wheat

This experiment comprising 19 treatments (Table 3.4) was conducted with the objective to find out most suitable natural occurring nitrification inhibitor for coating of urea for improving nitrogen use efficiency applied to wheat and rice crops. Wheat variety DBW17 was grown. The results showed that the

Table 3.4. Improving nitrogen use efficiency with natural nitrification inhibitors in wheat

Treatment	Biomass (q/ha)	Grain yield (q/ha)
Karanj oil coated urea at 120 kg N/ha	132.94	62.15
Karanj oil coated urea at 150 kg N/ha	140.87	65.45
Lemon grass oil coated urea at 120 kg N/ha	133.33	62.60
Lemon grass oil coated urea at 150 kg N/ha	145.63	71.14
Palmarosa oil coated urea at 120 kg N/ha	136.51	61.12
Palmarosa oil coated urea at 150 kg N/ha	138.10	64.42
Meliacin coated urea at 120 kg N/ha	131.35	61.50
Meliacin coated urea at 150 kg N/ha	133.33	61.41
Citronella oil coated urea at 120 kg N/ha	135.71	61.49
Citronella oil coated urea at 150 kg N/ha	140.08	64.62
Cotton seed oil coated urea at 120 kg N/ha	124.21	59.25
Cotton seed oil coated urea at 150 kg N/ha	130.56	63.76
Neem oil coated urea at 120 kg N/ha	130.56	61.50
Neem oil coated urea at 150 kg N/ha	136.11	66.21
DCD coated urea at 120 kg N/ha	138.10	61.78
DCD coated urea at 150 kg N/ha	142.46	66.53
Prilled urea at 120 kg N/ha (Control)	134.52	62.44
Prilled urea at 150 kg N/ha (Control)	142.06	66.20
No nitrogen (Absolute Control)	48.02	20.86
CD (0.05)	7.46	3.77

applications of 1000 ppm Karanj oil, Palmarosa oil and Citronella oil coated urea at 120 kg N/ ha gave statistically at par yield to that obtained with 150 kg N/ha indicating a saving of 30 kg N/ha i.e. 20% saving in fertilizer cost and higher nitrogen use efficiency.

Weed management in wheat

Weed infestation is one of the major biotic factors limiting wheat production and productivity. The average losses caused by weeds if not controlled are about 25 to 30% but in some cases depending on weed flora, weed intensity, time of emergence, soil and environmental factors the losses can be up to complete crop failure. For controlling weeds in wheat, herbicides are preferred due to cost and time effectiveness. Field experiments were conducted for evaluation of herbicides and herbicide mixtures against weeds in wheat and the results of which are as follows.

Early post emergence evaluation of pyroxasulfone

Pyroxasulfone alone and in combination with metsulfuron, triasulfuron and pyroxsulam was evaluated for control of broad spectrum weed flora in wheat. The major weeds infesting the experimental field were *P. minor*, *Avena ludoviciana*, *Rumex dentatus*, *Medicago denticulata*, *Melilotus alba, Coronopus didymus* and *Anagallis arvensis*. The herbicide treatments were applied one day before first irrigation. The herbicide were sprayed using knap sack sprayer. The dry weight of *P. minor, Avena ludoviciana*, *Rumex dentatus and Medicago denticulata* in untreated control was 514.8, 76.1, 8.5 and 0.1 g/m^2, respectively (Table 3.5).

Table 3.5. Performance of early post-emergence application of pyroxasulfone in wheat 2011-12

Herbicide	Dose/ha (g a.i.)	Weed dry weight (g/m^2)							Grain yield (q/ha)
		Phalaris minor	*Avena ludoviciana*	*Rumax dentatus*	*Medicago denticulata*	*Melilotus alba*	Others weed	Total weed	
Pyroxasulfone	21.25	10.25(110.2)*	5.43(30.8)	5.88(36.4)	3.13(13.7)	2.55(6.4)	1.35(0.9)	11.84(141.8)	41.05
Pyroxasulfone	42.5	5.73(33.4)	3.68(16.7)	4.21(20.6)	3.34(12.4)	2.32(5.3)	1.74(2.1)	7.06(52.1)	44.01
Pyroxasulfone	63.75	3.73(13.3)	3.41(11.3)	3.81(14.4)	2.45(5.8)	2.03(4.4)	1.57(1.6)	5.21(26.2)	47.60
Pyroxasulfone + Metsulfuron	21.25 + 4	11.15(131.0)	4.61(24.3)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.0(0.0)	12.07(155.4)	43.79
Pyroxasulfone + Metsulfuron	42.5 + 4	3.53(11.8)	3.21(17.9)	1.05(0.1)	1.03(0.1)	1.0(0.0)	1.16(0.4)	4.97(30.1)	46.75
Pyroxasulfone + Metsulfuron	63.75 + 4	2.82(7.0)	2.83(13.7)	1.04(0.1)	1.07(0.1)	1.0(0.0)	1.0(0.0)	4.16(20.7)	51.55
Pyroxasulfone + Triasulfuron	63.75 + 20	1.69(1.9)	2.42(5.9)	1.07(0.2)	1.0(0.0)	1.0(0.0)	1.07(0.2)	2.91(7.9)	51.08
Pyroxasulfone + Pyroxsulam	63.75 + 18	3.36(10.6)	1.0(0.0)	1.0(0.0)	1.03(0.1)	1.0(0.0)	1.10(0.2)	3.39(10.8)	48.98
Atlantis (Mesosulfuron + iodosulfuron)	14.4 (12+2.4)	4.46(18.9)	1.08(0.2)	1.0(0.0)	1.0(0.0)	1.0(0.0)	1.09(0.2)	4.50(19.2)	51.42
Total (Sulfosulfuron + metsulfuron)	32 (30+2)	3.75(13.1)	1.14(0.4)	1.04(0.1)	1.07(0.2)	1.0(0.0)	1.04(0.1)	3.81(13.5)	50.83
Weedy Check	-	22.68(514.8)	8.70(76.1)	2.97(8.5)	1.06(0.1)	1.0(0.0)	1.05(0.1)	24.30(591.0)	28.89
LSD (P=0.05)	-	2.64	3.26	1.86	1.64	1.02	*0.33*	3.31	4.49

*Original values in parenthesis and are square root transformed $\sqrt{(x+1)}$ for statistical analysis

Under untreated weedy control, *P. minor*, being the most dominant weed had the significantly highest dry weight accumulation (514.8 g/m^2) comprising of 75.3-87.1% of the total weed dry weight (591.0 g/m^2). Wild oat was second dominant weed. Pyroxasulfone alone and in combination with metsulfuron, triasulfuron and pyroxsulam, drastically reduced the dry weight of grassy (*P. minor* and wild oat) and broad leaved weeds. Pyroxasulfone alone was less effective against broad leaved weeds. However, pyroxasulfone at 63.75 g a.i./ha in combination with metsulfuron 4 g/ha, triasulfuron 20 g/ha and pyroxsulam 18 g/ha and Atlantis (mesosulfuron + iodosulfuron) 14.4 g a.i./ha and Total (sulfosulfuron + metsulfuron) 32(30 + 2) g a.i./ha were effective against complex weed flora. The total weed dry weight in these combinations was statistical similar.

Keeping in view the poor efficacy of pyroxasulfone against broad-leaved weeds, it will require a strong effective partner against broad-leaved weeds and will be better if the partner is from different group and is also effective against grassy weeds (like pyroxsulam). This strategy will help in delaying the evolution of herbicide resistance in weeds as well as managing the existing resistance problem along with providing the sustainability of wheat production.

Perusal of the data presented in Table 3.5 indicates that the uncontrolled weed competition throughout the season resulted in the lowest grain yield (28.89 q/ha). Pyroxasulfone at 63.75 g a.i./ha applied in combination with metsulfuron, carfentrazone, triasulfuron and pyroxsulam provided better yield compared to alone application of pyroxasulfone but was statistically similar to Atlantis and Total. The better yield under these treatments was due to broad-spectrum weed control. The various herbicide treatments significantly affected the tillering and crop biomass which ultimately affected the grain yield.

Performance of topramezone in combination with grass herbicides for the control of complex weed flora in wheat

Topramezone alone and in combination with safener and grass herbicide was evaluated against weeds in wheat as post emergence application. The major weed flora infesting the experimental plots comprised of *P. minor, Avena ludoviciana, Rumex dentatus and Medicago denticulata.* Among these weeds, *P. minor* was the most dominant grass weed. The various weed control treatments had significant effect on the dry weight of weeds (Table 3.6). The dry weight of *P. minor, Avena ludoviciana*, *Rumex dentatus and Medicago denticulata* in untreated control was 523.9, 146.7, 4.1 and 7.1 g/m^2, respectively (Table 3.6). Under untreated weedy control, *P. minor*, being the most dominant weed had the significantly highest dry weight accumulation comprising of about 76.7% of the total weed dry weight (682.7 g/m^2).

Topramezone applied alone was less effective compared to its application with clodinafop and pinoxaden. These combinations had the lowest weed dry weight. Topramezone applied without safener was phytotoxic to wheat crop (Fig. 3.11) and safety was significantly improved with addition of safener (cloquintocet).

Yield recorded in tank mix combination of topramezone with clodinafop and pinoxaden was significantly better compared to alone application of topramezone due to effectiveness in controlling complex weed flora (Table 3.6). The weed competition throughout the season

With safener

Without safener

Fig. 3.11. Effect of topramezone with and without safener on wheat

resulted in the lowest grain yield (28.04 q/ha). The presence of the weeds through out the crop season reduced the grain yield by 57.4% in comparison to best yielding treatment. The various herbicide treatments affected the grain weight and untreated weedy check had the lowest grain weight. Topramezone application without surfactant had high level of phytotoxicity and addition of safener or grass herbicide clodinafop or pinoxaden drastically reduced the crop phytotoxicity (Table 3.6).

Table 3.6. Performance of topramezone alone and in combination against weeds in wheat

Herbicide	Dose/ ha (g a.i.)	Weed dry weight (g/m2)						Grain yield (q/ha)	Phytotoxicity %
		Phalaris minor	*Avena ludoviciana*	*Rumax dentatus*	*Medicago denticulata*	Other weeds	Total weeds		
Untreated Weedy check	-	22.73(523.9)*	11.65(146.7)	2.11(4.1)	2.75(7.1)	1.37(0.9)	25.82(682.7)	28.04	0.0
Topramezone	24	15.39(241.9)	8.37(74.2)	1.93(4.1)	1.0(0.0)	1.0(0.0)	17.63(320.2)	48.36	7.5
Topramezone	48	13.53(186.6)	5.77(35.2)	1.99(3.2)	1.0(0.0)	1.03(0.1)	14.82(225.1)	49.69	33.3
Topramezone + Safener	24 + 8.4	12.75(164.4)	8.21(67.7)	1.50(1.5)	1.0(0.0)	1.0(0.0)	15.23(233.6)	50.74	2.0
Topramezone + Safener	30 + 8.4	9.83(97.6)	7.34(54.9)	1.52(1.3)	1.0(0.0)	1.04(0.1)	12.40(153.9)	52.53	1.3
Topramezone + Safener	36 + 8.4	7.52(56.4)	6.23(44.0)	1.58(1.7)	1.0(0.0)	1.0(0.0)	10.13(102.1)	54.72	1.2
Topramezone + Safener	48 + 8.4	6.80(45.8)	5.57(37.7)	1.04(0.1)	1.0(0.0)	1.0(0.0)	8.90(83.5)	57.40	2.2
Topramezone + Clodinafop	24 + 45	1.23(0.6)	1.0(0.0)	2.82(8.0)	1.04(0.1)	1.02(0.1)	2.92(8.7)	65.31	0.0
Topramezone + Clodinafop	30 + 30	1.37(1.0)	1.05(0.1)	1.43(1.2)	1.05(0.1)	1.07(0.1)	1.83(2.6)	64.76	0.0
Topramezone + Pinoxaden	24 + 32.5	1.14(0.3)	1.02(0.1)	3.33(12.9)	1.05(0.1)	1.24(0.6)	3.56(14.0)	63.60	0.0
Topramezone + Pinoxaden	30+ 25	1.50(1.4)	1.10(0.2)	3.48(12.2)	1.0(0.0)	1.07(0.1)	3.70(14.0)	64.23	0.3
Topramezone + Clodinafop	48 + 45	1.17(0.4)	1.08(0.2)	2.90(8.2)	1.0(0.0)	1.24(0.6)	3.10(9.3)	65.75	0.5
Topramezone + Pinoxaden	48 + 32.5	1.42(1.1)	1.0(0.0)	2.43(5.6)	1.0(0.0)	1.04(0.1)	2.65(6.8)	64.25	2.7
Topramezone	72	13.07(170.4)	5.52(34.5)	2.28(5.4)	1.0(0.0)	1.02(0.1)	14.49(210.3)	50.02	35.0
Clodinofop 60	60	1.53(1.9)	1.0(0.0)	5.35(28.0)	9.18(90.9)	1.77(2.6)	10.84(123.5	58.26	0.0
Pinoxaden 50 g/ha	50	1.48(1.7)	1.0(0.0)	6.21(37.6)	8.51(81.2)	1.24(0.6)	10.76(121.1)	57.35	0.0
LSD (0.05)		2.38	3.38	1.56	2.12	NS	4.12	4.87	

*Original values in parenthesis and are square root transformed $\sqrt{(x+1)}$ for statistical analysis

Water management in wheat crop for higher water use efficiency

Experiments were conducted to improve the water use efficiency of wheat crop with irrigation scheduling, residue management, identifying suitable wheat genotypes under restricted irrigation, and seed priming.

Irrigation scheduling at different SMP for higher water use efficiency in wheat crop

An experiment was conducted to study the water use efficiency of wheat crop at different soil matric potentials under residue retaining at surface and residue free conditions. This experiment consisting of 3 main plot treatments (no residue, residue retaining @ 5 t/ha and residue retaining @ 10 t/ha) and 4 sub plot treatments (60, 68, 75 & 82 kPa) was conducted in split plot design. Wheat cultivar DBW 17 was grown. The results revealed that irrigation scheduling at above mentioned soil matric potential produced yield with statistically non-significant difference. However, numerically maximum yield was recorded with irrigations at 60 kPa (52.45 q/ha). While, amongst the main plot treatments, the highest yield was recorded from treatment of residue retaining @ 5 t/ha (52.52 q/ha) followed by control i.e. non residue treatment (51.56 q/ha) and residue retaining @ 10 t/ha (50.87 q/ha) during first year of the experimentation.

Effect of seed priming in crop establishment under water stress conditions

This experiment consisting of 3 main plot treatments (seeding at optimum moisture level, seeding at sub optimal moisture and seeding in dry soil followed by irrigation) and 3 sub plot treatments (no seed priming, seed priming with plain water and sprouted seed) was conducted in split plot design. Wheat variety DBW 17 was grown. Results showed that the seed priming by water (59.67 q/ha) and sprouted seeds (61.68 q/ha) produced significantly higher grain yield as compared to no seed priming (56.08 q/ha), while seeding method was found statistically non-significant. However, seeding in dry soil followed by irrigation recorded higher grain yield (60.08 q/ha) followed by seeding at optimum soil moisture level (58.87 q/ha) and seeding in air dry soil i.e. sub optimum soil moisture level (58.47 q/ha). Priming is one of the seed enhancement method that might resulted in increasing seed germination and emergence under stress conditions consequently proper crop establishment. Seed priming can help in improving the germination, growth and vigour of seedling under moisture deficit conditions. The results of experiment showed that priming with plain water and sprouted seeds by plain water priming improve germination indices, seedling growth and crop establishment.

Evaluation of wheat genotypes under restricted irrigation for higher water use efficiency

The results of this experiment revealed that the yield of wheat genotypes was influenced by restricted irrigations. In this experiment, two irrigations were applied in whole crop season at the stages of crown root initiation and boot leaf stage. The genotype NI 5439 produced the highest grain yield for consecutive two year of experimentation. This genotypes was significantly superior to twelve genotypes (DBW 14, K 9107, WH 1021, PBW 343, HD 2733, GW 322, PBW 373, HUW 234, DBW 16, DBW 17 and UP 2425), while numerically superior to the WH 147 and Raj 3765. The highest yield of NI5439 genotype might be due to higher number of effective tillers and 1000 grains weight.

4 QUALITY AND BASIC SCIENCES

The wheat production in India was estimated at be 94.88 mt during the year 2011-12. This could be made possible by developing high yielding, disease resistant wheat varieties and also matching production technologies. 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. During 2011-12, 9902 AICW & BIP wheat grain samples belonging to AVTs, NIVTs, IVTs, Special Trials, QCSN and FCI were analysed.

Identification of product specific varieties

All the 2nd year AVT entries including checks were subjected to baking evaluation for chapati, bread, biscuit and pasta products apart from analyzing them and also all the 1st year AVT entries for physico- chemical properties (grain appearance, test weight, protein, sedimentation value, moisture, phenol test, extraction rate, grain hardness index, wet/dry gluten and gluten index), HMWGS and grain nutrition (protein, yellow pigment, iron, zinc, copper and manganese).

Product specific genotypes were identified from AVT trials (Table 4.1). For the evaluation of chapati, several parameters like water absorption, dough nature & colour (before and after maturation), chapati appearance and its colour, aroma, pliability, taste, puffing height and loss of water (just after baking and after 4 hours of baking) were considered. Only those genotypes were selected for chapati, which scored >8.0 score out of 10. For bread quality evaluation, parameters like loaf volume, stickiness, appearance, crust colour, crumb colour, texture, taste and aroma were considered. Genotypes with > 575 ml loaf volumes were selected for bread. The spread factor was calculated by dividing the diameter of the biscuit with its thickness. The highest spread factor of about 10.0 was exhibited by HS 490 (RILS, NHZ). This variety also showed lower SKCS grain hardness index of 25 indicating its higher potential towards biscuit making. For the evaluation of pasta products (macaroni), various cooking quality parameters like cooking time, water absorption, water uptake ratio, gruel solid loss and stickiness were considered. Apart from these, sensory evaluation was carried out where parameters like colour, texture, flavour and overall acceptability using a '9' point Hedonic scales were considered. Only those genotypes were selected which scored >7.0 point on the hedonic scale and after considering cooking and other quality parameters.

Table 4.1. Promising genotypes identified for wheat products

Products	Genotypes
Chapati (>8.0/10)	PBW 175, C 306, HI 1563, K 8027, HD 2888, HI 1500, NIAW 1415, Raj 4238, MP 3336
Bread (> 575ml loaf volume)	NW 2036, NIAW 34, Raj 4083, HD 2932, NI 5439, NIAW 1415, WH 1097, K 0906
Biscuit (>11 spread factor)	HS 490
Pasta (>7.5/9)	PDW 314, HI 8627, HI 8713, WHD 948

Three species of wheat namely, *T. aestivum*, *T. durum* and *T. dicoccum* are cultivated in the country. Bread wheat is contributing approximately 95 % while around 4% comes from durum wheat and just about 1% is the share of *dicoccum* wheat to the total wheat production. 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. For chapati, we need hard wheat, medium to high protein and medium & extensible gluten. For pasta products, hard wheat (*T. durum*) with strong gluten, high protein, low yellow berry incidence and high β-carotene content are required.

Promising genotypes for various quality parameters were also identified. For *T. aestivum*, parameters included were protein, wet gluten, dry gluten, gluten index, hardness index, sedimentation value, glu-1 score, extraction rate, yellow pigment, iron, copper and manganese. Likewise, *T. durum* genotypes were selected for various quality parameters and micronutrients (Table 4.2).

Table 4.2. Promising genotypes for various quality parameters

Parameter	Value	Genotypes
		T. aestivum
Protein	~14.5%	HD 3081, PBW 665, MACS 6222, NIAW 1773, HP 1939, HD 2932, HD 3096, UP 2825, NI 5439, NIAW 1415, DBW 93
Wet gluten	>35.0%	MACS 6222, NIAW 34, Raj 4083, HD 2932, NI 5439, NIAW 1415
Dry gluten	>12.0%	MACS 6222, NIAW 34, HD 2932, NI 5439, NIAW 1415
Gluten index	>70	WH 1105, HS 526, HPW 349, DBW 74, NW 2036, Raj 4083, NI 5439
Sedimentation value	~60 ml	HS 526, HPW 376, HS 560, HD 3080, HD 3059, PBW 658, HD 3098, NIAW 1849, HI 1579, NI 5439
Extraction rate	>72.0%	C 306, HI 1579, MACS 6222, NIAW 34, Raj 4083, NI 5439,NIAW 1415
Grain hardness index	~85	HS 536, HD 3070, C 306, Raj 4083, NIAW 1415, DBW 93, COW (W) 1, HW 5224
Yellow pigment	>4.00 ppm	VL 804, PBW 343, DBW 17, NW 2036
Iron	>40.0 ppm	WH 1097, PBW 175, C 306, HI 1500, NIAW 34, NIAW 1415
Zinc	>35.0 ppm	WH 1097, K 0906, DBW 39, C 306, K 8027, HD 2888, Raj 4238, MP 3336, HI 1500, NIAW 34, Raj 4083, NI 5439
Copper	~6.0 ppm	K 0906, DBW 14, NW 2036, HI 1563, C 306, K 8027, HD 2888, NI 5439, NIAW 1415
Manganese	~40.0 ppm	HS 490, DBW 39, K 8027, NIAW 1415
		T. durum
Protein	~14.5%	MPO 1255, AKDW 2997-16, GW 1280
Sedimentation value	>35 ml	A-9-30-1, UAS 442
Grain hardness index	>85	HI 8498, UAS 442, GW 1280
Yellow pigment	~6.5 ppm	HI 8713, MP 1255, HI 8627
Iron	~40.0 ppm	A-9-30-1, HI 8627, UAS 428
Zinc	~35.0 ppm	WHD 948, A-9-30-1, HI 8627, UAS 428
Copper	>6.0 ppm	HI 8713, HI 8627, NIDW 295, AKDW 2997-6
Manganese	>35.0 ppm	WHD 948, A-9-30-1, HI 8627, UAS 428

All the *T. aestivum* 1st and 2nd year AVT entries including checks (1252 nos.) were analysed for various quality traits which included grain appearance score, test weight, protein content, grain hardness index and sedimentation value. The 2nd year AVT entries including checks (578 nos.) were also analysed for wet gluten, dry gluten & gluten index and extraction rate. The Yellow pigment (ppm) for *T. aestivum* in NHZ, NWPZ, NEPZ, CZ, PZ, SHZ and overall were 3.64, 2.99, 3.32, 2.57, 2.76, 3.11, and 3.44 ranging from 2.96 to 4.90, 1.89 to 4.60, 1.96 to 5.11, 1.96 to 3.82, 2.17 to 4.06, 2.82 to 3.96 and 1.89 to 5.11, respectively (Table 4.3).

Table 4.3. Variability in the quality parameter of *T. aestivum* in AVTs

Parameter	NHZ	NWPZ	NEPZ	CZ	PZ	SHZ	Overall
Grain appearance (out of 10.0)	6.3 (4.1-7.8)	6.4 (4.7-7.8)	6.2 (5.0-8.0)	6.6 (4.0-7.8)	6.7 (5.2-7.9)	5.7 (5.2-6.4)	6.4 (4.0-8.0)
Test weight (kg/hl)	80.6 (72.6-84.6)	78.4 (69.5-83.0)	78.7 (71.3-84.0)	81.4 (78.0-84.6)	80.6 (75.3-83.5)	81.2 (80.0-82.4)	79.6 (69.5-84.6)
Protein content (%)	11.7 (7.9-17.8)	12.5 (7.4-18.9)	12.1 (9.4-15.0)	12.5 (7.8-16.7)	14.2 (11.5-17.5)	12.0 (11.4-12.6)	12.5 (7.4-18.9)
Grain hardness index	71 (18-95)	74 (53-100)	73 (47-98)	73 (43-89)	80 (66-99)	83 (75-87)	74 (18-100)
Sedimentation value (ml)	45 (31-68)	48 (31-68)	43 (31-56)	41 (30-53)	44 (31-59)	47 (40-53)	45 (30-68)
Wet gluten (%)	27.5 (20.2-42.2)	30.9 (18.7-43.8)	30.0 (23.1-35.1)	30.6 (18.1-42.5)	34.5 (29.6-42.5)	30.1 (28.1-31.5)	30.5 (18.1-43.8)
Dry gluten (%)	8.8 (5.7-14.5)	10.1 (5.5-16.1)	9.8 (7.1-11.5)	10.2 (5.9-14.3)	12.0 (9.6-14.1)	9.8 (9.1-10.2)	10.0 (5.5-16.1)
Gluten index (%)	61 (41-78)	61 (41-77)	59 (43-77)	56 (44-70)	61 (45-79)	55 (46-62)	60 (41-79)
Extraction rate (%)	64.2 (60.2-67.2)	69.8 (66.3-73.2)	70.8 (67.8-73.5)	70.5 (68.1-73.2)	72.1 (68.1-74.0)	69.5 (68.5-70.1)	69.3 (60.2-74.0)
Yellow pigment (ppm)	3.64 (2.96-4.90)	2.99 (1.89-4.60)	3.32 (1.96-5.11)	2.76 (1.96-3.82)	3.11 (2.17-4.06)	3.44 (2.82-3.96)	3.13 (1.89-5.11)
Iron (ppm)	29.9 (23.5-39.2)	34.9 (25.3-47.3)	33.5 (26.3-43.5)	34.5 (23.5-43.5)	39.4 (29.3-46.7)	35.7 (33.1-37.2)	34.3 (23.5-47.3)
Zinc(ppm)	27.6 (21.3-35.5)	30.7 (22.2-41.1)	32.3 (25.3-43.5)	32.3 (23.5-41.6)	34.7 (26.6-41.3)	29.1 (26.3-31.5)	31.0 (21.3-43.5)
Copper(ppm)	4.09 (3.21-5.45)	5.09 (4.11-5.75)	5.63 (4.67-6.37)	5.28 (4.38-6.30)	5.71 (4.80-6.48)	4.82 (4.67-4.95)	5.08 (3.21-6.48)
Manganese (ppm)	31.2 (22.2-43.3)	33.1 (23.5-45.1)	34.0 (24.6-43.2)	33.2 (23.5-41.6)	35.3 (26.5-44.4)	31.0 (28.5-33.3)	33.1 (22.2-45.1)

Range values are given within parenthesis.

All the *T. durum* 1st and 2nd year AVT entries including checks (378 nos.) were analysed for various quality traits like grain appearance, test weight, protein content, grain hardness index, sedimentation value, yellow berry incidence and yellow pigment. The 2nd year entries including checks (178 nos.) were also analysed for iron, zinc, copper and manganese. The mean values of yellow pigment (ppm) were distinctly high in *T. durum*. The mean values for NWPZ, CZ, PZ and overall were 5.54, 4.88, 4.60 and 5.05 ranging from 4.34 to 6.74, 3.73 to 7.51, 3.61 to 6.53 and 3.61 to 7.51 respectively (Table 4.4).

Table 4.4. Variability in quality parameters of *T. durum* in AVTs

Parameters	NWPZ	CZ	PZ	Overall
Grain appearance (Out of 10.0)	6.6 (5.2-7.6)	7.0 (5.6-8.5)	7.2 (5.8-8.2)	6.9 (5.2-8.5)
Test weight(kg/hl)	80.1 (76.8-82.5)	82.9 (75.4-84.8)	81.9 (76.0-84.8)	81.9 (75.4-84.8)
Protein content (%)	13.0 (8.7-17.9)	12.1 (9.1-16.6)	13.8 (11.8-16.3)	12.7 (8.7-17.9)
Grain hardness index	72 (52-90)	78 (48-100)	81 (71-93)	77 (48-100)
Sedimentation value (ml)	32 (25-40)	29 (17-41)	31 (20-40)	30 (17-41)
Yellow berry incidence (%)	23.2 (0.0-90.5)	11.2 (0.0-91.1)	2.9 (0.0-12.5)	13.6 (0.0-91.1)
Yellow pigment(ppm)	5.54 (4.34-6.74)	4.88 (3.73-7.51)	4.60 (3.61-6.53)	5.05 (3.61-7.51)
Iron (ppm)	30.9 (22.2-40.1)	34.9 (23.2-44.1)	35.6 (28.5-41.3)	33.7 (22.2-44.1)
Zinc (ppm)	30.0 (24.2-38.6)	33.7 (23.6-41.1)	33.6 (25.5-41.1)	32.4 (23.6-41.1)
Copper (ppm)	5.71 (4.85-6.25)	5.59 (4.36-6.25)	5.95 (5.47-6.25)	5.70 (4.36-6.25)
Manganese (ppm)	29.5 (21.6-41.2)	33.5 (20.5-43.1)	33.5 (25.5-41.1)	32.1 (20.5-43.1)

Range values are given within parenthesis

One hundred seventy seven 2nd and 1st year AVT entries including checks were evaluated for High Molecular Weight Glutenin Subunits (HMWGS). Subunits 5+10 and 2+12 were present in 57.63% and 42.37% of the total entries, whereas percent entries having 1, 2* and N subunits were 31.07%, 57.06% and 11.86% respectively. Likewise, percent entries having subunits 7, 7+8, 7+9, 17+18, 20 and 13+16 were 25.99, 24.29, 15.82, 28.81, 4.52 and 0.56, respectively.

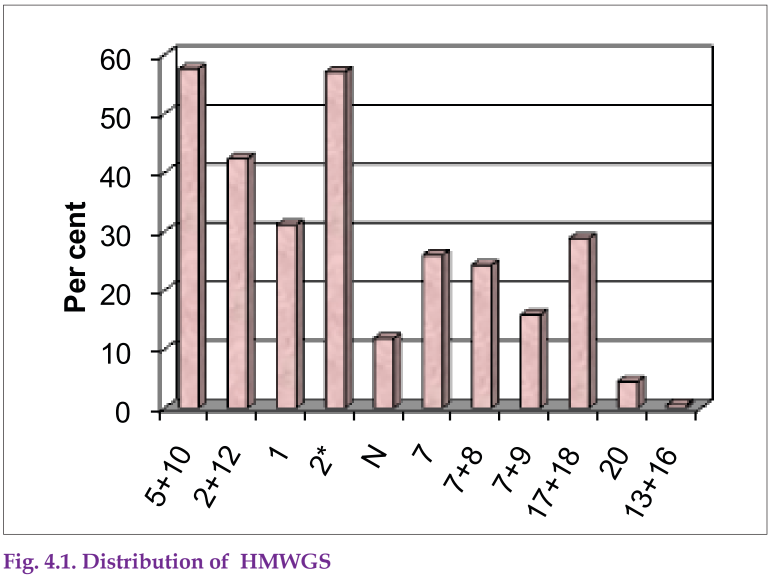


Fig. 4.1. Distribution of HMWGS

Developing product specific varieties

Germplasm evaluation

Stable genetic resources: Eleven entries developed at the Directorate were evaluated in QCSN to select useful stable donors for quality improvement. In the multilocation testing done at 15 sites, some lines registered consistent and stable performance for the component traits under screening (Table 4.5).

Table 4.5. Promising genotypes for individual quality trait

Entry name	Protein* (%)	1000- grain wt. (g)	Test wt. (kg/hl)	Sedimentation value (ml)	Hardness index	GAS (score)	Yield (g/m^2)
QLD 11	13.2	39.2	78.9	41.8	67	5.4	334
QLD 28	11.8	43.0	77.5	39.8	29	5.8	450
QLD 31	12.0	37.9	78.1	53.2	75	5.4	405
QLD 36	11.9	47.2	78.2	41.2	74	6.2	392
QLD 40	11.5	40.4	76.6	48.5	77	5.6	407
QLD 43	12.2	39.6	80.0	41.2	79	5.6	382
QLD 46	12.9	45.5	80.0	46.1	56	5.9	290
QLD 47	12.2	45.3	77.4	36.3	39	5.9	341
QLD 49	12.1	35.3	78.1	51.2	14	5.2	349
UP 2672 (C)	13.0	46.6	79.3	45.7	72	5.9	323
HI 977 (C)	11.9	39.3	77.8	50.1	74	5.2	371

* Grain protein content at 14% grain moisture

Creation of new variability

New germplasm: 56 new exotic selections were evaluated for yield and grain protein content to add new sources of yield and protein in the crossing block. Six of them had protein content ≥13.5% at 14% grain moisture like 5th STEMRRSAN 6135, 43rd IBWSN 1104, 18th SAWYT 360, CWANA 63, AM II 401, 43rd IBWSN 1137. Five genotypes namely 18th HRWYT 22, 1st HRWSN 2081, WAM II 324, 43rd IBWSN 1049 and 1137 were bold seeded (TGW: 44-56g) and registered high yield (5.5-6.8t/ha) in combination with high grain protein (13.2-13.5% at 14% grain moisture). 65 new accessions were selected from the international nurseries.

Target crossing: 629 new crosses were attempted and special emphasis was given to involve soft grain lines to improve biscuit making quality. Besides soft grain texture, the crossing block also included sources of grain hardness, sedimentation value, gluten index, test weight, chapati and bread qualities. 430 F_1 bulks were field evaluated and examined for grain protein content at 14% grain moisture. 51 of them had GPC in the range of 14-18% whereas another 130 combinations ranged between 13-14%. Several combinations expressed good hybrid vigor along with high GPC and TGW (Table 4.6).

Table 4.6. Promising combinations of high grain protein content

Cross	*Protein %
24th SAWSN 3192 / 3rd STEMRRSON 6071	18.0
24th SAWSN 3192 // WH 542 / K 307	16.9
24th SAWSN 3192 // DBW 17 / LOK 45	15.7
HD 2987 / 24th SAWSN 3192	15.7
3rd STEMRRSON 6071 / PBW 611	15.6
24th SAWSN 3192 / WH 1089	15.6
24th SAWSN 3192 // K 307 / DBW 17	15.5

*Grain protein content at 14% grain moisture

Evaluation of developed material

Selection in the segregating generations: 316 F_2 were raised and examined for yield traits and disease intensity. Selection was exercised at different plant growth phases and nearly 3500 spikes were picked from 281 crosses which shall be further tested as ear to row progenies during 2012-13. Nearly 8500 ear to row progenies and 304 F_3-F_4 families were field evaluated. It involved 2968 progenies of 285 crosses in F_4, 1467 progenies of 241 crosses in F_5 and 217 progenies of 17 crosses in F_6. On yield expression basis i.e. yield components and disease resections, 438 progenies of 161 crosses were selected in F_4. Similarly 301 progenies of 101 crosses and 41 progenies of 14 crosses were selected in advance generations i.e. F_5 and F_6. After grain quality analysis of field selected progenies, 158 progenies belonging to 88 crosses were promoted in F_4. In advance generations, 160 progenies of 88 crosses in F_5 and 22 progenies of 14 crosses in F_6 were also promoted. Several progenies selected on yield and quality basis excelled in different grain quality attributes. At 14 grain moisture content, 45 progenies had grain protein content ≥ 14%. Eighty nine progenies showed hard grain texture (grain hardness index ≥ 90) where as soft grains with hardness index below 30 could also be noted in 19 progenies (Fig. 4.2). High gluten strength could also be noted in 34 advance lines with sedimentation value in the range of 55-65ml (Table 4.7).

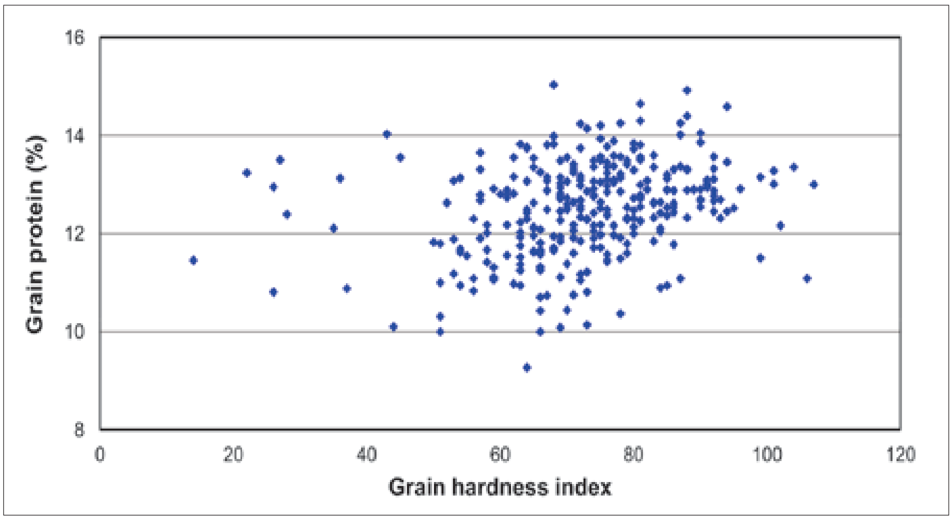


Fig. 4.2. Selection for protein and grain hardness in 300 F_5 lines to improve end-product quality

Table 4.7. Quality superior progenies in advance generations

Components	Criteria	F_6	F_5	F_4
Grain protein content (%)	≥ 14	3	15	27
Grain hardness index (%)	≥ 90	1	33	55
Grain hardness index (%)	≤ 30	8	6	5
Sedimentation value (ml)	≥ 55	1	7	26

Soft grain material: Breeding material was examined for grain hardness index to search soft-grain genotypes for improvement in biscuit quality. QLD 28, QLD 49 from QCSN and some advance derivatives from the breeding material like CAS 174/31st IBWSN 147, GW 322/37th IBWSN 146, 37th IBWSN 05/PBW 550, 36th IBWSN 72/5th IAT 43, GW 322/12th HRWYT 14 were found soft with grain hardness range 14-30. Biscuit spread factor of 9.6-10.1 (comparable to the best variety HS 490 released for the NHZ) could be noted in 2 F_5 derivatives i.e. CAS 174/31st IBWSN 147 and GW 322/ 37th IBWSN 146.

Evaluation in PYT: Seventy five fixed lines were evaluated for yield and quality traits along with popular check varieties seven derivatives had grain yield (60.7-67.6 q/ha) better than best check HD 2967 (58.9q/ah) and this elite group included 21st SAWSN 159/PBW 550, QLD 28, 21st SAWSN 159/PBW 550, 36th IBWSN 122/MACS 6151, 21st SAWSN 138/DBW 17, 12th HRWYT 17/DBW 17 and PBW 343/21st SAWSN 16. Four entries i.e. 1st ISWSN 206/10th SAWYT 27, 12th HRWYT 17/DBW 17, 21st SAWSN 138/DBW 17, 21st SAWSN 138/DBW 17 showed bread quality better than best check PBW 550. Besides bread quality, these entries also had an edge in protein content, grain yield and chapati score. Two exotic (41st IBWSN 1109 and 1113) and derived lines (12th HRWYT 26/15th HRWSN 22, PBW 533//H 98110/WH 542) had chapati score 8.0 in comparison to 7.6 noted in best check DBW 17 (Table 4.8). Seven derivatives registered grain protein content in the range of 13.5 to 14.8% at 14% grain moisture level.

Tale 4.8. Promising material in PYT

Genotype	Special feature	Loaf vol. (cc)	Chapati score	Yield (q/ha)	Protein * (%)	1000-gr. wt.(g)
1st ISWSN 206/ 10th SAWYT 27	Bread	610	7.70	58.4	12.3	41.2
12th HRWYT 17/ DBW 17	Bread	595	7.79	61.9	11.7	37.6
21st SAWSN 138/ DBW 17	Bread	590	7.29	57.4	14.1	36.1
41st IBWSN 1113	Chapati	510	8.00	56.4	11.7	36.4
41st IBWSN 1109	Chapati	535	8.00	55.2	12.0	36.4
12th HRWYT 26 / 15th HRWSN 22	Chapati	560	8.00	58.1	12.2	39.2
PBW 533 // H 98110 / WH 542	Chapati	555	8.00	57.6	12.9	47.2
25th ESWYT 24/ 21st SAWSN 171	Protein	560	7.20	54.5	14.8	36.2
25th ESWYT 24/ 21st SAWSN 171	Protein	575	7.41	55.1	14.5	34.1
37th IBWSN 05/ PBW 550	Protein	570	7.29	51.7	14.0	46.0
PBW 550	Check	580	7.45	56.4	11.1	40.4
DBW 17	Check	535	7.58	58.3	11.5	38.0
HD 2967	Check	555	7.29	59.8	12.2	38.8

* Grain protein content at 14% grain moisture

Material selected for NIVT's: On the basis of superior yield and disease levels in the station trials, four entries were elated to NIVT by the name DBW 98,114 and 116 in NIVT 1A and DBW 119 in NIVT 1B. All of them are bold seeded and have registered superiority in either grain quality components or end-product quality. DBW 98 and DBW 114 have high grain protein content (13.2-13.5% at 14% grain moisture content), good chapati score (7.8-7.9) and bread loaf volume (580cc). Chapati score in DBW 116 was 8.1 whereas DBW 119 was distinct with early flowering and long grain filling period.

Evaluation of elite germplasm lines for quality and molecular components

During the year (2011-2012), 97, 119 and 60 lines belonging to NGSN, EIGN-I and EIGN-II were grown at DWR, Karnal. All the lines of these three nurseries were analysed for processing quality parameters viz. test weight, protein content, sedimentation value, grain hardness index, wet gluten and dry gluten. These lines were also analysed for nutritional quality parameters viz. yellow pigment, iron, zinc, copper and manganese. Based on the quality analysis, selected samples were analysed for evaluating wheat products like chapatti, bread & pasta product and also for molecular characterization.

Processing quality: Different processing quality parameters like test weight, protein content, sedimentation value, grain hardness index, wet gluten and dry gluten showed wide variability as shown in the table 4.9.

Table 4.9. Variability in processing quality parameters

Parameters	NGSN	EIGN-I	EIGN-II
Test weight (kg/hl)	78.0 (69.2-83.5)	77.8 (67.7-81.8)	79.5 (75.5-81.8)
Protein content (%)	12.6 (10.7-14.9)	13.6 (11.9-15.8)	12.4 (10.7-14.3)
Sedimentation value (ml)	36 (22-52)	47 (30-65)	36 (26-42)
Grain hardness index	77 (35-108)	74 (21-105)	95 (64-113)
Wet gluten (%)	30.9 (26.7-36.1)	33.5 (28.9-40.5)	-
Dry gluten (%)	10.5 (8.7-12.5)	11.3 (9.7-13.5)	-

Attempts were made to identify promising genotypes for various processing quality parameters from all the three nurseries viz. NGSN (Table 4.10), EIGN I (Table 4.11) and EIGN II (Table 4.12) to be utilized in the quality wheat breeding programme.

Table 4.10. Promising genotypes for processing quality parameters in NGSN

Parameters	Value	Genotypes
Test weight (kg/hl)	>81.0	UAS 419, HS 8696 (d), HI 8681 (d), MPO 1226 (d), HD 2987, MPO 1220 (d), DBP 01-14 (d)
Protein content (%)	>14.0	HPW 309, KRL 249, PHS 1107, PHS 1108, GW 2007-77 (d)
Sedimentation value (ml)	>50	PBW 621, MACS 6222.
Grain hardness index	~100	PDW 316 (d), HI 8690 (d), HPW 308, HI 8693 (d), DBW 01-09 (d), DBP 01-16 (d), DDW 21 (d), DDW 22 (d)
	~45	KRL 249, WH 1076, LBPY 07-6

Table 4.11. Promising genotypes for processing quality parameters in EIGN-I

Parameters	Value	Genotypes
Test weight (kg/hl)	>81.0	IBWSN 1119, IBWSN 1181, IBWSN 1223, HRWSN 2066, HRWSN 2067, HLWSN 5034
Protein content (%)	>15.0	ESWYT 119, SAWYT 330, SAWYT 334, SAWYT 340, SAWYT 348, HLWSN 5017, HLWSN 5070, HLWSN 5076
Sedimentation value (ml)	>60	ESWYT 103, ESWYT 150, SAWYT 309, SAWYT 342, IBWSN 1094, IBWSN 1095, IBWSN 1133
Grain hardness index	>90	ESWYT 122, SAWYT 334, IBWSN 1039, IBWSN 1084, IBWSN 1107, IBWSN 1109, IBWSN 1148, HRWSN 2059, HRWSN 2066, HRWSN 2067
	<45	SAWYT 348, IBWSN 1175, IBWSN 1197, IBWSN 1202, HRWSN 2011, HLWSN 5059, HLWSN 5061, HLWSN 5076

Table 4.12. Promising genotypes for processing quality parameters in EIGN-II

Parameters	Value	Genotypes
Test weight (kg/hl)	>81.0	IDSN 103, IDSN 117, IDSN 123, IDSN 154, IDYN 10, IDYN 16, IDYN 44, IDYN 47, PDW 291
Protein content (%)	>14.0	IDSN 9, IDSN 52, IDYN 7, IDYN 43
Sedimentation value (ml)	>40	IDSN 53, IDYN 27, IDYN 34, IDYN 42, IDYN 44
Grain hardness index	>110	IDSN 172, IDYN 6, IDYN 44

Nutritional quality: Different nutritional quality parameters like yellow pigment, iron, zinc, copper and manganese showed wide variability as shown in the table 4.13.

Table 4.13. Variability in nutritional quality parameters

Parameters	NGSN	EIGN-I	EIGN-II
Yellow pigment (ppm)	3.12 (1.89-8.13)	2.94 (1.71-5.09)	6.78 (3.28-9.14)
Iron (ppm)	32.9 (18.5-45.2)	32.6 (19.6-44.1)	31.2 (17.8-42.3)
Zinc (ppm)	31.8 (18.7-43.5)	29.7 (18.2-43.5)	30.2 (18.0-42.8)
Copper (ppm)	5.15 (3.05-6.50)	4.96 (3.11-6.66)	4.91 (3.17-6.67)
Manganese (ppm)	31.0 (17.5-44.2)	31.6 (18.6-43.5)	29.3 (18.2-40.5)

Attempts were made to identify promising genotypes for various nutritional quality parameters from all the three nurseries viz. NGSN (Table 4.14), EIGN I (Table 4.15) and EIGN II (Table 4.16) to be utilized in the quality wheat breeding programme.

Table 4.14. Promising genotypes for nutritional quality parameters in NGSN

Parameters	Value	Genotypes
Yellow pigment (ppm)	>5.00	UAS 419, HI 8680, HI 8693, HI 8627, PDW 233, HI 8663, PDW 314, DBW 01-9, DBW 01-16
Iron (ppm)	>40.0	HPW 309, KRL 249, GW 2007-77, C 306, PHS 1107, PHS 1108
Zinc (ppm)	>40.0	TL 2966, HPW 308, HPW 309, HS 521, PHS 1101, MPO 1220, PHS 1105, C 306
Copper (ppm)	>6.00	HPW 308, HPW 309, KRL 249, DDK 1038, PHS 1101, PHS 1105, PHS 1108
Manganese (ppm)	>40.0	HPW 309, DBW 49, TL 2966, HPW 308, HS 521, PHS 1108

Table 4.15. Promising genotypes for nutritional quality parameters in EIGN-I

Parameters	Value	Genotypes
Yellow pigment (ppm)	>4.00	ESWYT 150, SAWYT 303, SAWYT 307, IBWSN 1084, IBWSN 1095
Iron (ppm)	>40.0	ESWYT 122, ESWYT 150, SAWYT 309, SAWYT 340, SAWYT 342, IBWSN 1094, IBWSN 1095, IBWSN 1148
Zinc (ppm)	>40.0	SAWYT 303, SAWYT 309, IBWSN 1006, IBWSN 1091, IBWSN 1172, HRWSN 2091, HLWSN 5076
Copper (ppm)	>6.00	ESWYT 103, ESWYT 132, ESWYT 150, SAWYT 342, IBWSN 1091, IBWSN 1148, IBWSN 1235
Manganese (ppm)	>40.0	ESWYT 132, SAWYT 340, IBWSN 1006, IBWSN 1094,IBWSN 1137, IBWSN 1175, HRWSN 2091, HLWSN 5076

Table 4.16. Promising genotypes for nutritional quality parameters in EIGN-II

Parameters	Value	Genotypes
Yellow pigment (ppm)	>8.00	IDSN 125, IDSN 138, IDSN 161, IDSN 172, IDYN 24, IDYN 34, IDYN 41, IDYN 48, IDYN 49, IDYN 50
Iron (ppm)	~40.0	IDSN 9, IDSN 52, IDYN 7, IDYN 43, IDSN 53, IDYN 42
Zinc (ppm)	~40.0	IDYN 7, IDYN 23, IDSN 104, IDSN 9, IDSN 52
Copper (ppm)	~6.00	IDSN 53, IDYN 7, IDSN 52, IDYN 43, IDYN 44, IDYN 45
Manganese (ppm)	~40.0	IDYN 7, IDYN 23, IDSN 104, IDSN 53, IDSN 9, IDSN 52, IDYN 43

Attempts were also made to identify promising genotypes for various end products like chapati and bread from all the three nurseries viz. NGSN, EIGN I and EIGN II to be utilized in the quality wheat breeding programme (Table 4.17).

Table 4.17. Promising product specific varieties

Parameters	Value	Genotypes
Chapati	>8.0/10.0	IBWSN 1043, IBWSN 1095, SAWYT 348, HRWSN 2081, HLWSN 5076, HRWYT 230, ESWYT 141, LOK 62, HI 1571, HI 1500, PBW 175, C 306
Bread loaf volume (ml)	>575	IBWSN 1202, HRWSN 2086, HLWSN 5061, HW 5207, PBW 612, PBW 610, LOK 62, Raj 4083, NIAW 34, MACS 6222, HD 2864
Pasta product	>7.0/9.0	IDSN 7, IDSN 114, IDYN 17, IDYN 35, IDYN 49, HI 8627, PDW 233

Selected superior lines of EIGN were analysed for molecular characterization for grain hardness (pin a & pin b), HMW & LMW glutenins and gamma gliadins (Fig 4.3).

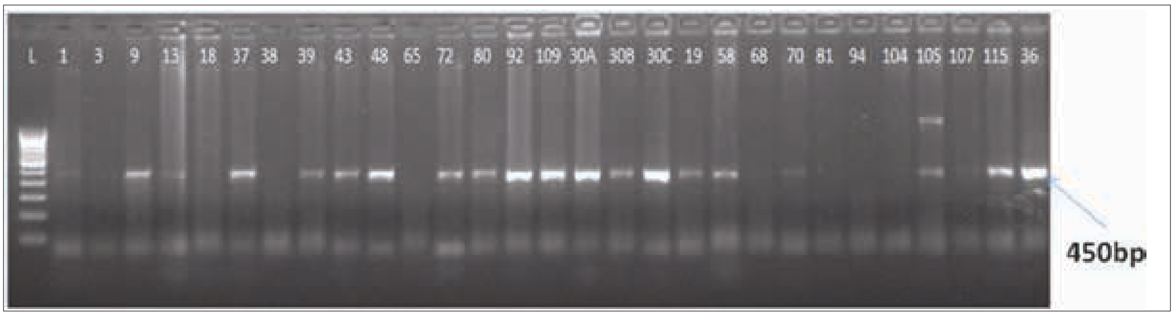


Fig. 4.3. PCR amplification of *HMW* Glutenin *Dx5* with allele-specific PCR marker in EIGN-I entries (1. ESWYT 103, 3. ESWYT 122, 9. ESWYT 150, 13. SAWYT 309, 18. SAWYT 342, 37. IBWSN 1091, 38. IBWSN 1094, 39. IBWSN 1095, 43. IBWSN 1111, 48. IBWSN 1133, 65. IBWSN 1187, 72. IBWSN 1210, 80. IBWSN1235, 92. HRWSN 2081, 109. HLWSN 5088, 30A. DBW 17, 30B. DBW 39, 30C. GW 322, 19, SAWYT 348, 58, IBWSN 1175, 68, IBWSN 1197, 70. IBWSN 1202, 81. HRWSN 2011. 94. HRWSN 2086, 104. HLWSN 5059, 105. HLWSN 5061, 107. HLWSN 5076, 115. HRWYT 222, 36. IBWSN 1090).

Characterization of LMW glutenin genes: Low molecular weight (LMW) glutenin subunits along with HMW glutenins have major effect on dough strength and extensibility. Recently DWR have characterized Indian wheat varieties for LMW glutenin alleles using PCR base approach which showed large allelic variation in Indian wheats. Three types of alleles were present at *Glu-A3* locus, seven types at the *Glu-B3* locus and 5 types at *Glu-D3* locus. In conclusion, the data found greater consistency between the SDS-PAGE and PCR amplification patterns of certain alleles and less consistency in some others. Work was initiated to characterize LMW alleles of LMW glutenin which could not be identified by using available PCR markers to achieve unambiguous identification of the inconsistent *Glu-3* alleles and thereby allow their greater utility in germplasm evaluation and breeding. Full length *Glu-B3* gene was cloned and sequenced from two varieties to develop *Glu-B3b* allele specific markers.

Both the sequences LMWB3.1 and LMWB3.2 were used for BLASTn search against the GenBank wheat EST database. Based on the nucleotide sequences of these LMW genes, phylogenetic analysis was conducted. The coding region of these genes shared 99% identity to AB567685 isolated from cultivar 'Kinunonami' and 97% similarity with AY831784 of 'Glenlea'. Both the sequences exhibited lower identities (88% homology) with TAU86027 from cultivar 'Cheyenne'. Both Kinunonami and Glenlea cultivars possess *Glu-B3g* allele and showed similar sequence at the S1F/S1R primer binding site, while Cheyenne had *Glu-B3e* allele and differed at the primer binding site (Fig. 4.4).

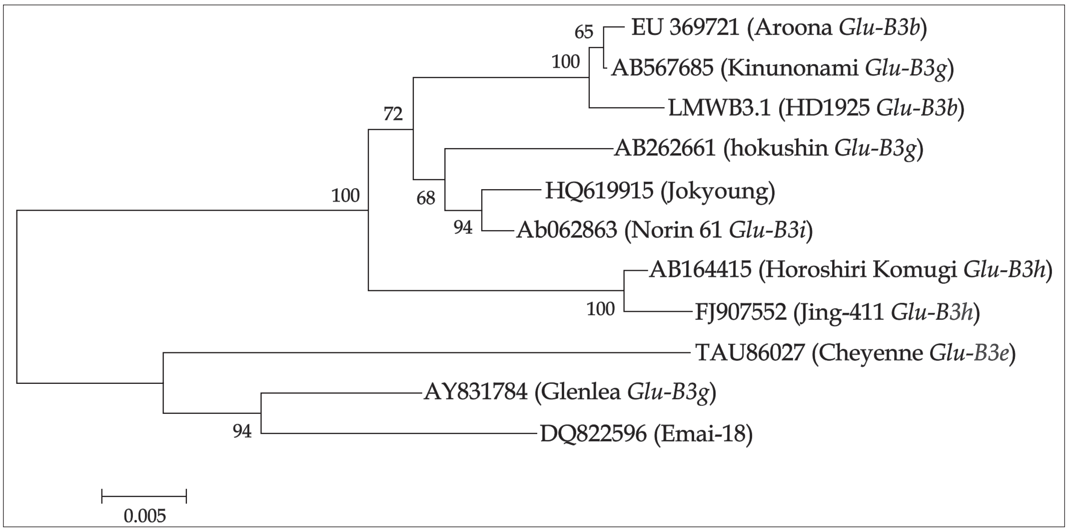


Fig. 4.4. Phylogenetic tree based on multiple sequence alignment of full length sequences of *Glu-B3b* gene from Indian cultivars investigated in this report and available sequences in NCBI database. Cultivars name and their corresponding *Glu-B3* alleles are indicated in the bracket (except for Emai-18 and Jokyoung). Bootstrap values are indicated and bootstrap percentages are based on 1000 iterations

Utilization of Nap Hal and other soft germplasm lines in the improvement of 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 for making crosses and generation advancement. BC_3F_5 seeds harvested from BC_3F_4 plants of a cross between PBW373 and NAP exhibited transgressive segrergants towards low sedimentation under soft background. High yielding and widely adapted varieties grown in North Western Plains Zones of India namely PBW 343 and HD 2687 were used as recurrent parents and germplasm lines identified with soft grain characteristics namely HPW114 and EC378793 as donors. Materials are at BC_3F_6 and BC_4F_6 stages. There was significant increase in the spread factor of BC_2F_6 back cross lines of a cross between HD2687 and HPW114.

Nutritional quality

Purification and Kinetic analysis of phytase

Absorption of micronutrients such as Fe and Zn is significantly inhibited in human beings by the presence of substances such as phytic acid (PA) leading to deficiency of these micronutrients Therefore, degradation of phytate present in the grain is needed to overcome the problem of micronutrient deficiency in humans and monogastric animals. In humans, phytic acid breakdown in the stomach and the intestine is influenced mainly by the dietary phytases, which are active in the human stomach. However, there are few reports of kinetic properties of phytase in wheat. Hence characterization of phytase in wheat can lead to better understanding of the role of phytase in improving nutritional quality. In this investigation phytase from DBW17 was isolated and purified using salt precipitation, electrophoretic and chromatographic techniques (Table 4.18). There was more than 100 fold purification of the enzyme. The kinetic properties were assessed in relation to substrate specificity, pH, temperature and inhibition by metals. Wheat phytase showed strong specificity to phytic acid and has the pH optima at 6.0 for *Phy1* and 5.5 for *Phy2* (Fig. 4.5). The molecular studies are being conducted to sequence the gene for phytase in wheat for use in breeding for wheat improvement.

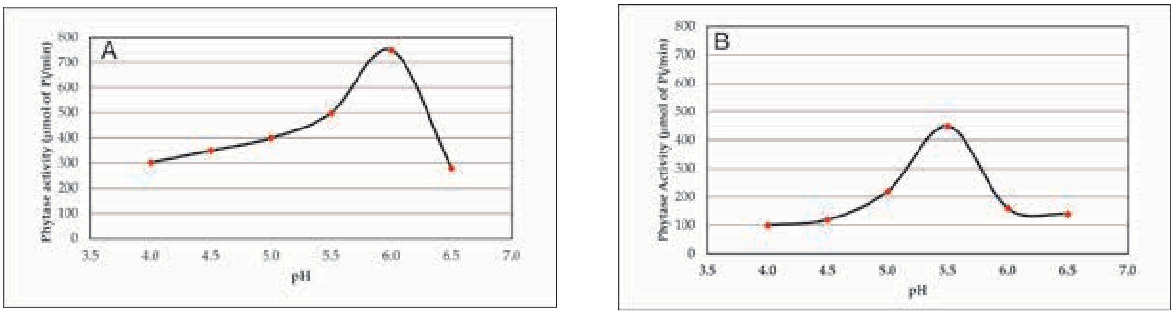


Fig. 4.5. Effect of pH on phytase activity. The purified phytase was assayed for activity at different pH range from pH 3.0 to pH 7.0. (a) The pH activity curve of PHY1 showing peak activity at pH 6.0 and (b) activity curve of PHY2 showing peak activity at pH 5.5.

Table 4.18. Summary of purification of phytase from whole meal of wheat variety DBW 17

SN	Steps	Volume (ml)	Activity (Units)	Protein (mg/kg)	Specific activity (Units/mg)	Purification (fold)	Yield of act. (%)
1	Crude enzyme	5000.0	738.9	119475.0	0.03	1.0	100.0
2	40-70%$(NH_4)_2SO_4$ fraction	264.0	608.3	4248	0.14	29.4	82.3
3	45-65% Methanol fraction	50.0	135.7	740.8	0.18	47.2	18.4
4	DEAE Tris acryl column	70.0	27.3	94.1	0.29	47.0	3.7
5	AcA34 filtration	72.0	22.8	50.2	0.46	73.6	3.1
6	SP- Trisacryl column PHY 1	1.00	0.18	0.36	0.49	79.0	0.02
7	SP- Trisacryl column PHY2	1.00	0.12	0.17	0.71	114.6	0.02

Biofortification: Synthetic hexaploids showed higher Zn content

Micronutrient malnutrition, or "hidden hunger", is a widespread problem in developing world countries including India. The consequences of this hidden hunger, in terms of mortality, impaired physical and cognitive development, or eye problems, are of staggering magnitudes. Therefore, biofortification of wheat with respect to Fe and Zn could greatly reduce micronutrient malnutrition. Fe concentration varied from 34 to 70 ppm with the average value of 45ppm and Zn from 22 to 50 ppm with the average value of 37 ppm in grains of wheat varieties and synthetic hexaploids. Higher content of Zn was observed in synthetic hexaploids as compared to bread wheat (Fig 4.6). Therefore synthetic hexaploids can be used in improving Zn content in Indian wheats. Two years study demonstrated positive correlation (R^2=0.35) between Fe and Zn content. This information has utility in improving micronutrient content in wheat (biofortification).

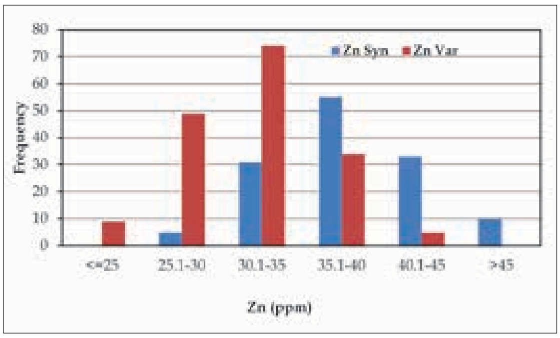


Fig. 4.6. Variability in Zinc content in synthetic hexaploid and Indian wheat varieties

Phenolic content in Indian Wheat varieties

The antioxidant activity in the cereals is mainly due to the presence of phenolic compounds. The Indian wheat varieties were evaluated for the total phenolic content. The free, bound and total phenolic acid content was estimated in the bran of 23 Indian wheat genotypes grown under different agro-climatic conditions. A wide variation was obtained in the content of different phenolic acid forms with significant differences between the genotypes (Fig. 4.7). The free phenolics contributed 6-40% and the bound phenolics 60-94% to the total phenolic content. On an average, bound phenolics were 4-fold higher than the free phenolics. Bound phenolic content was found to be more strongly correlated to the TPC (0.95, P<0.05) than the free phenolic content.

The free phenolic acid content (FPC) varied from around 270-1550 µgGAE/g with the mean around 790 µgGAE/g. Significant differences were observed in the FPC of the different zones (Table 4.19). The varieties from the NHZ and NEPZ had higher free phenolic acid content, while those from the NWPZ and CZ showed lower phenolic content. The bound phenolic acid (BPC) content varied from 1800-5300 µgGAE/g with the mean around 3500 µgGAE/g. Statistically significant differences were observed in the BPC also (Table 4.19). The varieties from CZ and NWPZ had higher bound phenolics, while those from NHZ and NEPZ showed the lower content of bound phenolics. A wide range of BPC was reported in this study than the previous studies. Total phenolic acid content varied from 2900-5650 µgGAE/g with the mean around 4300 µgGAE/g. Significant differences were observed in the TPC from different zones. CZ and NWPZ varieties had higher total phenolic acid content followed by PZ. NHZ and NEPZ varieties showed almost similar content of total phenolics.

Table 4.19. Mean phenolic content in different agroclimatic zones

Zone	Phenolic content (µgGAE/g)*		
	Free	Bound	Total[a]
NHZ	1199.78 ± 2 41.8a	2378.24 ± 449.4b	3578.02 ± 620.5b
NWPZ	498.58 ± 166.9b	4355.87 ± 459.8a	4854.45 ± 503.2a
NEPZ	1207.88 ± 313.7a	2332.34 ± 549.6b	3540.23 ± 469.4b
CZ	481.70 ± 179.8b	4272.17 ± 752.2a	4753.87 ± 634.0a
PZ	726.02 ± 181.3b	3617.38 ± 488.9a	4343.40 ± 585.7ab

* Values are means of varieties from each centre ± standard deviation. Values expressed as µgGAE/g bran. Means with the same letter in the same column are not significantly different (P<0.05).

[a] Sum of free and bound fractions.

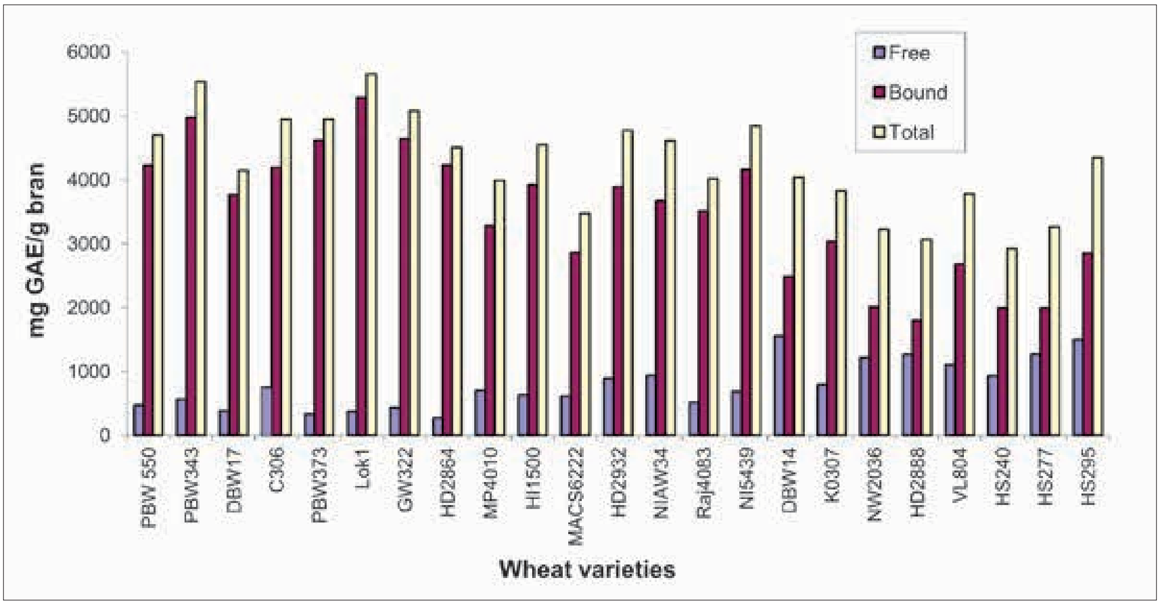
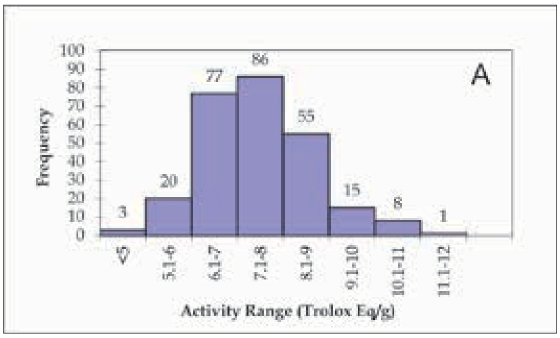


Fig. 4.7. Total phenolic content of wheat bran of Indian bread wheat varieties analyzed by Folin-Ciocalteau assay. Results are expressed as microgram gallic acid equivalents (GAE) per gram of wheat bran.

Antioxidant potential of barley

To assess the antioxidant potential of barley crossing block lines, the free radical scavenging activity was analysed in 265 lines using ABTS and DPPH assays. Using ABTS method, the antioxidant activity range was between 4.6-12.0 with an average of 7.5 Trolox Equivalents/g sample. 82% of the lines had activity between 6.0 – 9.0. By DPPH method, the antioxidant activity ranges between 10-70 % discoloration with an average of 45%. 90% of the lines showed activity between 30 – 60 % discoloration (Fig 4.8.). The antioxidant activity of barley is significantly higher than that of the whole grain wheat.



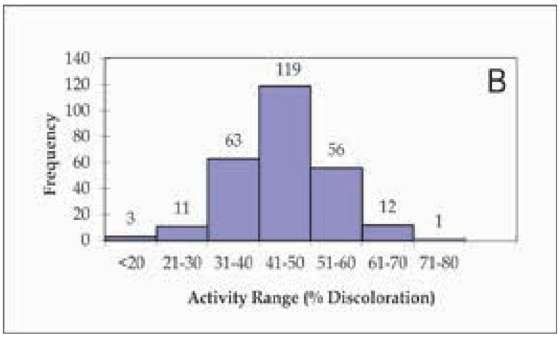


Fig. 4.8. Histograms representing the frequency distribution of the antioxidant activity by ABTS (a) and DPPH (b) assay

5 SOCIAL SCIENCES

India has achieved an all time high wheat production of 94.88 million tonnes during 2011-12 registering 8.44% increase over the last year as compared to 3.28% growth in agriculture during the last five years. Favourable climatic conditions throughout the crop season in 2011-12, varietal spectrum provided through different outreach programmes such as Front Line Demonstrations, National Food Security Mission, Rashtriya Krishi Vikas Yojana, Mini Kit and the most pronounced Second Green Revolution in Eastern States led to increased wheat production and productivity in the country.

There were some incidences of yellow rust particularly in the NWPZ. The preparedness of State Department of Agriculture in this region helped in controlling yellow rust. The advisory services and rigorous training of field level extension functionaries by the Directorate in NWPZ has also played a key role in dealing with various issues of wheat production, particularly yellow rust. Awareness created through mass-media on seed treatment, seed replacement, disease management and timely procurement of improved varieties' seed provided a platform to the farmers to increase wheat production with assured marketing. Wheat procurement by different agencies also created a record and now storage of wheat has emerged as a key challenge and it needs immediate action.

Availability of inputs in time, quantity and quality of inputs, availability of electricity and availability of canal water at required time are some of the administrative issues which need immediate attention. There is a dire need to involve all sources of communication to reach maximum number of farmers without time lag. Awareness programmes for farmers such as farmers' day, kisan mela, exhibitions, exposure visits, interstate exchange programmes, trainings, workshops, meetings, TV talk should be organized from time to time to update the knowledge of the farming community. Entrepreneurship development can be the key in increasing their income and making them self dependent.

Wheat Front Line Demonstrations (WFLDs)

During the wheat crop season 2011-12, 210 Wheat Front Line Demonstrations (WFLDs) of one hectare each were allotted to 80 coordinating centres of which 204 were conducted through 78 coordinating centers. The technologies on improved wheat (*T. aestivum* and *T. durum*) varieties with complete package of practices, zero tillage and bio-fertilizer were demonstrated. These WFLDs covered 226.64 hectares area of 569 farmers in 18 states. The maximum number of WFLDs were conducted in UP (31) followed by Haryana (20), Bihar (18), Maharashtra (17), Rajasthan (13), Gujarat (13), Jharkhand (12), J&K (12), Punjab (10), HP (10) and Chhattisgarh (9).The maximum yield gain (Table 5.1) was observed in MP (34.47%) followed by Chhattisgarh (32.52%), Uttarakhand (29.09%), HP (23.45%), Jharkhand (22.97%), J&K (17.98%), Rajasthan (17.74%), West Bengal (15.12%), Karnataka (14.91%), Bihar (14.73%), Maharashtra (14.05%), UP (13.82%), Gujarat (13.32%), Punjab (09.81%), Delhi (07.86%) and Haryana (06.90%).

Table 5.1. State wise performance of improved wheat varieties in FLDs

State	Mean yield (q/ha)		% Gain
	Improved	Check	
UP	48.44	42.56	13.82***
HP	29.80	24.14	23.45**
J&K	31.24	26.48	17.98***
Bihar	43.07	37.54	14.73***
Jharkhand	33.83	27.51	22.97***
Punjab	58.54	53.31	09.81**
Haryana	59.19	55.37	06.90***
Uttarakhand	42.96	33.28	29.09***
Delhi	56.38	52.27	07.86**
Gujarat	40.84	36.04	13.32*
MP	44.90	33.39	34.47***
Chattisgarh	29.30	22.11	32.52***
Maharashtra	32.96	28.90	14.05*
Karnataka	36.00	31.33	14.91***
West Bengal	31.67	27.51	15.12***
Assam	31.30	23.10	35.50 NS
Rajasthan	46.73	39.69	17.74***
Tamilnadu	36.35	-	-

*** Significant at 1% level, ** - Significant at 5% level, * Significant at 10% level, NS– Non-significant

The yield gain (Table 5.2) due to improved varieties was highest in CZ (49.58%) followed by NEPZ (35.28%), PZ (30.44%), NHZ (29.95%) and NWPZ (25.21%). Yield gap in the NEPZ and CZ need to be bridged if India has to meet its ever increasing food requirements. The specific problems faced by the farmers in these two zones are to be solved. Extension agencies have to use latest communication means to educate the farmers on technical matters.

Table 5.2. Zone wise productivity under WFLDs

Zone	Mean yield(q/ha)		% Gain
	WFLDs	Regional	
NHZ	32.41	24.94	29.95***
NEPZ	39.69	29.34	35.28***
NWPZ	53.29	42.56	25.21***
CZ	41.36	27.65	49.58***
PZ	33.64	25.79	30.44***
SHZ	36.35	-	-

*** - Significant at 1% level

FLDs on Bio-fertilizer (Azotobactor & PSB) alongwith 100 % inorganic fertilizer as compared to check (100% recommended dose of Inorganic fertilizer) showed that the yield gain was significant at West Singhbhum centre (33.13 %) in NEPZ followed Vijapur center (09.09 %) in CZ and DWR-Karnal (04.41 %) in NWPZ. In PZ, the yield gain was 16.67% at Dharwad centre but non-significant.

Improved durum variety HI 8663 (d) gave a yield of 48.29 q/ha at Indore centre followed by HI 8691 (d) (47.50 q/ha) at the same center in CZ which were positive and significantly higher over the check varieties. In PZ, UAS 415 (d) demonstrated significantly better yield (36.50 q/ha) than check variety at Dharwad centre.

In NHZ, improved rainfed variety HS 507 yielded significantly higher than the check varieties at Dhaulakuan (45.60 q/ha) followed by Almora (40.53 q/ha), Berthin-Bilaspur (31.82 q/ha), Tandwal-Rajauri (31.38 q/ha), Bajaura (31.00 q/ha), Srinagar (24.10 q/ha) and Malan-Kangra (20.75 q/ha). In CZ, MP 3288 variety (59.00 q/ha) at Kota centre yielded significantly higher followed by the same variety MP 3288 (47.00 q/ha) at Udaipur center. In PZ, UAS 415 (d) (36.50 q/ha) at Dharwad center yielded significantly higher followed by NIAW 1415 variety at Niphad (33.68q/ha), Solapur (32.42 q/ha) and Dhule (31.61 q /ha) centers.

Zero tillage gave positive but non-significant yield gain of 19.70%, 19.51%, 14.68%, 05.95% and 05.72% at Faizabad, Shillongani, Kathua-Jammu, Varanasi and Ambala centers, respectively (Table 5.3).

Table 5.3. Performance of zero tillage over conventional tillage

Zone & Centre	Mean FLDs Zero Tillage yield (q/ha)	Mean Check/ Conventional Tillage yield (q/ha)	% Gain
NEPZ			
Faizabad	39.50	33.00	19.70 NS
Varanasi	42.75	40.35	05.95 NS
Shillongani	24.50	20.50	19.51 NS
NWPZ			
Kathua-Jammu	37.50	32.70	14.68 NS
Agra	57.20	55.50	03.06 NS
IARI New Delhi	60.00	59.00	01.69 NS
DWR Karnal	65.00	64.00	01.56 NS
NDRI Karnal	60.25	58.63	02.76 NS
Ambala	42.50	40.20	05.72 NS
Kaithal	52.00	51.00	01.96 NS

NS– Non-significant

Constraints in wheat production

Data were collected on a well designed pre-structured questionnaire mailed to all the coordinating centres conducting wheat Front Line Demonstrations. The responses were collected on a three point continuum *viz;* Most Serious, Serious and Not Serious constraints. The scores were assigned as 3, 2, 1 for the most serious, serious and not serious constraints. Based on total score and sample size, the average score for each constraint was calculated to ascertain seriousness. The zone wise constraints are as given below.

NHZ : In northern hills zone, yellow rust, loose smut, lack of irrigation facilities and birds were most serious to serious constraints. Among serious to not so serious constraints were brackish water, *Phalaris minor* (Mandusi), *Chenopodium album* (Bathua), water logging, water stress and poor quality of seed.

NEPZ : *Chenopodium album*, small holding, *Rumex dentatus*, *Cyprus rotundus*, leaf blight, *Phalaris minor*, *Avena ludoviciana*, lack of irrigation facilities, high temperature at maturity, *Argemone mexicana and* rodents were identified as the most serious to serious constraints. Late sowing of wheat, Zn deficiency, water stress and low price of wheat in NEPZ were perceived as serious constraints.

NWPZ : In NWPZ, *Phalaris minor* (Mandusi), *Chenopodium album* (Bathua), *Convolvulus arvensis* (Hirankhuri), non availability of electricity, birds, rust, poor quality fertilizers, aphid, lodging, water logging, non availability of inputs, termite, non availability of diesel and small holdings were observed as serious constraints.

CZ : In central zone, leaf blight, rust, loose smut, grain discolouration, aphid, termite, *Phalaris minor*, *Chenopodium album*, *Avena ludoviciana*, *Malva parviflora* and *Convolvulus arvensis* were observed as serious constraints.

PZ : In peninsular zone, leaf blight, rust, grain discolouration, aphid, termite, *Phalaris minor*, *Cyprus rotundus*, *Chenopodium album*, *Avena ludoviciana* , *Malva parviflora*, *Convolvulus arvensis*, *Rumex dentatus* and *Anagalis arvensis* were observed as serious constraints.

SHZ : Wheat is a new crop for this zone, hence, there were few constraints reported by the farmers. Termite was perceived as the serious constraint. *Cyprus rotundus* and untimely rains were some of the other constraints but not so serious in nature.

Overall constraints in wheat production in India

Infestation of weeds such as *Chenopodium album*, *Phalaris minor* (Mandusi), *Rumex dantatus*, *Cyprus rotundus* (Motha), *Avena ludoviciana* (Jangali Jai) were found as the major weeds affecting wheat production of the country. Among insects and diseases, yellow rust, leaf blight and loose smut were the most serious constraints. Small land holdings and non availability of electricity were the other serious constraints and the latter needs government intervention (Table 5.4).

Table 5.4 : Overall constraints

Constraints	Average Score	Constraints	Average Score
Yellow rust	2.69	*Phalaris minor* (Mandusi)	2.28
Chenopodium album (Bathua)	2.52	*Rumex dentatus* (Jangali Palak)	2.27
Leaf blight	2.50	*Cyprus rotundus* (Motha)	2.26
Small holdings	2.31	Non availability of electricity	2.23
Loose smut	2.29	*Avena ludoviciana* (Jangali Jai)	2.13

Barley front line demonstrations

During the rabi crop season 2011-12, 40 Barley Front Line Demonstrations (BFLDs) were allotted to 13 different barley network centers all over India in six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP of which 33 were conducted by 10 network centers, covering 33.00 hectares area of 57 farmers. Improved barley varieties with complete package of practices (irrigation management, fertilizer dose and method of application, weed control, seed treatment etc.) were demonstrated.

The highest yield gain in barley (Table 5.5) was recorded in MP (41.44 %) followed by HP (19.62%), Rajasthan (16.03 %), Punjab (14.40 %), UP (12.88 %) and Haryana (06.89 %). The yield gain of improved variety over the check variety was more in MP state because the improved barley variety was compared with the local variety.

Table 5.5. State wise yield gain under BFLDs

State	BFLDs Yield (q/ha)	Check Yield (q/ha)	% Gain
HP	26.22	21.92	19.62**
UP	37.25	33.00	12.88**
Punjab	48.05	42.00	14.40**
Haryana	54.01	50.53	06.89***
Rajasthan	38.29	33.00	16.03***
MP	43.38	30.67	41.44***

*** Significant at 1% level, ** Significant at 5% level.

The highest increase in barley yield (Table 5.6) was recorded in NEPZ(52.04%) followed by NHZ (36.21%), CZ(31.69%) and NWPZ (15.28%). Therefore, efforts should be made to increase barley yield in the NEPZ and CZin collaboration with the State Department of Agriculture.

Table 5.6. Zone wise yield gain under BFLDs

Zone	BFLDs yield (q/ha)	Regional mean yield (q/ha)	% Increase
NHZ	26.22	19.25	36.21**
NEPZ	37.25	24.50	52.04**
NWPZ	48.97	42.48	15.28***
CZ	40.31	30.61	31.69***

*** Significant at 1% level, ** Significant at 5% level.

Constraints in barley production

Over all analysis of constraints in different zones clearly indicated that infestation of *Phalaris minor* in barley field, aphid attack, high cost of custom hiring, small holdings, high cost of inputs their quality and non-availability were observed as most serious constraints impeding barley production in the country.

Wheat and barley front line demonstrations by DWR, Karnal

During 2011-12, eight Wheat FLDs of DPW 621-50 variety were conducted in 4 hectares area in the villages namely Chopri, Kailash, Ramba, Karsa, Brass, Singhra, Katlaheri in district Karnal and Kandroli in district Yamunanagar. Zero tillage, Bio-fertilizer and varietal demonstrations were conducted with complete package of practices. During the same period, seven Barley FLDs of DWRB 73 and DWRUB 52 varieties were conducted in 5 hectares area in the villages namely Malkana, Behman Jassa Singh, Phulokeri, Sangat Khurd in district Bathinda; Kheri Musalmania in district Patiala in Punjab state in collaboration with United Breweries Limited, Patiala. In Haryana state, the Barley FLDs were conducted in Khanpur Kolian village in Kurukshetra District and Peont village in Karnal District.

Monitoring of FLDs

The wheat and barley FLDs were monitored periodically. Dr. Randhir Singh and Dr. Ramesh Chand monitored the wheat front line demonstrations at Bajaura, HP during 1-3 May, 2012. The crop was good, no disease was observed, there were weeds in the demonstration plot. The farmers do not apply herbicide and weeds are used as cattle fodder. The farmers were happy with the crop establishment. Dr. Randhir Singh along with Mr. Waghmare Sr. Tech. Assistant , PD Pulses, Bhopal monitored the wheat and barley frontline demonstrations at Rewa, Jabalpur centres during 25-27 February 2013 with local cordinators. Dr. Ramesh Chand along with Dr. Manoj Kumar Jangid monitored the Wheat and Barley frontline demonstration on 3-4 March 2013 at Udaipur centre alongwith Dr. Jagdish Chaudhary, MUA&T, Udaipur. At Kota centre, the wheat frontline demonstrations were monitored on 5-6 March 2013 alongwith Dr. Arun Kumar Sharma , Agriculture Research Station, Ummedganj, Kota (Rajasthan). The crop was very good and farmers liked HI 1544 wheat variety than Raj 3077, Raj 3765 and Lok 1. Though the crop was free from diseases, there were weeds at some farmers' field. Dr. Sendhil R along with Shri MN Raju, Joint Director, Directorate of Oilseeds Development, Hyderabad monitored Wheat FLDs conducted by Dharwad and Wellington Centres during 09.02.2013 to 21.02.2013. All the front line demonstrations had shown promising results and were better than the check plots at all the sites.

Weed management strategies at farmers' field in India

The survey was conducted during 2012 in randomly selected Patiala, Sangrur, Jalandhar and Mansa districts of Punjab in northern India representing rice-wheat, potato-wheat and cotton-wheat rotations. From each district, four villages and from each village 10 farmers were randomly selected, making the sample size 160.

Majority of the farmers were middle aged, literate, lives in joint families with more than 6 family members, had membership of some organization (cooperative societies) and more than 20 years of experience in agriculture. They sought information from fellow farmers, agriculture officers, newspapers, TV and input dealers for growing wheat crop. They used their own seed as well as purchased from private/ government seed agencies. Majority of them treated seed, however, a significant number of them had to adopt it. They used optimum seed rate and grew more than one variety of wheat. The main crop rotations were rice-wheat, cotton-wheat, rice-potato-wheat, potato-wheat-maize. Due to shortage of labour, combine harvesting was very common in the sampled area. They were aware of crop rotation strategy to manage weeds and more than 43% of them had adopted it. All the farmers had applied herbicides to control weeds, some of them did use herbicide twice in the same year, sprayed herbicide using cut nozzle and applied same herbicide next year. To achieve higher production, there should be timely sowing (Last week of October to 20th November), adopt zero tillage technique, grow latest recommended varieties, seed treatment, maximum usage of certified/quality seeds, nutrient usage as per soil testing, timely control of weeds with uniform spray using flat fan nozzle and rotation of herbicides and crop rotations as effective strategies to control weeds.

Factors affecting wheat yield in western UP

Wheat is grown in all the 26 districts of Western UP in an area of 3.13 m ha with an average estimated production of 11.01 mt (2010-11). The productivity of wheat in Western UP during 2010-11 was 35.14 q/ha. Among different regions of UP, western UP has much potential to harness the potential yield by bridging the existing yield gap.

Despite of concerted efforts by the various state governments, persistence of wide yield gaps are causing concern to the planners. Bridging the yield gaps could help to achieve and sustain food security to a larger extent. The awareness level and knowledge of farmers needs to be improved so as to fully exploit the latest technologies. Simultaneously, it is of great importance to assess the constraints faced by the farmers in wheat production. Keeping the above points in view, an attempt was made in the present study to identify the factors influencing the wheat yield and the constraints faced in wheat production in Western UP.

From the state of UP, district Saharanpur was selected for the study conducted during 2011-12. There are five tehsils in Saharanpur district i.e. Saharanpur, Nakur, Rampur Maniharan, Deoband and Behat. From each tehsil, one village was selected randomly, thus total five villages were selected. From each selected village and from each of the four categories of farmers, a total of 20 respondent farmers were selected proportionately through proportionate random sampling technique, making a total sample size of 100 respondent farmers.

Majority of the farmers were middle aged, matriculate, never attended an agriculture related training. Main occupation of all the farmers was agriculture for their livelihood and about one third of them were having dairying as their subsidiary occupation in addition to agriculture, 20 years experience in agriculture, joint family, 5 to 6 family members, members in two organisations, consult their neighbours/friends/relatives and progressive farmers, scientists/experts for agriculture related information, use multiple sources of mass media for agriculture related information. It was observed that newspapers and TV have emerged as important sources of information for the farmers. Majority of the farmers were marginal. The main crop rotations were rice-wheat and sugarcane-wheat. Across the crop rotations, 35% farmers had cultivated wheat crop in 50-75% of the total land area. Generally the farmers purchase wheat seed of new varieties from government and private agencies. The average wheat yield obtained was 18.19 q/acre and 17.10 q/acre under rice-wheat and sugarcane-wheat cropping system, respectively. The wheat yield have shown a decreasing trend when the sowing is delayed. The highest average wheat yield was obtained by marginal category of farmers followed by medium (18.15 q/acre), large (18.00 q/acre) and small (17.44 q/acre) farmers. Majority of the farmers had used broadcast method of wheat sowing. It was observed that the density of tree plantation has adverse effect on wheat yield. Majority of the sampled respondent farmers had medium level of attitude towards wheat production technology, medium level of knowledge, medium level of adoption of scientific wheat cultivation practices. In the analysis of different categories of constraints, it was observed that yellow rust, termite, *Phalaris minor* (mandusi), declining water table, non availability of labour, high cost of inputs, imbalanced use of fertilizer, lack of knowledge among farmers about recent technologies and non availability of electricity were the most serious constraints.

Impact of resource conservation technologies of wheat in Haryana

The study was conducted during 2012 in Karnal district of Haryana with 124 farmers who have adopted either of the three resource conservation technologies viz; zero tillage, rotary tillage and laser land leveler. Majority of the farmers belonged to middle age group and were well educated. Agriculture was their main occupation and most of the sampled farmers were also rearing animals for milk production. When farmers were categorized based on land holding it was observed that half of the farmers having less than 10 acres of land but when it was done on the basis of total land holding the percentage under very large category increased it means that taking land on rent for wheat cultivation was very common practice. Extension contact and mass media exposure was medium for majority of the farmers and majority of the farmers were under medium category for material possession. Custom hiring of machines was very common practice. Average rate of custom hiring/acre for zero tillage, rotary tillage and laser land leveler per hour was ₹ 490, ₹ 624 and ₹ 603, respectively. Tube well and canal water were major sources of irrigation in the study area and quality of water was good. The soil was medium to high fertile and was medium to light in texture. Burning of straw was also observed although farmers were using reaper for straw making. The positive impact of adoption zero tillage was on cost saving, time saving, management of *Phalaris minor*, fertilizer saving, fuel saving and germination. It was also observed that continuous use of zero tillage increases organic carbon in soil, improves water retention capacity, improves fertility status of soil, decreases lodging, avoid terminal heat. The increase in broad leaf weeds was observed in zero tillage fields especially Malwa parviflora. It was observed that adoption of rotary tillage had positive impact on better yield but some of the farmers reported that lodging and formation of hard pan in the soil. Due to adoption of laser land leveler farmers can increases area under cultivation, reduces water requirement, less lodging and more yield. Farmers suggested that these technologies should be promoted in the state by increasing/continuing subsidy on machines, Govt. should increase laser land leveler in each block for custom hiring, attach spreader with combine harvester to promote resource conservation technologies.

Costs and returns from wheat cultivation (2011-12)

As demonstrated by the comparative economics (Table 5.7), a significant difference in returns was noticed between FLD and check plots. Across zones, the gross returns and operational costs are higher in FLD plots in comparison to check plots with the exception of peninsular zone. The operational costs are higher in the SHZ followed by NHZ and NEPZ. However, the gross and net returns are highest in SHZ followed by NWPZ. Overall analysis indicated that profit per hectare from FLDs was more than the check varieties establishing the fact that FLDs carry the successful technologies from experimental farm to farmer's field. The present estimates are only the indicators for comparison and the difference in net returns is subject to farmer specific and region specific conditions as it varies from zone to zone and technology to technology.

Table 5.7. Costs and returns from wheat cultivation in ₹/ha

Wheat growing zones	FLD/ Check plot	Gross returns	Operational costs	Net returns
NHZ	FLD plot	60191	30794	29397
	Check plot	47600	28503	19097
NWPZ	FLD plot	84454	23077	61377
	Check plot	76086	22250	53836
NEPZ	FLD plot	64411	26896	37515
	Check plot	55890	26385	29505
CZ	FLD plot	69524	20018	49507
	Check plot	53589	17682	35907
PZ	FLD plot	61513	23507	38006
	Check plot	52264	23732	28532
SHZ	FLD plot	104056	39549	64507
	Check plot	NA	NA	NA

6 REGIONAL STATION, FLOWERDALE, SHIMLA

Incidence of wheat rusts

Owing to the dry weather, development of rusts occurred almost one month late than the previous two years. Except for yellow rust, incidence of other rusts was minimal. In some localities in Northern India, high severity of yellow rust of wheat was observed. Chemical intervention in the initial stages checkmated the yellow rust. Black rust was recorded in Ladakh and Nilgiri hills on summer crop only. In Ladakh, the high incidence of wheat and barley rusts was observed due to the cultivation of old varieties and land races. Brown rust occurred late in the season and incidence was very low.

Observations on aecial collections from different *Berberis* species

Since wheat rusts appear every season, therefore, a need was felt to revisit the role of alternate hosts in the life cycle of wheat rusts especially *Berberis*. None of the aecial samples from at least six *Berberis* species could infect wheat, barley and oat. These samples were drawn from at least four districts of Himachal Pradesh, Uttarakhand and Nepal. It indicated that the aecial cups in these areas do not relate to wheat rust. Similarly grass samples did not infect wheat, however, one sample infected oat and was recorded as leaf rust of oat.

Further fact to support the non-functional role of alternate hosts in India, is the occurrence of only few races. In countries where alternate hosts are operational for wheat rusts, the races occur in hundreds. The sexual reproduction results in independent assortment of different combinations resulting in large number of new races. Since, there are only few races of wheat rusts in India (around 100) during last 90 years, which is further indicative of the fact that alternate hosts may not be functional under Indian conditions.

Maintenance of national repository of pathotypes of rust pathogens

National repository of 126 pathotypes of different rust pathogens of wheat, barley, oat and linseed was maintained as live cultures and stored for long term also. To enable rust research elsewhere and creation of artificial epiphytotics, nucleus inocula of rust pathotypes was supplied to 49 Scientists/centers.

Sample receipt and analysis

During this period 1655 samples of different rusts of wheat and barley were received/ collected for pathotype analysis. These samples were from fifteen states of India, Nepal, Bhutan and Bangladesh. To know the pathotype distribution, this year 1006 samples of different wheat and barley rusts have been analysed so far.

Pathotype distribution

Emergence of new pathotypes of wheat rust pathogens render resistant wheat varieties susceptible. Therefore, a vigil is kept on the arisal of new pathotypes and distribution of the pathotypes in different wheat growing areas. A new pathotype builds to epidemic proportions in 4-5 years. Wheat rust samples are analyzed and new pathotype, if any is identified in initial stages. Consequently rust resistance sources are identified and anticipatory breeding is initiated. It makes high yielding, rust resistant wheat germplasm available before the new pathotype becomes epidemic. Occurrence of new pathotype was not recorded this year. A report on the pathotypes of *Puccinia* species occurring on wheat and barley during the year is presented here.

a. Brown rust of wheat (*Puccinia triticina*)

More than 360 samples of brown rust of wheat were analysed from 13 states of India, Bhutan, Nepal and Bangladesh. Among the 20 pathotypes identified this year, pathotype 121R63-1 (77-5) was most widely distributed and was observed in all the areas followed by pathotypes 21R55(104-2), 21R63 (104-3) (Table 6.1). These pathotypes constituted more than 80% population of *P. triticina* in this part of Asia. Pathotype 93R57 (104-4), which was identified in 2010 from Solan district in Himachal Pradesh has further spread to Uttrakhand, Delhi and Uttar Pradesh and was identified in 36 samples. Another pathotype which was recorded in 19 samples was 121R60-1 (77-9) which occur only in three states and Bangladesh. Pathotype 121R55-1(77-6) was also identified in 15 samples from four states. Other pathotypes except 93R39(162-2), were observed in few samples only.

Like India, pathotype 121R63-1(77-5) was widespread in Nepal and Bhutan. In Nepal, four pathotypes were identified in 21 samples. Likewise, in Bangladesh, four pathotypes were identified in 18 samples, of which 21R63 (104-3) was most common.

Table 6.1. Predominant pathotypes of *Puccinia* on wheat in India

Wheat Rusts	Predominant pathotypes
Black	62G29(40A),62G29-1(40-1)
Brown	121R63-1(77-5)followed by 21R55 (104-2), 21R63 (104-3)
Yellow	46S119 followed by 78S84 (virulent on PBW343) in Northern India whereas 38S102(I) in Nilgiri hills

b. Yellow rust of Wheat and Barley (*P. striiformis*)

During this year 510 samples of yellow rust were analysed from 8 states of India and Nepal. Among the 8 pathotypes reported on wheat, 46S119 was most frequent and widely distributed followed by 78S84 in Northern India. Other pathotypes were observed in very low frequency. In Nilgiri hills pathotype 38S102 (I) was observed in all the samples. This pathotype does not occur in Northern India. Occurrence of pathotype 46S119 in this area needs further verification.

In barley 18 samples from India and Nepal were analysed for yellow rust. Among the four pathotypes identified, pathotype 1S0 (M) was most common. Other pathotypes occurred in few samples only.

Leh Ladakh area (Jammu and Kashmir)

In this area pathotypes 14S64 (CI) followed by 15S64 (CII) and 78S64 (CIII) were observed during 2011 summer crop. These pathotypes are very simple and can infect Kalyansona only. There is no change in racial pattern in this area in comparison to 1992. All the present day wheat varieties or those released for cultivation in the last 20 years in Northern India are resistant to these pathotypes. Pathotype 1S0 (M) was observed in the samples of barley yellow rust from this area.

c. Black rust of Wheat (*Puccinia graminis tritici*)

Seventy samples of black rust of wheat were analysed from five states of India and Bhutan. Pathotype 62G29 (40A) was the most frequent and was observed in 40% of the samples. In four samples from Karnal, pathotype 79G31(11) was observed in four, 127G29(40-3) in two and 62G29(40A) in one sample only. All the 8 samples from Gujarat were of pathotype 62G29 only. In Tamil Nadu pathotype 62G29-1 (40-1) was more predominant followed by 62G29. One sample analyzed from Bhutan was of pathotype 58G13-3(40-2).

Ladakh Area

All the samples of *Puccinia graminis tritici* (Black rust) from this area harbour pathotype 10G13 (34-1). Common *Sr* genes like *Sr* 8, *Sr* 11, *Sr* 31 of Indian wheat varieties are resistant to this pathotype. Wheat varieties under cultivation or released for cultivation in Northern India for the last 20 years are resistant to this pathotype.

Adult plant evaluation of AVT IInd year entries against yellow and brown rust under polyhouse conditions

Forty two lines of AVT II pertaining to North Western Plain Zone and Northern Hills Zones were evaluated against the pathotypes 77-5,104-2 of *Puccinia triticina* and 78S84, 46S119 of *P. striiformis* in controlled conditions of polyhouse (Fig. 6.1). The material was tested in seedling and adult plant stages simultaneously. It was observed that HS541, HS542 HD3059, HD3065, WHD 948, HD3043, PDW291, PDW314 and WH1021 possessed substantial resistance

Fig. 6.1. Evaluation for adult plant resistance in poly house

to both the rusts. In addition HS490, BL892, HD3070, NIAW1594, PBW658, WH1097, WH1098 were resistant to stripe rust whereas, MACS3828, PBW660, PBW599 were resistant to leaf rust. Remaining lines showed varying degree of susceptibility to one or other rust.

Seedling resistance test against wheat and barley rusts

To identify rust resistant pipeline material and know their genetics of rust resistance more than 1625 lines comprising advance varietal material and breeders material were evaluated against different pathotypes of rust pathogens. To identify rust resistance in wheat, 230 lines of AVT were subjected to multi-pathotype tests at seedling stage (Fig 6.2) against different pathotypes of *Puccinia triticina* (brown rust), *Puccinia graminis tritici* (black rust) *Puccinia striiformis* (yellow rust). The tests were repeated to confirm the consistency of infection types and effect of temperature on the resistance.

Fig. 6.2. Screening for rust resistance at seedling stage

Rust resistant lines

During 2011-12, two hundred thirty lines of AVT material were evaluated against different pathotypes of yellow rust (*Puccinia striiformis*) brown rust (*Puccinia triticina*) and black rust (*Puccinia graminis tritici*) under controlled conditions. To ascertain the host-pathogen interaction, the experiment was repeated with selected pathotypes.

Resistance to all the rusts was not observed in any of the lines. All the lines that possessed *Sr*31 were resistant to black rust.

Resistant to brown and black rusts : Thirteen lines viz. Cow(W)-1, GW432, HD2864, HD3093, HD3095, HI1544, HI1563, HUW652, NIAW1689, RAJ4240, RAJ4245, RAJ4270 and UP2825.

Rust resistance genes in AVT lines

Rust resistance genes were characterized in more than 170 lines on the basis of gene matching technique. Morphological markers, linked resistance genes and characteristic infection types were also criteria for postulation of rust resistance genes when host- pathogen interaction was not sufficient to postulate resistance genes.

Lr genes

Ten *Lr* genes (*Lr*1,3,10,13,18,23,24,26,28,34) were characterized in 151 lines. Most of the lines possessed more than two resistance genes. *Lr*23 was the most common resistance gene and was characterized in 58 lines followed by *Lr*13 (56 lines). The proportion of lines with *Lr*26 has reduced and was identified in 42 lines only. Likewise *Lr*10 was postulated in 46 lines *Lr*1 in 25 lines. *Lr*28, *Lr*3 and *Lr*24 were inferred in few lines only. Evaluation of durum showed that four lines possessed *Lr*18. *Lr*34 was postulated in eight lines only.

Rust resistance genes
Lr: *Lr*1,3,10,13,18,23,24,26,28,34
Sr: *Sr*2,5,7b,8a,8b,9b,9e,11,12,13,24,30,31
Yr: *Yr*2, A, 9,18,27

Yr genes

Five *Yr* pattern were postulated in 117 lines . *Yr*2 was the most commonly identified resistance gene and was identified in 64 lines. However, *Yr*2 is susceptible to most of the pathotypes. *Yr*9 linked to *Lr*26 and *Sr*31 was identified in 42 lines. Other resistance genes like *Yr*A, 18, 27 were identified in 8 lines each.

Sr genes

Thirteen *Sr* genes (*Sr*2,5,7b,8a,8b,9b, 9e,11,12,13,24,30,31) were characterized in 159 lines. *Sr*11 was postulated in 59 lines followed by *Sr*31 and *Sr*2 in 42 and 37 lines, respectively. Postulation of *Sr*31 is based on its linkage to *Lr*26 and *Yr*9. *Sr*8a was identified in 30 lines. *Sr*5 in 17, *Sr*7b in 10, *Sr*30 in 7 lines. Other resistance genes were postulated in few lines only. Most of the durum wheat varieties had resistance based on *Sr*7b,*Sr*9e, *Sr*11 and *Sr*13.

Wheat disease monitoring nurseries

To keep a vigil on wheat rusts, their incidence, spread and performance of cultivated varieties, Wheat disease monitoring nursery is planted regularly. It was proposed to be planted in 2011-12 at 38 locations covering all the major wheat growing areas in the country, especially those situated near the bordering areas to the neighbouring countries. Data on wheat disease situation was received from 38 locations. Information on disease situation was received from Almora, Pantnagar, Dhaulakuan, Malan, Sundernagar, Shimla, Bajaura, Dalang Maidan, Sangla, Kukumseri, Kangra, Kathua, Jammu, Rajauri, Leh, Dera-Baba-Nanak, Abohar, Ludhiana, Hisar, Yamuna Nagar, Kalyani, Sabour, Ranchi, Faizabad, Kanpur, Bilaspur, Sagar, Powarkheda, Vijapur, Junagarh, Pune, Niphad, Akola, Dharwad and Wellington. Incidence of disease was less in most of the areas. Wheat rusts were not observed in the locations at Akola, Sagar, Indore, Pusa and Kalyani.

During 2011-12, SAARC wheat disease monitoring nursery was planted at 23 locations across the six SAARC nations. Observations on the occurrence of wheat diseases have been received from Bangladesh, Nepal, Pakistan and all the 14 locations in India. Yellow rust was more prevalent in Northern India, Pakistan and Afghanistan whereas blight was common in Eastern India, Bangladesh and Nepal. Incidence of yellow rust was more in Northern India than Pakistan and Bangladesh, indicating a different racial pattern of *P. striiformis*.

7 REGIONAL STATION, DALANG MAIDAN, LAHAUL 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 & barley during summer (May to Oct.) as off season nursery.

Generation advancement of wheat and barley material

During the year 2012, about 36,000 lines of wheat and 900 lines of barley from 19 co-operators were advanced at DWR regional station Dalang Maidan, which was a record in the history of this national service centre. The station received three species of wheat i.e. *Triticum aestivum*, *T. durum* and *T. dicoccum* which were advanced at the station during this season. Apart from this some wild species were also grown at the centre. Besides Directorate of Wheat Research, Karnal, Indian Agricultural Research Institute, New Delhi; Chaudhary Charan Singh Haryana Agricultural University, Hisar; VPKAS, Almora, National Agri-Food Biotechnology Institute, Mohali and National Bureau of Plant Genetic Resources, New Delhi and Punjab Agriculture University, Ludhiana were major centers that extensively utilized this national facility for wheat and barley research programs.

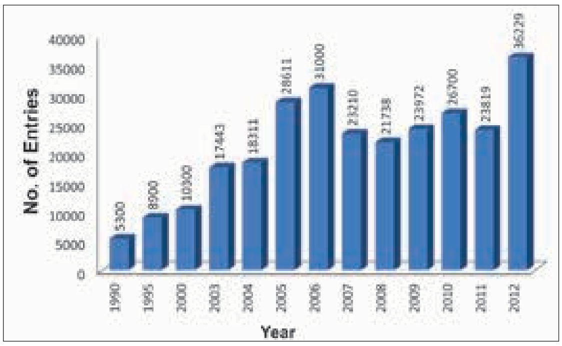


Fig. 7.1. Wheat lines grown during 1995 to 2012

Corrective hybridization

During this year about 1000 corrective crosses were attempted by the researchers across the institutes. DWR, Karnal attempted 254 crosses followed by IARI, New Delhi (232 crosses). A new initiative for doubled haploid production was also initiated 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. Approximately 15,000 lines were screened by various centers. This season showed that this station could also act as screening centre for powdery mildew.

Wheat × 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 F_1'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 (Fig. 7.2).

Fig. 7.2. Double haploid production in Wheat

8 BARLEY NETWORK

The Barley Network Unit at DWR Karnal coordinates the research programme on barley in country under the AICW&BIP. It is done through multi-disciplinary experiments conducted across the barley growing zones at funded and voluntary centres. This facilitates the identification of new cultivars for commercial cultivation with wider adaptability, resistance to various biotic and abiotic stresses prevalent in the area, suitability to specific production conditions and with desired quality. In addition the experiments are also conducted on aspects of improvement/ optimization of production technologies, including conservation agriculture. The crop protection programme includes the screening of new genotypes under artificial epiphytotic/ hot spot conditions. The experiments on chemical control and IPM are also organized at various test centres. The annual review and work planning meeting and zonal monitoring programmes are organized to achieve these objectives. Varietal improvement in barley through organization of yield evaluation trials, diseases/ pests screening and malting quality evaluation for the network centres is the most important activity of DWR. Updating of package of practices for barley cultivation and standardizing optimum inputs for new genotypes are achieved through agronomic trials. The barley growing area in country is grouped in four major zones i.e. NWPZ, NEPZ, CZ, NHZ with respect to prevailing climatic conditions and /or the disease/ pest spectrum.

The research efforts of the barley network are also supplemented by DWR through research on specific aspects/ areas of barley improvement especially in malt barley improvement, application of biotechnological tools in disease resistance and quality improvement, improvement of cultivation package and basic studies on pathogens. Promotion of utilization of the new/ exotic genetic resources and creation of new variability are the important aspects in improvement of barley quality traits as well as resistance to diseases. In addition, DWR also has linkages with international organizations like ICARDA, Syria to facilitate the access to new germplasm of diverse origin for evaluation and utilization by the national programme under the network activities. A set of international yield trials and observation nurseries are received every year from ICARDA, Syria and organized at desired locations under AICW&BIP.

New barley varieties released

Four new barley varieties namely viz. DWRB 91, RD 2786, RD 2794 and VLB 118 were identified during 51st AICW&BIP workers meet at RRS, SKRAU, Durgapura, Jaipur and the varieties namely DWRB 91 (Fig. 8.1), RD 2786 and RD 2794 were released/ notified by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) during the year, for cultivation in different zones (Table 8.1).

Fig. 8.1. Two row malt barley variety DWRB91 for irrigated late sown condition of NWPZ

Table 8.1. New barley varieties released for commercial cultivation

Variety	Parentage	Area of adaptation	Production conditions	Salient characteristics	Developed at
DWRB91	DWR46 / RD2552	NWPZ	Irrigated late sown	Two row malt barley with good grain under late sown conditions, resistant to stripe and leaf rusts	DWR Karnal
RD 2786	RD 2634/NDB 1020//K 425	CZ	Irrigated timely sown	Six row feed barley with tolerance to yellow and brown rust	RRS, SKRAU, Durgapura
RD 2794	RD 2035 / RD 2683	NWPZ and NEPZ	Saline/ alkaline soils	Six row feed barley for saline and alkaline soils	RRS, SKRAU, Durgapura

Coordinated yield evaluation trials

Out of 125 yield evaluation trials proposed, 121 (96.8%) trials were conducted. Four trials were either not conducted/failed or rejected by monitoring team/data were not received in time. After the analysis, only 112 trials (89.6% of proposed / 92.6% of conducted) were found good for reporting (Fig. 8.2). This has shown an improvement over previous year's performance of the network programme. These trials were conducted at 12 main centres and 37 testing centres (including ICAR, SAUs and State Department of Agriculture) during rabi 2011-12. In all 120 test entries contributed by 12 centres, were evaluated against 21 checks in the coordinated yield trials under rainfed (plains and hills), irrigated (plains) and saline soils conditions under timely/ late sown conditions. The new barley entries include malt, feed or dual purposes types and mostly were hulled type with a few hull-less types in northern hills zone. Out of these 120 entries, 18 were found promising, in which five were promoted for final year evaluation in different trials (Table 8.2).

Table 8.2. Promising genotypes observed in barley network yield trials during Rabi 2011-12

Trial name	Promising genotypes	
	AVT	IVT
Irrigated (Malt Barley)-TS	DWRB92,	DWRB101, RD2849
Irrigated (Malt Barley)-LS	-	BH968
Irrigated (Feed Barley) NWPZ	HUB113, BH946	RD2830, RD2832
Irrigated (Feed Barley) NEPZ	HUB113, RD2811	
Irrigated (Feed Barley) CZ	-	RD2830, RD2833, BH959
Rainfed (NHZ)	BHS400	HBL712
Dual type (Rainfed Hills)	-	VLB129, VLB130, VLB132, UPB1021
Total	5	13

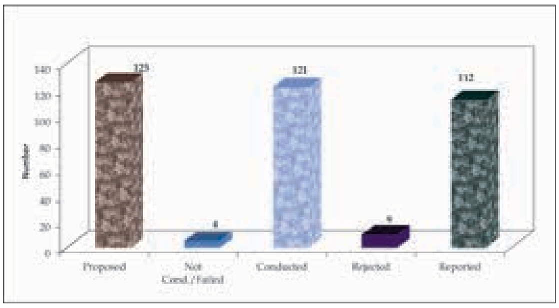


Fig. 8.2. Details of barley coordinated yield trials

Zonal monitoring

The teams constituted for monitoring of barley network yield trials & nurseries in CZ, NWPZ, NEPZ and NHZ, visited different locations of the three zones at the most appropriate stage of the crop and recorded observations about the varietal performance, conduct of trials, disease/ pest incidence and genetic purity of the test entries. The team in NHZ was common for wheat and barley crops, while in other two zones barley monitoring was done little earlier keeping the crop stage in mind (Table 8.3). On the spot decisions were taken about the rejection of trials and purity of test entries through consensus.

Table 8.3. Zonal monitoring visits of the barley team

Zone	Dates	Centres visited	Team members
CZ	13-16 Feb., 2012	Kota, Bhilwara, Banswara, Udaipur	Drs. AS Kharub, Dinesh Kumar, Sudesh Kumar, PS Shekhawat
NEPZ	20-24 Feb., 2012	Dalipnagar, Kanpur, Faizabad, Masodha, BHU Varanasi, Tissuhi, Mirzapur, Rewa	Drs. RPS Verma, B Sarkar, R Selvakumar, PK Gupta, SR Vishwakarma, AK Singh
NWPZ	28 Feb. to 4 March, 2012	Durgapura, Tabiji, Bawal, Hisar, Sriganganagar, Bathinda, Ludhiana	Drs. RPS Verma, AS Kharub, R Selvakumar, Dinesh Kumar, M Shrimali, PS Shekhawat, Sudesh Kumar , SR Verma,
NHZ	16-19 April, 2012	Two teams, one each in H.P. & Uttarakhand	Joint wheat and barley groups

Nucleus and breeder seed production and test stock multiplication

The consolidated indent of 1841.60q breeder seed of twenty-eight varieties was received from the Department of Agriculture and Cooperation (DAC) for the production during *rabi*, 2011-12.

The indent included requirement of nine states, three public sector corporations and private agencies (SAI). The major proportion of the breeder seed indent (Fig 8.3.) was for Rajasthan state (1080q) followed by UP (360q) and SAI (241.55q). The indent was allocated to eleven coordinated centres over eight states for the production. The net production of 1905.80q breeder seed was reported, which was 64.20q surplus over the allocated quantity. The maximum production was observed for variety RD 2035 (449q) followed by RD 2592 (243q), RD 2552 (232q), RD 2668 (186q), RD 2715 (110q), RD 2052 (97q), K 551 (76q), NDB 940 (75q), BH 393 (70q), K 508 (65q), BH 902 (60q), NDB 1173 (50q), K 560 (43q), RD 2660 (37q) etc. In most of the varieties sufficient breeder seed was produced to meet the DAC requirement, however, a deficit seed production was reported for the varieties viz. PL 426 (-63.60q), RD 2660 (-48q), DWRB 73 (-35q), NDB 1173 (-35q), RD 2668 (-26q), NDB 940 (-21q) DWRUB 52 (-15.50q), NDB 1020 (-12.50q) etc. at different production centres.

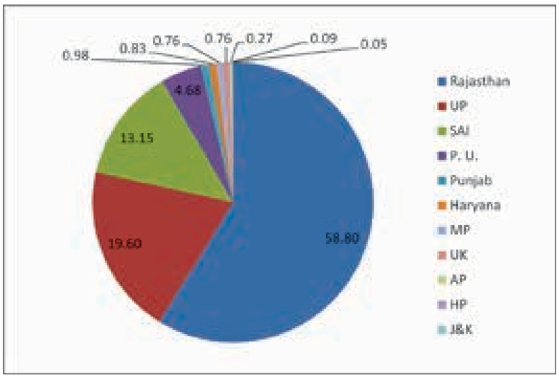


Fig. 8.3. Proportion of breeder seed indent by various agencies

During *rabi*, 2011-12, 98q nucleus seed for twenty eight varieties was allocated and production of 79.72q of seventeen varieties was reported. The maximum nucleus seed production was observed for the variety RD 2035 (20.25q) followed by RD 2552 (11.70q), RD 2668 (7.30q), RD 2052 (6.85q), RD 2592 (6.25q) etc.

Apart from this, 27q test stock multiplication of the variety DWRUB 64 was also reported from State Farms Corporation of India Ltd (SFCI).

Germplasm exchange and evaluation

Plant genetic resources are the basic raw material, essentially required for crop improvement programme. The change in the racial flora of the pathogens, depleting natural resources and rising population pressure especially in the era of climate change has forced the plant breeders to seek the genetic diversity for its continuous improvement. At the Directorate the following activities were carried out :

National Barley Genetic Stock Nursery (NBGSN)

The NBGSN with promising entries from network centres was constituted with 22 entries having donors for high yield, malting quality traits and disease resistance. The nursery was supplied to all 11 centres under barley network however, nine centres (Karnal, Durgapura, Varanasi, Hisar, Faizabad, Kanpur, Rewa, Pantnagar and Ludhiana) supplied feedback of its utilization.

Elite International Barley Germplasm Nursery (EIBGN)

An elite international barley germplasm nursery was constituted with 54 genotypes selected from international trial/nurseries and evaluated at barley network centres. This nursery included 13 entries from IBYT-HI, 5 entries each from INBYT and IBYT-LRA-M, 4 entries from IBYT-LRA-C, 10 entries from INBON and 17 entries from ISEBON. Most of these entries were utilized by all centres either directly or in hybridization programme or selected for further evaluation and use in their breeding programmes.

Rejuvenation

To ensure proper storage and viability of germplasm accessions maintained in the germplasm repository of the DWR, rejuvenation of the available germplasm is a high priority regular activity. During the year, 922 accessions were rejuvenated for maintenance of germplasm under active collection at DWR, Karnal .

Conservation

Presently the directorate have a total collection of 7975 barley accessions which are being conserved at medium term storage (MTS) facility for 6-8 years at DWR under 4±2 ^{0}C temperature with 35±5% relative humidity. During the year, new BCU numbers (382) were added including yellow rust resistance lines, international accessions and advanced breeding lines in active collections at DWR.

Coordination and evaluation of international trials/ nurseries

The national barley improvement programme needs regularly the new diversity in order to facilitate the availability of new germplasm from diverse sources. During the year 2011-12, different international trials and nurseries received from ICARDA were sown at Karnal centre and various under barley network (Table 8.4).

Table 8.4. International trials / nurseries grown in India

SN	Trial / nursery	No. of entries	No. of sets	Evaluation centres
1	IBYT-HI	25	Five	Karnal, Hisar, Durgapura, Varanasi, Kanpur
2	IBYT-MRA	25	Three	Karnal, Rewa, Kanpur
3	IBYT-LRA-C	25	One	Karnal
4	INBYT	25	One	Karnal
5	IBYT-LRA-M	25	Three	Karnal, Rewa, Durgapura
6	IBON-HI	103	Six	Karnal, Hisar, Durgapura, Varanasi, Kanpur, Faizabad
7	ISEBON	91	One	Karnal
8	IBON-LRA-C	90	Two	Karnal, Ludhiana
9	IBON-LRA-M	96	Four	Karnal, Durgapura, Rewa, Faizabad
10	IBON-MRA	87	Four	Karnal, Hisar, Kanpur, Faizabad
11	INBON	112	One	Karnal
12	IBCB-S	144	One	Karnal
	Total	**848**	**32**	

Twelve yield trials/nurseries were received from ICARDA, Syria, comprised of 848 new genotypes evaluated at Karnal and other coordinated centres. From different trials / nurseries, 257 selected genotypes on the field day were dispatched to the respective breeders.

Malt barley improvement

New varieties developed/ released

A new genotype DWRB91 developed under the project, has been released and notified by the CVRC for commercial cultivation in the north western plains zone as malt barley. It is a two-row malt barley variety for irrigated late sown conditions of north western plains zone (NWPZ), which was identified during the 51st AICW&BIP annual workshop at Jaipur in August, 2012 and subsequently released in January 2013 in CVRC meeting. DWRB91 has recorded good grain yield levels with acceptable quality in barley network yield trials. The variety has opened up the new possibilities of the cultivation in the late sown (especially in cotton belt) areas of the country by combining high grain yield, disease/ pest resistance and good malting quality in two-row background.

Promotion of entries in barley network trial

The malt barley entries submitted from the programme have performed better in coordinated trials during Rabi 2011-12 crop season. Entry DWRB 92 has been advanced to the final year of AVT (TS-MB) for evaluation. Entry DWRB101 has been advanced to AVT (TS-MB) first year from IVT. These promotions are based on their superior performance with respect to grain yield, resistance to rust and malting quality in the multi-location trial conducted in NWPZ. The detailed performance of these entries in coordinated yield trials is summarized in Table 8.5.

New entries submitted to barley network trials (2012-13)

The efforts had resulted in development new strains which after qualifying in DWR Station Trials have been submitted for multi-location yield evaluation trials under Barley Network. During the year nine new entries which performed better in station trials have been

Table 8.5. Performance of new entries under barley network trials

SN	Name	Parentage	Yield (q/ha) (Avg. & Range)	Rk	H. days	Tiller/ meter	YR score (ACI)	LB (mean/ HS)
AVT-TS-MB								
1	DWR 92	DWR28/ DWR45	49.0 (35.0-65.5)	1	89	138	10S (2.0)	45/99
2	DWRUB52 (C)	DWR17/K551	48.1 (31.4-58.6)	3	87	154	0.0	34/99
3	BH902 (FB) (C)	BH495/RD2552	48.2 (29.6-61.1)	2	91	117	0.0	46/78
IVT (TS-MB)								
1	DWRB101	DWR28/BH581	50.4 (36.2-64.6)	3	85	152	TMS*(0.11)	35/78
2	RD2668 (C)	RD2035/BCU73	43.2 (30.8-75.5)	19	85	138	30S (5.0)	34/78
3	DWRUB52 (C)	DWR17/K551	47.1 (24.8-64.6)	9	87	151	0.0	34/99
4	BH902 (FB) (C)	BH495/RD2552	50.6 (37.8-62.8)	2	91	106	0.0	35/78

submitted from the project to coordinated trials during 2012-13 crop season (Table 8.6).

Table 8.6. New entries submitted to IVT 2012-13

SN	IVT No. (12-13)	Entry No. in BST	Parentage	Trial
1	DWRB113	BK1121	DWRUB52/ DWRUB54	IVT- MB – TS + LS
2	DWRB114	BK1103	VJM515/ DWR38	IVT- MB –TS
3	DWRB115	BK1101	VJM514/ DWR38	IVT- MB –TS
4	DWRB116	BK1110	BCU522/ DWR51	IVT- MB –TS
5	DWRB117	BK1109	DWR47/ BCU78	IVT- MB –TS
6	DWRB118	BK1122	DWRUB52/ DWRUB54	IVT- MB –LS
7	DWRB119	BK1123	DWRUB52/ DWRUB54	IVT- MB –LS
8	DWRB120	BK1124	DWRUB52/ DWRUB62	IVT- MB –LS
9	DWRB121	BK1119	BCU4765/ DWR28	IVT- MB –LS

Evaluation of parental lines

A collection of 265 different lines was grown and evaluated for various morphological and agronomic traits as malt barley crossing block. In order to enrich the parental lines collection 29 new entries from ICARDA, Syria (exotic popular malt barley cultivars released in Europe and other countries) have been acquired from different sources and included in the crossing block for the malt barley breeding project. The DWR programme has immensely benefited from these acquisitions as many lines are having excellent grain quality. The grain and malt traits analysed on the new additions. The parental lines with excellent malting quality were identified for use in the breeding programme at DWR Karnal.

Hybridization programme

In order to incorporate yield, quality, disease/ pest resistance, local adaptation and early maturity in two-row exotic barleys, 126 new crosses were made during 2011-12 season. Based on seed availability 90 F_1s were sent for advancement to F_2, but only 88 could be recovered from off season nursery. Various sources of resistance (aphid, rusts, blights and nematode) and early maturity have been utilized in hybridization programme. Also the semi winter x spring type and two x six-row crosses for improvement of various parameters in both types of barleys, along with good malting qualities were attempted (Table 8.7).

Table 8.7. Malt barley breeding material grown in rabi 2011-12

Generation	Grown		Selected			
			Field selection		Grain selection	
	Families	Crosses	Families	Crosses	Families	Crosses
F_9	1	1	1(B)	1	1(B)	1
F_8	7	4	4(B)	4	4(B)	4
F_7	1	1	-	-	-	-
F_6	51	29	19(B) +5	18 (B)+2	19(B) +5	18 (B)+2
F_5	93	39	6(B)+127	36	6(B)+84	(6)+36
F_4	139	76	234	73	143	69
F_3	166	77	302	75	169	66
F_2	238	238	434	196	248	180
F_1 *	124	124	1	1	1+88**	1+88**
Total	696	465	1132	405	676	382

* Not included in respective totals, (B) = Bulks made for preliminary yield trial , **Crosses made and advanced to F_2 in off season

Some double and three way crosses have also been attempted. During the year 2011-12, the breeding material in different generations (696 families representing 465 crosses involving several generations from F_2 to F_8) was grown and screened for stripe rust and leaf blight under artificial epiphytotic condition. The single plant selections were made in different generations for phenotypic appearance, disease reactions. In all, 1132 single plants representing 405 crosses were selected, for generation advancement based on desirable morphological traits, resistance to stripe & leaf rusts, blights & aphid. These selections were subjected for grain scoring and rejecting undesirable grain types in laboratory. Based on desirable grain score 676 single plant progenies representing 382 crosses were selected, for generation advancement.

Feed barley improvement

In the second year of the project, 265 indigenous and exotic germplasm accessions and released varieties were evaluated to identify breeding material/parental lines. 46 winter barley accessions were also evaluated to introduce the exotic superior barley varieties/ breeding lines in crossing block. In the process of evaluation of exotic lines received from ICARDA in the form of international trials/nurseries, six superior lines were selected and evaluated under station trial in the crop season 2011-12. Four strains were found superior and promoted for IVT-FB (DWRB 109, DWRB 110) and AVT-RF-NHZ (DWRB 111 and DWRB 112), respectively. The exotic entries from international trial /nurseries were put under observation trial to identify suitable lines and eight high yielding strains viz. BK 1232 to 1239 were contributed for station trial (timely sown) for further testing.

Hybridization programme and breeding material

In order to incorporate disease/pest resistance, local adaptation and high grain and fodder yield 144 new crosses were made during 2011- 12 and 117 F_1s were advanced to F_2s in off-season nursery (summer, 2012) at DWR regional station L&S (HP). During 2011-12, 137 F_2s were multiplied and advanced for which crosses were attempted during last season and 181 selections were also made from 68 F_2s. 14 three-way crosses were also made using the F_1s. Various sources of resistance (aphid, rusts, and blights) and yield attributes including winter gene-pool, indigenous and exotic lines have been utilized in hybridization programme. Also the winter x spring type and two x six-row crosses for improvement of various parameters in both types of barleys were attempted.

Molecular studies for spot blotch resistance in barley

The research work to identify markers linked to spot blotch resistance and to study their genetic inheritance in barley has been in progress under barley molecular program. Contrasting parental lines for cross DWR49 X RD2503 were screened with 270 SSR markers and total 50 SSR markers segregated co-dominantly for this trait. These 50 SSR markers were used to genotype individual 142 RILs to generate genotypic data for QTL analysis. The genotypic and two years (2009-2011) phenotypic data were analyzed for single marker analysis. Interval mapping using SSR markers Bmac213, ABG059 and Bmag211 on chromosome 1H were found to be closely linked with leaf blight resistance in barley during single marker analysis. The data were further analyzed for Interval mapping using GTQ Map Manager. SSR markers Bmac213 (20.7) and ABG059 (25.1) on chromosome 1H were found linked with leaf blight resistance during QTL mapping at p=0.05. This information may help for QTL studies of spot blotch resistance in Indian barley breeding program.

Molecular profiles of barley genotypes

A set of 46 SSR markers covering all the seven chromosomes of barley was screened with the final year test entries (VLB118, BH933, RD2784, RD2786, RD2787, BH932 and DWR91) and important check varieties (HBL113, UPB1008, BHS352, PL751, BH902, RD2035, RD2552, K551, DWRUB64 and DWRB73) to develop DNA fingerprinting data. In total 68 marker alleles were scored in selected genotypes, thereby approximately 1156 data points were considered during molecular markers analysis. Molecular weights for microsatellite products, in base pairs, were estimated and the summary statistics including the number of alleles per locus and polymorphism information content (PIC) values were determined. Out of screened markers, only 22 were found polymorphic and number of alleles ranged from 0 to 2 with an average of 1.48 alleles per locus. The band fragment size varied from 108 bp to 1200 bp with PIC values ranging from 0 to 0.4160. This average level polymorphism and PIC values suggested the lesser level of genetic variability among the prominent cultivars of barley and candidate varieties identified in crop season 2011-12 under AICW&BIP for major three barley sowing regions (North, North Western Plains and Central zones) of India.

A set of 120 SSR/STS molecular markers covering whole genome of barley was used to develop amplification profiles of the identified varieties for year 2011-12. Identified variety DWR91 with four checks DWRUB 64, DWRB 73, BH902 and K 551, identified variety VLB118 with checks HBL113, UPB1008 and BH352, identified variety RD2786 with check PL751, identified variety RD2552 with checks NDB1173 and RD2794 were screened with selected molecular markers to develop amplification profiles for registration purpose as per the recommendation of registration committee. These molecular profiles efficiently discriminated the identified varieties from their respective checks (Fig 8.4).

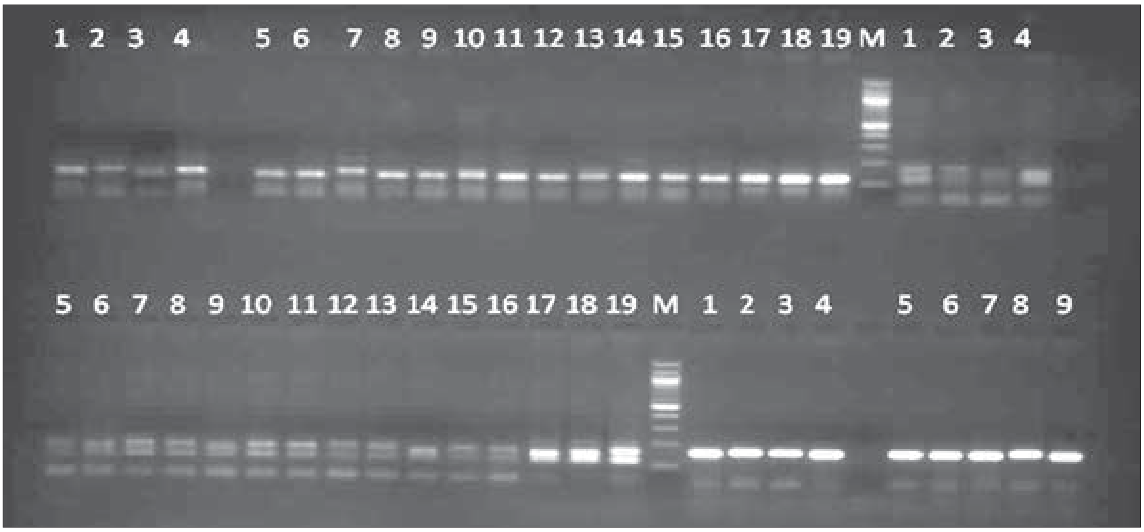


Fig.8.4. Amplification profiles of advanced varietal lines and checks with markers Bmag125, Bmag 849 and Bmag 749 located on barley chromosome 2H. Well: M-Ladder, 1-VLB118, 2-HBL11B, 3-UPB1008, 4-BHS352, 5-RD2552, 6-NDB1173, 7-BH933, 8-RD2784, 9-RD2786, 10-RD2787, 11-PL751, 12-BH932, 13-BH902, 14-RD2035, 15-RD2552,16-DWR91, 17-K551, 18-DWRUB64, 19-DWRB73

Malting quality evaluation

The Barley network unit took up the evaluation of grain samples of Advanced Varietal Trial (AVT) and Initial Varietal Trial (IVT) on malt barley received from various test sites at its central facility for malting quality evaluation. The malt barley varietal trials were conducted in NWPZ during Rabi 2011-12, in two sowing dates as separate sets. The grain samples were received from eight locations (Hisar, Karnal, Bawal, Ludhiana, Bathinda, Durgapura, Pantnagar and Mathura) in timely sown and from six locations (Hisar, Karnal, Ludhiana, Bathinda, Pantnagar and Durgapura,) in late sown conditions. This year a total of 392 coded entries were received. There were 16 test entries in IVT (TS) which were analyzed with four checks, while 13 test entries in IVT (LS) were evaluated with five checks. In case of AVT (TS), two entries (DWRB92 and DWRB93) with three checks and in AVT (LS) also, two entries (DWRB91, DWRB92) with four checks were analyzed.

The samples were first analyzed for physical and biochemical grain parameters important for malting based on the approved guidelines. The different traits (test weight, bold / thin proportion, germinative energy, 1000 grains weight and husk content) were analyzed as per EBC approved procedures. The processed grain samples (thin grains removed) were subjected to micro-malting taking 100 g sample from each variety. The check varieties were included in each batch of 80 varieties during malting and the cycles were adjusted keeping in view the performance of checks during malting process. The Analytical Guidelines for Barley Breeders in India approved by the "National Core Group on Malt Barley Development" (NCGMBD) were followed for the minimum standards of physical and biochemical properties of barley grain and malt, for evaluation of new genotypes. The analytical methods of EBC (Analytica EBC, 2003) were followed for determination of various quality parameters. The analysis of diastatic power (D.P.) of malt was done as per the IOB method and expressed in °Linter value.

There were several entries observed promising for individual traits, after the detailed analysis across locations in the NWPZ (Table 8.8). This was done by the system of scoring giving due weightage to important traits. Thus based on the ten important traits (a maximum possible score of 30) entries DWRB102, DWRB103, DWRB104, RD2848 and RD2849 were having better overall malting quality score under timely sown conditions. In late sown trials BH968 was found promising.

Table 8.8. Promising entries for individual malting quality trait

Traits	Promising entries	
	Timely sown	Late sown
Test weight (≥65kg/hl)	BH966, DWRB101, DWRB103, DWRB104, PL867, PL870, RD2848, RD2849, RD2851, DWRUB52 (Check)	BH968, DWRB104, PL870
Grain plumpness (>90 %)	BH966, DWRB92, DWRB93, DWRB102, DWRB104, DWRB105, PL867, PL870, RD2851	DWRB92
Protein content (< 11.0 %)	BH964, BH966, DWRB92, DWRB101, DWRB103, DWRB104, DWRB105, PL869, RD2848, RD2849, RD2851, RD2668 (Check)	BH968, DWRB91, DWRB108, RD2853, RD2855, DWRUB64 (Check), DWRUB52 (Check), K551 (Check), BH902 (Check)
Husk content (<11.0 %)	BH963, BH964, BH965, DWRB102, DWRB103, DWRB104, PL870, RD2849, RD2851, RD2668(Check)	BH967, BH968, DWRB103, DWRB104, DWRB106, DWRB107, PL870, RD2855
Malt friability (>70%)	BH965, DWRB101, DWRB102, DWRB104, PL869	DWR92, DWRB103, DWRB104, DWRB106, DWRB107, DWRB108, RD2854
Hot water extract (≥81%)	BH963, BH965, DWRB101, DWRB102, DWRB103, RD2850, RD2668(Check)	BH967, DWR92, DWRB103, RD2854, RD2855, DWRB73 (Check)
Filtration rate (>210 ml/hr)	BH965, DWRB102, DWRB104, RD2848, RD2849, RD2668 (Check)	DWR92, DWRB103, DWRB106, DWRB107, RD2854
Beta glucan % (≤ 4.0 %)	DWRB103, DWRB105, DWRUB52(Check), K551(Check)	DWR103, RD2852, RD2853, RD2854, DWRUB52(Check), K551(Check)
Over all MQ	DWRB102, DWRB103, DWRB104, RD2848, RD2849, DWRUB52(Check)	BH968, DWRUB52(Check)

Quality evaluation of non-malt purpose barley

The feed grain samples from various trials and grown at different locations were analysed for few physical parameters and protein content. Each centre was requested to provide a grain sample of 250 g. The parameters analysed included grain crude protein content (%), test weight (kg/hl), thousand grains weight (g) and grain plumpness.

A total of 760 samples were received encompassing 140 of AVT (RF) from NHZ; 40 of AVT (Irrigated) from NWPZ; of AVT (Irrigated) 30 from NEPZ; 30 of AVT (Irrigated) from CZ; 270 of IVT (Irrigated) from NW, NE and CZ; 80 of IVT (Rainfed) from NEPZ; 90 of AVT (SAL/ALK) from NW and NEPZ; 20 from AVT (Dual purpose barley) of NHZ and 60 of IVT (dual purpose barley) NW, NE and CZ. The promising genotypes observed for individual grain quality trait are given in table 8.9.

Table 8.9. Promising entries from feed barley trials on the basis of quality parameters

SN	Trial	Promising entries
1	AVT (Rainfed Barley) – NHZ	BHS404, VLB129
2	AVT (Irrigated Feed Barley) – NWPZ	HUB113
3	AVT (Irrigated Feed Barley) – NEPZ	RD2811, HUB114
4	AVT (Irrigated) – CZ	RD2787
5	IVT (Irrigated Feed Barley) – NWPZ/NEPZ/CZ	PL865
6	IVT (Rainfed Feed Barley) –NEPZ	K1183, JB249
7	AVT (SAL/ALK) – NWPZ/NEPZ	HUB222, RD2820
8	IVT (Dual Purpose Barley) – NWPZ/NEPZ/CENZ	HUB224, RD2835
9	AVT (Dual Purpose Barley) – NHZ	VLB131, VLB132

Barley quality component screening nursery

A nursery of 73 entries having diverse range of protein and beta glucan content were sent to Karnal, Hisar, Durgapura and Rewa for growing under timely sown conditions. The aim of the exercise is to identify entries having good grain plumpness coupled with variability in protein and glucan content. The nursery was constituted after screening some of the germplasm lines with high or low protein content and high or low beta glucan content. The centres were requested to supply the grain samples for quality evaluation. The samples were analysed for crude protein content, test weight, thousand grain weight and grain plumpness. The entries BK306, BCU4966, BCU5070, BCU5474 and DWR49 have been found to contain higher protein content coupled with good grain development. Entries with low protein content and good grain development included DWRUB-68 and VM 152. Among the entries included on the basis of beta glucan content only DWRUB-76 (high beta glucan) was found to have good grain development.

Biochemical evaluation of germplasm lines

A total of 265 lines available in malting quality crossing block were evaluated for crude protein and starch content using NIR system. Five lines were identified having crude protein content of >14% on dry weight basis. These genotypes had bold grain percentage of >94% and test weight of >63 kg/hl. Taking all parameters together BK 303 was identified as the most promising genotype (Table 8.10). For starch content four genotypes were having starch content of >64% (DWR 62, DWR 80, SK 9 and CARAFE), however, bold grain percentage was <90%. These genotypes will be further confirmed for higher starch content through wet chemistry analysis and multi location testing.

Table 8.10. Grain characteristics of high protein genotypes

Genotype	Protein	Test wt (kg/hl)	1000 gr. wt. (g)	Bold (%)
BK 303	14.4	66.5	62.7	94.4
VJM 522	14.3	64.2	45.8	96.6
DWR 97	14.2	63.5	60.9	97.8
VJM 516	14.1	66.8	45.4	98.7
DWR 96	14.1	64.8	55.3	98.9
DWRUB 52 (c)	8.7	67.1	53.5	96.0
K 551 (c)	10.4	64.4	44.8	83.7

Use of NIR system for grain and malt quality analysis

Barley grains were screened for starch content by wet chemistry and then result were compared to

NIR predictions of starch content. A correlation of 0.47 was obtained when values by two were compared. The barley malt prepared from around 200 genotypes was screened for hot water extract and malt protein using wet chemistry analysis and a correlation of 0.45 was obtained for hot water extract and of 0.68 for malt protein.

Grain protein content is known to influence the malt quality and in this context correlation was studied in 100 samples for malt friability. A negative correlation of 0.61 was obtained between grain protein content and malt friability.

Evaluation of released barley varieties for β glucan content

Seventy six barley varieties grown at DWR, Karnal were screened for grain beta glucan content. Varieties with >5% beta glucan (dry weight basis) were BHS352 (Huskless), Dolma (Huskless), HBL276 (Huskless), NB2 and NB3 (Table 8.11). These varieties were also screened for grain protein content and varieties Azad, BHS352, Dolma, Jagriti and RS6 have been found to contain crude protein content of >14% (dry weight basis).

Table 8.11. Beta glucan content in barley varieties (dry weight basis)

SN	Variety	β -glucan (%)	SN	Variety	β-glucan (%)	SN	Variety	β-glucan (%)
1	BHS352	6.0	26	RD2052	4.1	51	RD2715	3.6
2	Dolma	5.5	27	KARAN16	4.0	52	RD2508	3.5
3	NB2	5.1	28	Clipper	4.0	53	Jyoti	3.5
4	HBL276	5.0	29	VLB1	4.0	54	BG25	3.5
5	NB3	5.0	30	VLB56	4.0	55	BHS46	3.5
6	RD2668	4.9	31	K508	4.0	56	Balia Barley	3.4
7	NB1	4.9	32	RD2503	4.0	57	Alpha93	3.4
8	Gitanjali	4.9	33	PL419	3.9	58	K409	3.3
9	DWRUB52	4.7	34	BHS380	3.9	59	RD31	3.3
10	VPB1008	4.7	35	Kailash	3.9	60	K560	3.3
11	Ranjit	4.6	36	Vijaya	3.9	61	K551	3.3
12	DWR28	4.5	37	RD2660	3.9	62	K603	3.2
13	NDB1173	4.5	38	HBL113	3.8	63	RD2592	3.2
14	BH393	4.5	39	C164	3.8	64	LSB2	3.2
15	BH902	4.4	40	PL751	3.8	65	K12	3.0
16	PL172	4.4	41	BG105	3.8	66	BHS169	2.9
17	RDB1	4.4	42	RD2552	3.8	67	LAKHAN	2.8
18	RD-2624	4.2	43	PL426	3.7	68	Manjula	2.7
19	JB58	4.2	44	RD57	3.7	69	RD103	2.7
20	Ratna	4.2	45	Sonu	3.7	70	Bilara2	2.7
21	BCU73	4.2	46	PL56	3.7	71	K141	2.6
22	BH75	4.1	47	C84	3.7	72	Azad	2.6
23	Himani	4.1	48	HBL316	3.7	73	Jagriti	2.5
24	DL88	4.1	49	RS6	3.7	74	Amber	2.4
25	RD2035	4.1	50	C138	3.6	75	C164	3.8
						76	PL751	3.8

Resource management

The researchable issues in barley agronomy are fine tuning of sowing dates under changing climatic conditions, irrigation timings and methods, seed density per unit area, fertilizer dose, source and scheduling, optimum input use under saline conditions for high and low input conditions etc. Use of resource conservation techniques in barley is also important to save time, energy, money and to improve soil health. The long-term objective is to improve the productivity and quality of barley on sustainable basis. Brief research highlights of barley agronomy were as follows:

Evaluation of new genotypes for wide adaptability and nutrient supply

The second year AVT genotypes of feed and malt barley were evaluated for sowing conditions and fertility levels at different locations in different zones. Twenty two trials proposed for varietal evaluation and twenty six special trials (26) for fine tuning package of practices in different zones were conducted during the year.

The performance of test entry (VLB 118) was evaluated against three checks (UPB 1008, HBL 113 and BHS 352) at Malan, Bajaura, Shimla and Almora in NHZ. The test entry and checks were statistically at par and genotypes responded up to 60 kg N/ha. The performance of test entry BH 932 evaluated against three checks (RD 2552, RD 2035 and BH 902) at Agra, Durgapura, Hisar, Ludhiana and Karnal was not superior in NWPZ. In late sown malt barley trial in NWPZ, test entry (DWR 91) was significantly superior to best check DWRB 73 and nitrogen response was up to 90 kg/ha. The performance of test entry RD 2794 was also superior to checks and nitrogen response was up to 80 kg/ha under salinity conditions. In central zone feed barley trials, test entries (BH 933, RD 2784) were superior to check PL 751.

Production technologies refinement

Nutrient management and tillage options in malt barley

The experiment was conducted with three tillage options (zero, reduced and conventional) and six nutrient combinations (1. 100% Inorganic fertilizes (IF) 2. 50% IF +5 t FYM /ha 3. 50% IF+ 1.5 t vermicompost/ ha 4. 100% through FYM -12.5 t / ha 5. 100% through vermicompost - 4.0 t/ha 6. absolute control) to see the effects of integrated nutrient combinations and tillage on malt barley.

The results show that reduced tillage and conventional practice were at par in grain yield irrespective of nutrient combinations whereas zero tillage gave significantly low yields (Table 8.12). 100% inorganic application gave highest yield and superior to integrated nutrient supply and organic application (Table 8.12). 100% organic application either FYM or vermicompost gave lowest yields. Tillers/m^2 and grains/ear head were found to be more under inorganic and integrated use of fertilisers as compared to organic nutrient supply whereas 1000 grains wt. and hectolitre wt. were at par among different nutrient combinations. The bold grains were found to be more under inorganic fertilizer application and integrated nutrient supply as compared to organic application. Protein % was more under inorganic as compared to organic nutrient supply. Malt characteristics like, malt friability, homogeneity, DP, hot water extract were similar in all nutrient combinations and tillage treatments except that friability, homogeneity were comparatively low in zero tillage.

Table 8.12. Barley productivity (q/ha) under different tillage and nutrient supply

Nutrient supply	Tillage options		
	Zero	Reduced	Conventional
NPK	48.2	48.25	48.8
50NPK+5.0 t/ha FYM	45.65	47.2	46.25
50NPK+1.5 t/ha Vermi	45.4	46.2	46.55
12.5 t/ha FYM	42.9	45.05	44.55
4.0 t/ha Vermi	42.1	43.85	43.65
Abs control	33.2	34.7	33.45
Mean	42.85	44.2	44.15

The yield was similar under N application after and before first irrigation. The yield characters like grains/spike, tillers/m^2, 1000 grains weight were also similar under after and before irrigation application of Nitrogen. The similar results were obtained in last year also in this experiment. Nutrient application in three or two splits were at par and more than the one time fertilizer application either at basal or at 1st irrigation. Nutrient combinations as NP_0K_0, NP_0K, NPK_0, NPK, NPK_{40}, NPK_{60} were at par in malt barley productivity, highest yield was obtained where the three (NPK) nutrients were applied. No application of phosphorus and potash did not affect the yield significantly. Protein % was higher under NPK application. Malt characteristics such as friability, homogeneity, DP, hot water extract were similar in all nutrient combinations. The results trend was similar as in case of previous year (Fig. 8.5).

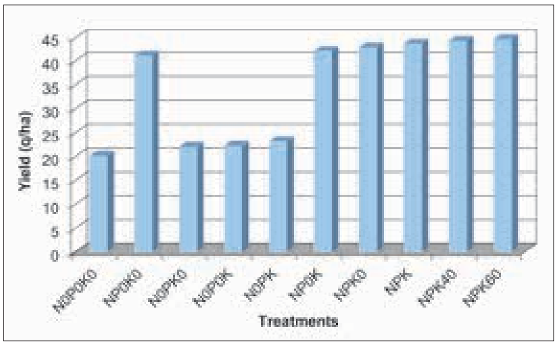


Fig. 8.5. Grain yield under different NPK combinations

Optimisation of seed rate and spacing in malt barley

The malt barley (2-row type) varieties are of compact plant type and bold seeded as compared to traditional six row feed barley varieties. Keeping in view the above fact, the trial was conducted to optimise seed rate and line spacing. The row spacing of 18 cm was significantly superior to 23 cm in grain yield and the seed rate of 80 and 100 kg/ha were at par. The highest yield (41.8 q/ha) was obtained under 18 cm spacing with 100 kg seed/ha. After three years of experimentation it is recommended that 2 row malt barley varieties may be sown at 18 cm row spacing and with 100 kg seed/ha (Fig. 8.6). There was no definite trend in yield and malt characteristics.

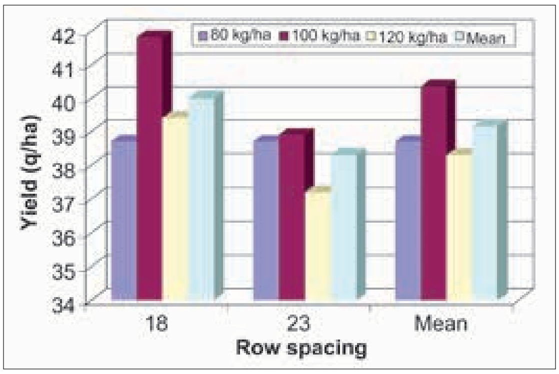


Fig. 8.6. Grain yield under different seed rate and spacing

Performance of varieties under restricted irrigation

The four varieties (RD 2035, RD 2552, BH 902 and DWRUB 52) were evaluated for their response to irrigation at four irrigation levels (zero, one, two, and three). All the varieties responded up to two irrigation level because of lodging at higher irrigation. Two and three irrigations were at par. The irrigation response was more in DWRUB 52 and BH 902 as compared to RD 2552. The interaction effect was not significant. The yield attributing characters (earhead/m^2, 1000 grains wt. and grains/ear) increased with the increase in number of irrigations. Grains/ear was at par under one, two and three irrigation whereas 1000 grains wt. was at par under one and two irrigations (Fig 8.7). Malt characteristics were similar under different irrigation levels and also of varieties except that malt friability varies among varieties.

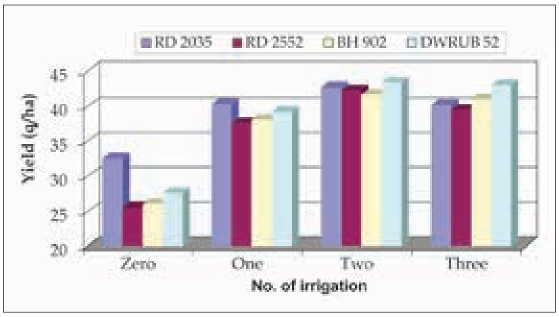


Fig. 8.7. Performance of varities under different irrigations

Barley crop protection

Barley crop health report

Moderate to high incidence of stripe rust on barley was recorded in summer crop of Leh & Ladakh area as well as in hills of Northern India. Leaf and stem rusts were not reported in barley growing areas. In Kanpur, the leaf rust was not observed but many entries were infested with aphids. In Kumarganj, Faizabad and Varanasi leaf blight was observed. In Mirzapur, Tissuhi and Rewa there was no disease in the fields.

In Rajasthan, the crop was healthy and none of the rusts was observed in farmers' field. The disease and insect problem in barley was very less in Hisar, Sriganganagar and Bathinda. In Ludhiana, the stripe rust was present in the fields.

Status of resistance in breeding lines and advanced entries

During the year 2011-12, barley entries (598 Nos.) were screened under various nurseries (IBDSN, NBDSN and EBDSN) for resistance against various diseases, aphid and CCN in different cooperating centers. Out of 598 entries, 358 entries were received for IBDSN, 194 were for NBDSN and 46 for EBDSN.

Seedling resistance test (SRT)

To find out rust resistant barley material, 240 lines including 194 of NBDSN and 46 of EBDSN were evaluated against five pathotypes and mixture of pathotypes of *Puccinia striiformis hordei* (stripe rust), mixture of pathotypes of *P. hordei* (leaf rust) and four pathotypes of *P. graminis tritici* (stem rust). The screening was conducted at seedling stage under controlled light and temperature conditions. Three entries viz. PL830, UPB1021 and VLB132 were resistant to all the rusts of barley. Twenty four lines were resistant to both stripe and leaf and 12 to leaf and stem rusts (Table 8.13).

Table 8.13. Sources of resistance identified from coordinated nurseries

Resistant to rusts	No. of lines	Genotypes
All 3 rusts	3	PL830, UPB1021, VLB132
Stripe and leaf rust	24	BH902, BHS404, JB 240, RD 2552, RD 2715, RD2784, RD 2786, RD 2787, RD2808, RD 2810, RD 2815, RD 2816, RD2820, RD2828, RD 2831, RD 2834, RD2836, RD 2837, RD 2839, RD 2840, RD 2844, RD 2845, RD2851, RD2887
Leaf and stem rust	12	BHS405, BHS409, BH962, DWR85, DWRB73, DWRB106, DWRB108, HBL712, JYOTI(c), PL866, VLB124, VLB130

Initial barley disease screening nursery (IBDSN)

Three hundred fifty eight entries contributed by 12 centres were screened under IBDSN, out of which 175 entries were found to be resistant (ACI=10) to stripe rust. In case of leaf blight screening, 38 entries were found to have resistance. There were 13 entries found to possess resistance to stripe rust and moderately resistant to leaf blight.

National barley disease screening nursery (NBDSN)

Out of 194 entries, all the entries were found to be either S or HS to CCN. None of the entries were showing resistance to aphids and all were showing HS = 5. The 58 entries were observed with resistance to rust or blights (Table 8.14).

Table 8.14. NBDSN entries identified as resistant for different diseases

Disease name	Resistant entry
Stripe rust only (ACI<1.0) (47 entries)	BH961, BH962, BH966, BH969, BHS409, DWRB101, DWRB102, DWRB105, DWRB107, DWRB108, HBL711, HBL711, HUB113, HUB221, JB240, JB240, RD2784, RD2786, RD2787, RD2794, RD2808, RD2809, RD2811, RD2811, RD2816, RD2832, RD2833, RD2834, RD2835, RD2836, RD2837, RD2839, RD2840, RD2844, RD2845, RD2846, RD2847, RD2848, RD2849, RD2851, UPB1021, UPB1022, VLB124, VLB130, VLB130, VLB131, VLB132
Leaf Blight Resistance (AV 14-35 HS ≤ 57) (11 entries)	BH960, BH962, BH965, NDB1544, PL864, PL866, PL867, PL870, RD2842, VLB118, VLB128

Elite barley disease screening nursery (EBDSN)

Out of 46 entries screened in EBDSN, the following entries were confirmed for resistance against the particular disease based on two consecutive years under AICW&BIP (Table 8.15).

Table 8.15. Confirmed sources of resistance in barley for different diseases.

Disease name	Resistant entry
Yr + Sr (ACI =0)	RD2809
Yr alone (ACI =0)	RD2715, RD2816, RD2786, RD2787, RD2828
Sr only (HS = 0)	BH943, BH944, DWR85, HUB115, NDB1516, PL863, RD2552, RD2668, RD2794, RD2811, RD2813 , RD2815, RD2819, RD2829, VLB124
LB only (HS ≤ 57)	BH932, BH942, PL860
SR & LB	BH945, BH946, VLB123

Screening of NBDSN barley entries (2011-12) against foliar aphids

The 194 numbers NBDSN entries were screened against aphids at five locations. Aphid counts/shoot was recorded at weekly interval. There was no NBDSN entry showing resistance to barley foliar aphid. All the entries were either susceptible (grade 4) or highly susceptible (grade 5) to barley aphid at most of the locations.

Chemical control of foliage feeding barley aphids

The objective of conducting this experiment was to find out eco-friendly and high potent molecules, which are more efficient, at lower doses than presently recommended molecules against foliage feeding barley aphids. The insecticide Clothianidin @ 15g ai/ha or Imidacloprid @20g ai/ha can be recommended for management of aphids.

Chemical control of barley foliar blight

To validate the effectiveness of various fungicides against foliar blight an experiment was conducted and it has been observed that seed treatment with Vitavax @ 3g/kg followed by spraying with Tilt / Folicur @ 0.1% is effective for management of leaf blight.

Chemical control of stripe rust

To validate the effectiveness of various fungicides against stripe rust experiments were conducted at hot spot locations on susceptible varieties and it has been observed that spray with Bayleton @ 0.1% is effective for control of stripe rust in barley.

Studies on host pathogen interaction

SRT analysis of all released varieties was done with individual races of stripe rust of barley. The varieties DWRUB52, RD2660, RD2715, UPB1008, RD2552, RD2592, BG25, RD2624, BH902, BG105, PL56, LSB2, HBL113, Kailash and Alfa93 showed differential reactions to the races M (1S0), Q, G(4S0), 24, 57 (0S0) but all other varieties showed 33+ reactions to all races. The adult plant resistance screening revealed that more than 40 varieties were showing resistance under field conditions.

9 MEETINGS/WORKSHOPS, SPECIAL ACTIVITIES AND TRAININGS ORGANISED

Meetings/Workshops

51st All India Wheat and Barley Research Workers' Meet

August 24-27, 2012: The 51st All India Wheat and Barley Research Workers Meet was organised by the Directorate of Wheat Research in collaboration with the Agricultural Research Station, Durgapura, Jaipur under Swami

Keshwanand Rajasthan Agricultural University, Bikaner. The participants were from National Agricultural Research System, CGIAR System, Industries and State Agricultural Department Officials. During the workshop, previous year recommendations were discussed and strategic planning was done for the next crop season. During the meet, 10 wheat and 4 barley varieties were identified for release by the Varietal Identification Committee of Wheat & Barley.

Wheat Promotion Strategies for North Western States

October 05, 2012: Workshop on "Wheat Promotion Strategies for North Western States" was organized at DWR Karnal. Sh. Ashish Bahuguna, Secretary (Agriculture & Cooperation) chaired the meeting. Dr. Indu Sharma, Project Director, DWR; Dr. Mukesh Khullar, Jt. Secretary (DAC); Dr. AK Singh,

DG (Agriculture), Haryana were also present in the meeting. More than 47 participants from Haryana, Punjab, HP, UP, Rajasthan and J&K attended the meeting.

Quinquennial Review Team

October 20-21, 2012 and February 11-12, 2013: QRT meetings were held at DWR Karnal to review the progress of work at AICW&BIP Centres. The QRT is being headed by Dr. B Mishra, Former Vice Chancellor, SKUAST, Jammu.

Research Advisory Committee

March 02, 2013: 17th Research Advisory Committee (RAC) meeting was held at this Directorate under the Chairmanship of Dr. PL Gautam, Ex-Chairman, PPVFRA, NASC Complex, New Delhi. Dr. RK Gupta, CIMMYT-India; Dr. VSP Rao, Former Director ARI, Pune; Sh. Ved Pal; Dr. SM Bhatnagar; Ex-Head, RAU, Durgapura; Dr. BK Mishra, Ex-PI Quality Improvement, DWR were the members of the Committee. All PI's presented their Division research output and plan of research in the coming years before the Committee in the presence of Project Director and Scientists of the Directorate.

Institute Research Committee

January 21-22, 2013: 19th Institute Research Committee (IRC) was held to review the progress of the ongoing research projects and to approve the new research projects. Significant research findings were presented and discussed.

Special Activities

Foundation Day

September 9, 2012: Directorate celebrated "Foundation Day". Dr. Gurbachan Singh, Chairman ASRB, New Delhi was the Chief Guest on this occasion and inaugurated the exhibitions. Other scientific organizations like NDRI, NBAGR, CSSRI, agricultural university etc. also put up their stall during the exhibition. He addressed the gathering and showed his concern about depleting natural resources.

Agriculture Education Day

September 26, 2012: Agriculture Education Day was celebrated. On this occasion a lecture on 'Reorienting Agriculture Education for Excellence' was delivered by Dr. GS Dubey, Ex-Dean, BAU, Ranchi. He had given a vast detail on evolution of Agriculture Education in India and its role in shaping the Modern Agriculture in the country.

Innovator-cum-Seed Day

October 31, 2012: Organized "Innovator cum Seed Day". Dr. RP Dua ADG (FFC), ICAR New Delhi was the chief guest. Dr. Indu Sharma, Project Director, DWR chaired the programme. More than 600 farmers attended the programme. On this occasion, seeds of newly released wheat varieties were provided to farmers. Dr. Randhir Singh PI (Social Sciences) coordinated the programme.

Training Organised

September 19-24, 2012: The Directorate has organized a training programme on "Prevalence of yellow, brown and black rust" at KVK, Leh, J&K. Dr. Indu Sharma, Project Director was the Chief Guest and Dr. Randhir Singh, PI (Social Sciences) coordinated the programme. Dr. RPS Verma, Dr. Sushila Kundu, Dr. MS Saharan, Dr. Parmod Kumar and KVK scientists delivered lectures to more than 40 participants.

October 08-09, 2012: Training programme was jointly organized by State Department of Agriculture, H.P. and DWR at SAMETI, Shimla on "Increasing wheat production with special reference to rust management in H.P". Forty two farmers, Project Director, ATMA, and Senior SMS of H.P. participated in the training organized. Dr. Randhir Singh, PI (Social Sciences) coordinated the programme in collaboration with the State Department of Agriculture.

February 18-21, 2013: The Directorate organised training programme "*Vigyanic Tarike Se Gehoon Ki Unnat Kheti*" for 55 farmers of Gujarat.

February 18-21, 2013: The Directorate organised training programme "*Gehoon Utpadan Badane Ki Prodogiki*" for 15 farmers of Bijnor, U.P.

10 EXTENSION ACTIVITIES

Farmer's day /Awareness programme

September 20, 2012: Awareness programme on "Protection of Plant Varieties and Farmers' Rights" was organized in Diskit village, Leh. Dr. Indu Sharma (Project Director), Dr. Sushila Kundu, Dr. Randhir Singh, Dr. RPS Verma, Dr. MS Saharan and Dr. Parmod Kumar were also present. The programme was organized off campus and more than 35 farmers were educated.

December 27, 2012: Organized Kisan Mela in Veeram Village, District Amritsar, Punjab in collaboration with KRIBHCO. Awareness programme on protection of plant varieties and farmer's right was also organized. More than 200 farmers including farm women attended the programme. Fifteen sewing machines were distributed by KRIBHCO to the farm women to enhance their income. Dr. Indu Sharma, Project Director, DWR was the chief guest and Dr. Randhir Singh coordinated the programme. Dr. KS Sandhu, Deputy General Manager, KRIBHCO, Dr. Dhanju, CAO, Amritsar, Dr. NS Bains and many experts from PAU were available on this occasion. Sh. VS Garcha, Senior Area Manager anchored the programme. Sh. Rishi Pal Singh Rathor and team put up exhibition on this occasion. Dr. Harjinder Singh, Retired Professor, PAU was felicitated in this programme.

February 23, 2013: Awareness programme on "Protection of Plant Varieties and Farmers' Rights" was organized at KVK Pali (Rajasthan). Dr. MM Rao, Director, CAZRI was the chief guest on this occasion. Dr. Indu Sharma, Project Director, Dr. Sushila Kundu, Dr. Randhir Singh, Dr. Arun Gupta and Dr. Sindhu Sareen were also present. The programme was organized off campus and more than 200 farmers were educated.

March 4, 2013: Awareness programme on "Protection of Plant Varieties and Farmers' Rights" was also organized at KVK Bharatpur (Rajasthan) in collaboration with Sawera Samiti, Bharatpur. Dr. Indu Sharma, Project Director was the chief guest on this occasion; Dr. RPS Verma, Dr. Randhir Singh, Dr. Arun Gupta and Dr. Vishnu Goel were also present. Dr. Amar Singh, Head, KVK, Bharatpur, Dr. Udaibhan Singh, Dr. Ashok Sharma, Dr. Saxena also participated. About 200 farmers and farm women participated in the programme.

March 24, 2013: Organised Farmers Day at Gullarpur village. Dr. B Mishra was the chief guest and Dr. Indu Sharma, PD, DWR presided over the function. Prof. Yadvinder Singh, Dr. SK Nayyar and Dr. SC Gulati, the members of QRT were also present on this occasion. Dr. Randhir Singh anchored the programme. The programme was organized in collaboration with State Department of Agriculture and Dr. Radhe Shyam Gupta made the necessary arrangements at wheat front line demonstration site. More than 150 farmers attended the Farmers' Day.

March 26, 2013: Organised Farmers Day at Jamber Basti (Jagram Tirath) village. Dr. Randhir Singh, Dr. RPS Verma and Dr. Satyavir Singh attended the programme. The programme was organized in collaboration with United Breweries Ltd. Sh. Jitender Singh made the necessary arrangements at barley front line demonstration site. DWRUB 64, a late sown malt barley variety was sown which was appreciated by more than 125 farmers.

Visit Coordination

Foreign Delegations

Date of visit	Visitors
02.05.2012	25 members (US delegation)
09.05.2012	11 members (Afghan delegation)
22.05.2012	Five members (Nigerian delegation) from Ibadan University of Nigeria
15.06.2012	Four members from the Republic of Mozambique led by Mr. Mahammed Vala, Director Nacional, Direccao Nacional de Servicos Agrarios, Ministerio de Agricultura, Republica De Mozambique
10.09.2012	Thomas A. Lumpkin, DG, CIMMYT and Dr AK Joshi, CIMMYT, Nepal

National Visitors

Date of visit	No. of Visitors	From
09.04.2012	37 farmers	Orissa
11.04.2012	7 farmers	Meerut, U.P.
02.05.2012	24 Farmers, industry representatives, academicians	Sponsored by Texas Agricultural Lifetime Leadership Program, USA
12.07.2012	50 farmers	Bathinda (NHRDF) Punjab & Haryana
12.06.2012	33 students	Delhi
24.07.2012	10 farmers	EEI Nelokheri, Haryana
28.07.2012	25 farmers	Janjgir Chattisgarh
24.08.2012	140 students	Annamalai University, T.N.
24.08.2012	12 Agriculture Officers	Haryana, Punjab, HP, Jharkhand, Bihar, and J&K
22.09.2012	52 farmers	Veelupuran, T.N.
24.09.2012	5 farmers/officers	Sitapur, U.P.
01.10.2012	87 Students	Kilikulum, T.N.
10.10.2012	30 farmers	Alwar, Rajasthan
03.11.2012	45 women farmers	Hanumangarh, Rajasthan
04.11.2012	25 farmers	Arwal, Bihar
07.11.2012	25 farmers	West Singhbhum, Jharkhand
08.11.2012	30 farmers	M.P.
05.12.2012	34 farmers	Bokaro, Jharkhand
25.12.2012	50 farmers	Pali, Rajasthan
28.12.2012	40 farmers	Pali, Rajasthan
10.01.2013	30 farmers	Kullu, H.P.
28.01.2013	50 farmers	Nagaur, Rajasthan
30.01.2013	30 farmers	Gurgaon, Haryana
30.01.2013	24 farmers	Latehar, Jharkhand
06.02.2013	10 progressive farmers	Nilokheri, Haryana
06.02.2013	10 SMS and BAO State Deptt. of Agril	Haryana
06.02.2013	50 farmers	Bharatpur, Rajasthan
07.02.2013	50 statisticians	Haryana
10.02.2013	50 farmers	Haridwar, Uttarakhand
16.02.2013	32 farmers	Balkot, Karnataka
23.02.2013	35 farmers	Rajkot, Gujarat
26.02.2013	130 farmers	Nilokheri, Kranal, Haryana
28.02.2013	28 farmers	Indri, Karnal,Haryana
04.03.2013	15 farmers	Pratapgarh, U.P.
05.03.2013	18 farmers	Kodernma, Jharkhand
07.03.2013	18 farmers	UAS, Dharwad

SMS to Farmers

DWR collaborated with IFFCO to send wheat and barley crop messages to the farmers through mobile phone to increase production and productivity. A message on weed control strategies and yellow rust was sent to the farmers of Punjab, HP and Haryana with the efforts of Dr. Randhir Singh.

Exhibitions organized/Participated

September 21, 2012: Participated in the exhibition organized by NBAGR, Karnal on the occasion of its Foundation day.

October 19, 2012: Participated in the exhibition organized by NDRI, Karnal.

December 22, 2012: Participated in the Kisan Mela at NDRI, Karnal organized by Haryana Kisan Ayog. Sh. BS Hooda, CM of Haryana was the chief guest. Dr. RS Paroda, Chairman, HKA presented the report of the activities of Haryana Kisan Ayog.

February 2-3, 2013: Participated in exhibition organised by NHRDF, Salaru on the occasion of National Seminar on “Unnat Takniki Dwara Sabji Utpadan, Katai Uprant Prabandhan Evum Bhandaran" at NDRI, Karnal.

February 25-27, 2013: Participated in the National Dairy Mela-2013 held at NDRI, Karnal and got the best stall award.

March 01, 2013: Participated in exhibition in Rabi Kisan Mela held at CSSRI, Karnal and got the best stall award.

11 AWARDS AND RECOGNITIONS

Chaudhary Devilal Outstanding All India Coordinated Research Project Award

July 16, 2012: Chaudhary Devilal outstanding All India Coordinated Research Project Award 2011 was conferred to AICW&BIP led by the Directorate for playing key role in enhancing the wheat and barley productivity.

Fellow Award of the Indian Virological Society

November 7, 2012: Dr. Pradeep Sharma, Senior Scientist has been awarded Fellow Award of the Indian Virological Society (IVS) at VIROCON 2012 conference at Mukteshawar.

AUSaid Award Fellowship

Dr. Rekha Malik received Australian Government AUSaid Award Fellowship (ALAF) for the year 2012-13.

Best Workers' Award

September 9, 2012: During the foundation day, Dr. Rajender Singh Khokhar and Dr. Gyanendra Singh in scientific category, Dr. Ramesh Chand and Dr. BK Meena in technical officer category, Sh. Rahul Singh in technical category, Sh. Anil Kumar and Sh. Mahaveer Singh in administrative category and Sh. Khem Chand in skilled staff category were bestowed with best workers' award for the year 2011-12.

Best Stall Award

The Directorate got best stall award in the following exhibitions:

- NHRDF, Salaru at NDRI, Karnal, February 2-3, 2013.
- National Dairy Mela-2013 at NDRI, Karnal, February 25-27, 2013.
- CSSRI Karnal, March 1st, 2013.

Runner-up in Basketball and Cycling Race

January 18-21, 2013: The Directorate basketball team comprising of Dr. RS Chhokar (Captain), Dr. Ratan Tiwari, Dr. Anuj Kumar, Dr. SK Singh, Dr. Ramesh Chand, Sh. Vinod Kumar Khokhar, Sh. Ram Kumar Singh, Sh. PC Babu, Sh. Om Parkash and Sh. Rajinder Kumar Sharma bagged runner-up trophy, while, Mr. Ramu Shah secured second position in cycle race in the ICAR Inter-Zonal Sports Tournament held at IARI, New Delhi.

12 DISTINGUISHED VISITORS

Visitors to Karnal

- April 9, 2012: Dr. PK Gupta from DBT
- April 18, 2012: Dr. Abdul Kalam Azad, Director, SAARC Agricultural Centre, Dhaka, Bangladesh
- May 22, 2012: Five member delegation from University of Ibadan, Nigeria
- May 29, 2012: Dr. JP Tandon and official from ITC Chaupal
- June 13, 2012: A delegation from Ministry of Agriculture, Government of Iran led by Dr. MR Ashgri
- June 15, 2012: Four member delegation from the Republic of Mozambique led by Mr. Mahammed Vala, Director Nacional, Direccao Nacional de Servicos Agrarios, Ministerio de Agricultura, Republica De Mocambique
- June 30, 2012: Dr. MV Rao, Former Special DG, ICAR
- September 9, 2012: Dr. Gurbachan Singh, Chairman ASRB, New Delhi
- September 10, 2012: Dr. Thomas Lumpkin, DG, CIMMYT along with Dr. AK Joshi, CIMMYT-Nepal office and Dr. Ajai Kumar, CIMMYT-Delhi office
- October 26, 2012: Drs. Hans Gunter, Bains and Marcus Weilder from Bayer
- October 31, 2012: Dr. RP Dua, ADG (FFC) ICAR, New Delhi
- November 20, 2012: Dr. Nizam Ahmed, University of Sydney, Australia
- November 28-29, 2012: A delegation of scientists namely Drs. Ian King, John Foulkes, Martin Broadly and Scott Young from University of Nottingham, UK; and Drs. Peter Sharp and Richard Trethowan from University of Sydney, Australia
- December 21, 2012: Dr. Kulvinder S. Gill, Professor and The Vogel Endowed Chair in Wheat Breeding and Genetics, Washington State University, USA
- December 28-29, 2012: Dr. S Ayyappan, Secretary, DARE and DG, ICAR along with Dr. AK Srivastava, Director NDRI

Visitors to Regional Station Flowerdale, Shimla

- July 18, 2012: Dr. Sukhwinder Singh, Molecular Geneticist, Global Wheat Program, CIMMYT Mexico
- July 19, 2012: Dr. ML Lodha, Ex. Prof & Head, Division of Bio-chemistry, IARI, New Delhi, Dr. TR Sharma, Principal Scientist and NAAS Fellow
- October 9, 2012: H.P. Government officials from Department of Agriculture which included Subject matter specialists, Deputy Directors, Deputy Director ATMA
- November 21,2012: Ms Anna Garber Hammond from Cornell University, USA and Sh. Akshat Medakker, General Manager, Technical Management Advisory Services
- November 21,2012: Sathguru Management Consultants, Hyderabad, India
- November 22, 2012: Dr. Nizam Ahmed, Sr. Wheat Breeder, PBI, Cobetty, Australia

Dr. S Ayyappan, DG, ICAR inaugurating temperature controlled phenotyping facility

Visitors to Dalang Maidan

- August 3 - 5, 2012: Dr. (Mrs.) Indu Sharma, Project Director, DWR, Karnal
- October 6-8, 2012: Dr. SS Singh, Consultant, Bioversity International, New Delhi

Dr. SS Singh, Consultant, Bioversity International at Dalang Maidan

13 PARTICIPATION OF SCIENTISTS IN WORKSHOPS / CONFERENCES/TRAININGS

Outside Country

Name	Title	Duration
Drs. RPS Verma, AS Kharub, Dinesh Kumar, B Sarkar and Rekha Malik	11th International Barley Genetics Symposium at Hangjhou, China	April 15 - 20, 2012
Drs. RK Gupta and Gyanendra Singh	Participated in Regional Consultation on Improving Wheat Productivity in Asia at Bangkok, Thailand	April 26 -27, 2012
Dr. DP Singh	ITEC assignment at Guyana	For 2 years w.e.f. July 4, 2012
Dr. Om Prakash	Advance Wheat Improvement Training Program at CIMMYT, Mexico	August 1 - September 28, 2012
Drs. (Mrs) Indu Sharma, Ravish Chatrath, SC Bhardwaj, Ratan Tiwari and MS Saharan	Borlaug Global Rust Initiative and South Asia Specific Site meeting at Bejing, China	August 31 - September 4, 2012
Dr. Sushila Kundu	Visited Netherlands as a Member of high level official team of PPV&FRA	September 10 - 14, 2012
Dr. SC Bhardwaj	Visited Kenya Agricultural Research Institute (KARI) Research Station, Najoro, Kenya to attend "Standardization of stem rust note taking and evaluation of germplasm with emphasis on emerging threats of yellow rust and leaf rust"	September 25 - October 5, 2012.
Dr. Raj Kumar	Visited Phnom Penh, Cambodia to attend the Plant Breeding and Seed Production Alumni Follow-up Workshop	October 3 - 5, 2012
Dr. (Mrs) Indu Sharma	Attended United Nation Conference (UNECA-UNCC) on "Wheat for food security in Africa"	October 8 - 14, 2012
Drs. Gyanendra Singh and MS Saharan	Participated in the Annual General Meeting of ACIAR collaborative project at DWAFA, Perth, Australia and visited water logging screening trials at Katanning, West Australia and MAS genotyping laboratories at Murdoch University	October 14 - 20, 2012
Dr. RK Sharma	Participate in the 1st meeting of the Institutions' Coordination Committee (ICC) of International Wheat Initiatives at Mexico	November 16 - 17, 2012
Drs. RK Gupta and R Chatrath	Participated in 4th Annual Review Meeting on Wheat Breeding of the project *Cereal Systems Initiative for South Asia* (CSISA) at Kathmandu, Nepal.	December 16 - 20, 2012
Dr. Rekha Malik	Training on "Marker Assisted Selection of Rust Resistance in Wheat" at PBI, Cobbity, University of Sydney, Australia	November 15, 2012 - February 21, 2013
Dr. (Mrs) Indu Sharma	SCPRID workshop at UK	February 6 - 8, 2013
Dr. Sindhu Sareen	3rd Wheat Yield Consortium Workshop at Mexico	March 5 - 7, 2013

Indian delegation at International Barley Genetics Symposium

Within Country

Name	Title	Duration
Dr. Randhir Singh	MDP programme on "Leadership development" at NAARM, Hyderabad	April 9 - 20, 2012
Dr. (Mrs) Indu Sharma	XXVII Annual Group Meeting of AICRP – National Seed Project (Crops) 2012 at Anand Agricultural University, Gujarat	April 14 - 16, 2012
Drs. Pradeep Sharma and Sonia Sheoran	Training program on "Statistical tools for molecular Breeding" at Knowledge and Study Centre, Jalna, Maharashtra	April 24-26, 2012
Dr. (Mrs) Indu Sharma	Brainstorming Session on Agriculture Policy for Haryana at NASC Complex, New Delhi	April 30, 2012
Drs. (Mrs) Indu Sharma and S Kundu	62nd Meeting of Central Sub-committee on Crop standards, Notification and release of Varieties for Agricultural Crops at DAC, New Delhi	May 5, 2012
Dr. (Mrs) Indu Sharma	Meeting of Crop Science Division at NASC Complex, New Delhi	May 9, 2012
Dr. (Mrs) Indu Sharma	Indo Australian Program on Marker-Assisted Wheat Breeding (IAP-MAWB) Steering Committee Meeting at ICAR, Pusa, New Delhi.	May 14, 2012
Drs. (Mrs) Indu Sharma, S Kundu, RPS Verma and Arun Gupta	DUS Review Meeting and Plant Genome Saviour Award ceremony at NASC Complex, Delhi	May 21, 2012
Dr. R Selvakumar	15 days refresher course on Agricultural Research Management held at NAARM, Hyderabad	June 5 - 18, 2012
Dr. (Mrs) Indu Sharma	Executive Committee Meeting of Borlaug Institute for South Asia (BISA) at NASC Complex, New Delhi.	June 6, 2012
Dr. S Kundu	XXV Meeting of Plant Germplasm Registration Committee held at NBPGR, New Delhi	June 11, 2012
Dr. (Mrs) Indu Sharma	Selection Committee Meeting for the posts of SMS/Scientist (Plant Pathology) at UAS, Dharwad	June 25 - 26, 2012
Dr. S Kundu	63rd Meeting of Central Sub-committee on Crop standards, Notification and release of Varieties for Agricultural Crops at SKUAST, Srinagar	June 28 - 29, 2012
Drs. (Mrs) Indu Sharma and Gyanendra Singh	Meeting on Wheat Production Strategy for the UP state held at Directorate of Agriculture, Krishi Bhawan, Lucknow	July 29, 2012
Dr. (Mrs) Indu Sharma	Knowledge Meet at NASC Complex, Pusa, New Delhi under the chairmanship of Director General, ICAR.	August 21, 2012
Dr. Sneh Narwal	MDP Workshop on "Policy and Prioritization, Monitoring and Evaluation (PME) support to Consortia-based Research in Agriculture" at NAARM, Hyderabad	September 11 - 17, 2012
Dr. (Mrs) Indu Sharma	Extension of Indo-Australian IAP MAWB program at Australian High Commission, New Delhi	October 1, 2012
Dr. Sindhu Sareen	Delivered a lecture on "Role of women in Agriculture" at Workshop on "Defining the Role of Women Scientists and Teachers in Promotion and Application of Science and Technology" organized by NASI, Allahabad	October 5 - 6, 2012
Dr. (Mrs) Indu Sharma	Panel discussion "Status and management of Plant Trans Boundary diseases" organised by DG (ICAR) and Ex-DG (ICAR), Dr. RS Paroda at Delhi	October 10, 2012

Name	Title	Duration
Drs. Gyanendra Singh and BS Tyagi	Task Force meeting of DBT funded project held at DBT, New Delhi	October 10, 2012
Dr. S Kundu	ICAR Institutes-SAU-Development Department and Stakeholder Interface held at NDRI, Karnal	October 15 - 16, 2012
Dr. Randhir Singh	ICAR-CIMMYT workplan meeting	October 15 - 18, 2012
Dr. (Mrs) Indu Sharma	Research issues between ICAR-CIMMYT/BISA for defining research agenda for BISA and present India's workplan under AICW&BIP and proposed research agenda for BISA	October 16, 2012
Dr. R Chatrath	HarvestPlus meeting to review and plan wheat biofortification research at ICRISAT, Patancheru, India	October 19, 2012
Drs. (Mrs) Indu Sharma and Gyanendra Singh	Wheat Research Programme for enhancing wheat production in Bihar with AICW&BIP Scientists and University authorities and IV Research Council Meeting for Rabi at Bihar Agricultural University, Sabour	November 2, 2012
Drs. (Mrs) Indu Sharma and S Kundu	64th Meeting of Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops at NBPGR, Pusa, New Delhi	November 3, 2012
Dr. (Mrs) Indu Sharma	Executive committee of SAWR (Society for Advancement of Wheat Research) at New Delhi	November 19, 2012
Drs. RK Sharma, SK Singh, RS Chhokhar, R Selvakumar, Sonia Sheoran, Satish Kumar, Venkatesh, HM Mamrutha, Vikas Gupta and Sendhil R	International Conference on “Sustainable Agriculture for Food and Livelihood Security" at PAU, Ludhiana	November 27 - 29, 2012
Drs. (Mrs) Indu Sharma, RPS Verma and Arun Gupta	Review and Steering Committee Meeting on the progress of ICAR-ICARDA collaborative research work-plan at NASC Complex, New Delhi	November 29, 2012
Dr. Shabana Parveen	Training course on “Field trial on R and R/QTL" at ICRISAT, Patancheru, Hyderabad	December 3 - 6, 2012
Dr. (Mrs) Indu Sharma	AICRPs & Network Projects meeting for XII Plan at NBPGR Auditorium, New Delhi	December 06, 2012
Dr. (Mrs) Indu Sharma	XXII Meeting of the ICAR Regional Committee No. V at Library Conference Hall, Library building, IARI, Pusa, New Delhi	December 14 - 15, 2012
Dr. RK Sharma	6th National Seminar on “Emerging challenges and paradigm for sustainable agri-rural development" at Dr. YS Parmar University of Horticulture & Forestry, Solan (H.P.)	December 18 - 19, 2012
Dr. Sendhil R	International Conference on "Statistics and Informatics in Agricultural Research" at IASRI, New Delhi	December 18 - 20, 2012
Dr. Randhir Singh	Haryana State Food Security Mission Executive Committee (SFSMEC) meeting chaired by Chief Secretary, Haryana	January 7, 2013
Dr. Sendhil R	Programme on “Modeling Agricultural Research Priority Setting and Policy Communications" organised by the International Food Policy Research Institute (IFPRI), New Delhi	January 7 - 9, 2013
Dr. S Kundu	2nd Meeting of the Task Force 3/2011 held at NASC Complex, New Delhi	January 8, 2013
Dr. (Mrs) Indu Sharma	International Conference on “Increasing Agricultural Productivity and Sustainability in India: The Future We Want" at NIAS, IIS, Bangalore	January 8 -10, 2013

Name	Title	Duration
Dr. (Mrs) Indu Sharma	RFD meeting at DMR, New Delhi attended on 15.01.2013	January 14, 2013
Drs. Randhir Singh and Sendhil R	First i-Government ICT for development conference organized by Department of Electronics and Information Technology, Ministry of Communication & Information Technology, Govt. of India at India Habitat Centre, New Delhi	January 14 - 15, 2013
Dr. (Mrs) Indu Sharma	Krishi Karnam Awards 2011-12 ceremony in Rashtrapati Bhawan Auditorium, New Delhi	January 15, 2013
Dr. (Mrs) Indu Sharma	65th meeting of the Central Sub Committee on Crop Standards, Notification and Release of varieties for agricultural crops at CICR, Nagpur	January 18 - 19, 2013
Dr. S Kundu	XXVI Meeting of Plant Germplasm Registration Committe held at NBPGR, New Delhi	January 31, 2013
Dr. Randhir Singh	Meeting of DDAs of Haryana	February 4, 2013
Dr. (Mrs) Indu Sharma	Task Force Meeting on wheat rust diseases at ICAR, Krishi Bhawan, New Delhi	February 12, 2013
Drs. (Mrs.) Indu Sharma, RK Gupta, R Chatrath, Gyanendra Singh, M Saharan, R Tiwari, Sonia Sheoran, HM Mamrutha	Annual Science Meeting of Indo-Australian Program on Marker Assisted Wheat Breeding at YASHDA, Rajbhavan Complex, Baner Road, Pune	February 18 - 19, 2013
Dr. (Mrs) Indu Sharma	Executive Committee Meeting of Borlaug Institute for South Asia (BISA) at NASC Complex, New Delhi	February 28, 2013
Dr. S Kundu	7th DUS Review Meeting held at IIVR, Varanasi (UP)	February 28 - March 1, 2013
Dr. HM Mamrutha	National Workshop on “Foresight and future pathways of Agricultural Research through involvement of youth in India" at NAAS complex, New Delhi	March 1 - 2, 2013
Dr. (Mrs) Indu Sharma	Inaugural ceremony of ATIC, BSL-III facility, & VTCC at CIRB/ NRCE Hisar	March 9, 2013
Dr. S Kundu	3rd Meeting of the Task Force 3/2011 held at NASC Complex, New Delhi	March 10, 2013
Dr. (Mrs) Indu Sharma	Director's Conference at NASC Complex, Pusa, New Delhi	March 19 - 20, 2013

14 RESEARCH PROJECTS

Institute Projects

Project No.	Project Title	PI	Associate/s
DWR/RP/10-1	Multilocational and Multidisciplinary research programme on wheat and barley improvement	Indu Sharma (Project Director)	All PIs and other scientists
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, Sushila Kundu, Vikas Gupta, Hanif Khan
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	Ravish Chatrath, Satish Kumar, CN Mishra, Hanif Khan
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 and Vikas Gupta
DWR/RP/10-3.2	Wheat Improvement for Eastern and Far Eastern regions of the country	Gyanendra Singh	Charan Singh, DP Singh, RP Meena, Sewa Ram, Arun Gupta
DWR/RP/10-3.3	Wheat Improvement for warmer areas of the country	SK Singh	BS Tyagi, Vinod Tiwari, RK Gupta, Pradeep Sharma, DP Singh and RS Chhokar, CN Mishra
DWR/RP/10-3.4	Improvement of spring wheat through introgression from winter wheat gene pool	V Tiwari	CN Mishra, Ratan Tiwari and Lakshmi Kant (Almora).
DWR/ RP/10-4	**Maintenance and evaluation of wheat and barley germplasm**	S Kundu	Arun Gupta, Charan Singh, Vishnu Kumar Goyal
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	Hanif Khan, Pramod Prasad
DWR/RP/10-5.3	Molecular characterisation of DREB gene(s) in Indian wheat (Triticum aestivum)	Pradeep Sharma	OP Gupta
DWR/RP/10-5.4	Molecular characterisation of stress related genes responding to abiotic stress in wheat	Sonia Sheoran	Sneh Narwal, Mamrutha HM
DWR/RP/10-5.5	Development and utilisation of TILLING population for important traits of agronomic importance	Rajender Singh	R Tiwari, Sonia Sheoran and SK Singh
DWR/RP/10-5.6	Genetic studies on abiotic stress tolerance in wheat	Sindhu Sareen	BS Tyagi, Pradeep Sharma, Mamrutha
DWR/RP/10-6	**Improvement of wheat seed multiplication ratio through agronomic, pathological and technology interventions**	Raj Kumar	RS Chhokar and DP Singh
DWR/RP/10-7	**Improvement of barley varieties, protection and production technologies**		

Project No.	Project Title	PI	Associate/s
DWR/RP/10-7.1	Barley improvement for malting quality and resistance to prevalent biotic / abiotic stresses	RPS Verma	R Selvakumar, Dinesh Kumar and Vishnu Kumar
DWR/RP/10-7.2	Improvement of barley for feed and dual purposes	Joginder Singh	Vishnu Kumar, RPS Verma, R Selvakumar
DWR/RP/10-7.3	Molecular markers assisted improvement of barley for disease, pest and malt quality	Rekha Malik	RPS Verma, Dinesh Kumar and R Selvakumar
DWR/RP/10-7.4	Studies on biochemical parameters of grain in relation to the malting quality of barley	Dinesh Kumar	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
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 (*suspended till the joining of Dr. DP Singh*)	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	Indu Sharma
DWR/RP/10-8.3	Development of IPM module for the management of storage insect-pests in wheat and barley under ambient conditions *(suspended till the joining of entmologist)*		
DWR/RP/10-8.4	Detection of Cereal Cyst Nematode (CCN) resistant genes in wheat and barley genotypes and development of technologies for CCN *management (suspended till the joining of nematologist)*		
DWR/RP/10-8.5 (RRS Shimla)	Monitoring variability in wheat and barley rusts and rust resistance in wheat and barley	SC Bhardwaj	Om Prakash Gangwar, Hanif Khan, Selvakumar
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, Anita Meena
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, Raj Pal Meena, Anita meena

Project No.	Project Title	PI	Associate/s
DWR/RP/10-9.4	Evolving effective weed management strategies in wheat	RS Chhokar	RK Sharma, SC Gill, Rajender Singh
DWR/RP/10-9.5	Developing strategies for increased water use efficiency in wheat crop	Raj Pal Meena	SC Tripathi
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, Omprakash Gupta
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	Weed management strategies at farmers' field in India	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, R Sendhil
DWR/RP/10-11.3	Impact assessment of resource conservation technologies in wheat in Haryana	Anuj Kumar	Randhir Singh, Satyavir Singh , R Sendhil
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	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	-
New Projects (From November 2011 to October, 2015)			
DWR/RP/11-1.1	Elucidating the role of endogenous plant substances for ameliorating terminal heat stress in wheat	HM Mamrutha	K Venkatesh
DWR/RP/11-1.2	Studies on leaf rust resistance of wheat and utilization of specific *Lr* genes for varietal improvement	CN Mishra	Ratan Tiwari, OP Gangwar
DWR/RP/11.1.3	Race dynamics, epidemiology and genetics of resistance in yellow rust of wheat and Barley	OP Gangwar (Shimla)	

Externally funded projects

SN	Title of the project	Name of the funding agency	Name of the participating Institutes	Duration	Budget ₹ (in lakhs)
1	Agri-Bioinformatics Promotion Programme	Department of Information Technology, Ministry of Communication & IT	DWR, Karnal	5 years	229.10
2	DUS project on wheat under central scheme for implementation of PVP legislation	Protection of Plant Varieties and Farmers Rights Authority, New Delhi	DWR, Karnal UAS, Dharwad CSAUAS&T, Kanpur	Continuing since 2000	9.5 for 2012-13
3	Identification & validation of genomic regions involved in spot blotch resistance in Barley	DBT, New Delhi	DWR, Karnal	2 years	14.97
4	Mapping of heat tolerance genes and assessment of genetic variation in available heat tolerant wheat genotypes	ICAR-LBSYSA scheme	DWR, Karnal	Up to September, 2012	28
5	Pathogenic and molecular variation among *Tilletia indica* isolates/ monosporidil lines causing Karnal bunt of wheat	Department of Science & Technology, Govt. of India	DWR, Karnal	3 years	21.80
6	*Puccinia triticina* genomics network on De Novo genome sequencing, fitness, variation and pathogenicity	DBT, New Delhi	DWR, Flowerdale PAU, Ludhiana TNAU, Coimbatore IARI regional station Wellington	5 years	74.55
7	Genetic enhancement of wheat and pyramiding of rust resistance genes through molecular approach	DBT, New Delhi	DWR, Flowerdale Shimla VPKAS, Almora	5 years	32.32
8	Improving productivity of Wheat through enhanced Nitrogen	CRP-WHEAT-CIMMYT	NRCPB, New Delhi, IARI, Indore, UAS, Dharwad	3 years	US$ 314,000
9	Phenotyping of mapping populations at hot spots and tagging of major QTLs associated with spot blotch resistance in wheat	DBT	DWR, Karnal UBKVV, Punibari, Cooch Behar	3 years	70.99
10	Seed production in Agricultural Crops and Fisheries under DSR	DSR, MAU (UP)		5 years	90.50
11	DUS project in Barley	PPV&FRA	Project mode	2 years	17.80
12	Molecular characterization and genetic enhancement of fungal disease resistance and terminal heat tolerance	Indo-Swiss Collaboration in Biotechnology (ISCB)	University of Zhurich, Switzerland Punjab Agricultural University, Ludhiana Delhi University (South Campus), Delhi DWR, Karnal	Upto September, 2012	69.50
13	Molecular marker technology for faster breeding in India	ACIAR	DWR, Karnal PAU, Ludhiana NRCPB, New Delhi PBI, Sydney	3 years	Aus$ 430,910

SN	Title of the project	Name of the funding agency	Name of the participating Institutes	Duration	Budget ₹ (in lakhs)
14	High yielding, stress tolerance, good quality wheat varieties for current and future cereal systems in South Asia	CIMMYT CSISA	DWR, Karnal PAU, Ludhiana IARI, Indore UAS, Dharwad		
15	Wheat improvement for water logging, salinity and element toxicities in Australia and India	ACIAR	DWR, Karnal NDUAT, Faizabad CSSRI, Karnal	3 years	Aus$ 61,036
16	Root and establishment traits for greater water use efficiency in wheat (Indo-Australian Collaboration)	ICAR	DWR, Karnal Cooperating centres: IARI, Indore and ARI, Pune	3 years	42.22
17	Biotic stress-Rusts (Indo-Australian Collaboration)	ICAR	DWR, Karnal DWR, Flowerdale, Shimla IARI, New Delhi IARI, R.S. Wellington JNKVV, Powarkheda MPKV, Mahabaleshwar	3 years	75.65 (for all the centres)
18	Wheat grain quality (Indo-Australian Collaboration)	ICAR	DWR, Karnal Cooperating centres: IARI, New Delhi PAU, Ludhiana UAS, Dharwad	3 years	26.52
19	Crop simulation studies to understand the effect of moisture and temperature stress on growth and yield of wheat	NBSFARA	IARI, New Delhi DWR, Karnal	3 years	50.10

15 PUBLICATIONS

Research papers in journals

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Bhardwaj SC, OP Gangwar, SB Singh, MS Saharan and Sangeeta Sharma 2012. Rust situation and pathotypes of *Puccinia* species in Leh Ladakh in relation to recurrence of wheat rusts in India. *Indian Phtopathol.* **65(3)**: 230-32.

Bhardwaj SC, S Kumar, Neha Gupta and Sangeeta Sharma. 2011. A new pathotype 93R57 of *Puccinia triticina* on wheat from India. *J. Wheat Res.* **3(1)**: 24-25.

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Bipinraj A, B Honrao, M Prashar, SC Bhardwaj and S Tamhankar. 2011. Validation and identification of molecular markers linked to the leaf rust resistance gene *Lr*28 in wheat. *J. Appl. Genetics* **52**: 171-175.

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Garg D, S Sareen, S Dalal, R Tiwari and R Singh. 2013. Grain filling duration and temperature pattern influence the performance of wheat genotypes under late planting. *Cereal Res. Communications doi: 10.1556/CRC.2013.0019*.

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Islam S, Sushila Kundu, Jag Shoran, N Sabir, Kirti Sharma, Samir Farooqi, R Singh, HO Agarwal, KK Chaturvedi, RK Sharma and AK Sharma. 2012. Selection of wheat (*Triticum aestivum*) variety through expert system. *Indian J. Agric Sci.* **82(1)**: 43–47.

Kant Lakshmi, RPS Verma, HS Gupta, PK Agarwal and JC Bhatt. 2012. Malt Quality Evaluation of Exotic Barley Germplasm Grown in Northern Hills: A Non-Traditional Malt Area. *Indian J. Plant Genet. Resour.* **25(3)**: 246–250.

Kumar J, RS Chhokar, R Yadav, M Sivasamy, GP Singh, J Peter, P Jayprakash and VK Vikas. 2012. Effect of herbicide application on leaf rust development in wheat under artificial epiphytotics. *Indian Phytopathol.* **65 (3)**: 227-229.

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Long-Xi Yu, Alexey Morgounov, Ruth Wanyera, Mesut Keser, SK Singh and Mark Sorrells. 2012. Identification of Ug99 Resistance loci in winter wheat germplasm using genome-wide association analysis. *Theor. Appl. Genetics* Online version (doi:10.1007/s00122-012-1867-x).

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16 हिन्दी कार्यक्रमों पर विवरण

वर्ष 2012 के दौरान निदेशालय के हिन्दी अनुभाग द्वारा विभिन्न कार्यक्रम आयोजित किये गये तथा राजभाषा प्रचार–प्रसार के लिए निर्धारित लक्ष्यों की प्राप्ति के लिए हर सम्भव प्रयास किया गया। अनुभाग की कुछ प्रमुख गतिविधियों का संक्षिप्त विवरण नीचे दिया जा रहा है:

1. इस निदेशालय की राजभाषा कार्यान्वयन समिति की चार तिमाही बैठकें (24.04.2012, 01.08.2012, 29.11.2012 तथा 06.02.2013) को आयोजित की गई, जिनमें निदेशालय द्वारा राजभाषा हिन्दी की प्रगति पर चर्चा की गई। निदेशालय की कार्यान्वयन समिति द्वारा सुझाये गये अधिकतम मुद्दों पर प्रगति सराहनीय रही।

2. दिनांक 14 सितंबर को 'हिन्दी दिवस' मनाया गया जिसमें निदेशालय के सभी अधिकारियों/कर्मचारियों ने भाग लिया। हिन्दी में अधिक से अधिक कार्य करने वाले अधिकारियों/कर्मचारियों को 'उत्कृष्ट कर्मचारी पुरस्कार' से सम्मानित किया गया।

क्र.स	श्रेणी/वर्ग	कर्मचारी का नाम
1.	वैज्ञानिक	डॉ. विष्णु कुमार गोयल
2.	तकनीकी	श्री जे.के. पाण्डेय
3.	प्रशासनिक	श्री कृष्ण पाल
4.	कुशल सहायक	श्री नंदन सिंह

3. हिन्दी पखवाड़ा 14–28 सितंबर, 2012 को गेहूँ अनुसंधान निदेशालय, करनाल में मनाया गया। इस दौरान सभी वर्ग/श्रेणियों के लिए प्रतियोगिताओं का आयोजन किया गया तथा निम्न विजेताओं को हिन्दी पखवाड़ा के समापन समारोह (28.9.2012) के अवसर पर परियोजना निदेशक, डॉ. इन्दु शर्मा द्वारा सम्मानित किया गया।

श्रेणी/वर्ग	प्रतियेगिता	पुरस्कार	विजेताओं के नाम
नराकास स्तर (सभी वर्ग)	निबंध लेखन विषय : सिमटते परिवार घटते नैतिक मूल्य	प्रथम पुरस्कार	श्री मुकेश कुमार तोमर, दूरदर्शन केन्द्र, करनाल
		द्वितीय पुरस्कार	डॉ. रविन्द्र कुमार, भारतीय कृषि अनुसंधान संस्थान, करनाल
		तृतीय पुरस्कार	श्री रामकुमार सिंह, गेहूँ अनुसंधान निदेशालय, करनाल
		प्रोत्साहन पुरस्कार	श्री राकेश कुमार जैन, केनरा बैंक, अंचल कार्यालय, करनाल
वैज्ञानिक	भाषण विषय : सूचना का अधिकार कितना कारगर/ भोजन के अधिकार की सार्थकता	प्रथम पुरस्कार द्वितीय पुरस्कार तृतीय पुरस्कार प्रोत्साहन पुरस्कार	डॉ. विष्णु गोयल डॉ. रतन तिवारी डॉ. संजय सिंह डॉ. कर्नम वेंकटेश
तकनीकी	कविता पाठ	प्रथम पुरस्कार द्वितीय पुरस्कार तृतीय पुरस्कार प्रोत्साहन पुरस्कार	श्री राजेन्द्र सिंह श्री राजेन्द्र कुमार श्री राम कुमार श्री पी चन्द्र बाबू

प्रशासनिक	टिप्पण एवं मसौदा लेखन	प्रथम पुरस्कार	श्री कृष्ण पाल
		द्वितीय पुरस्कार	श्री मुकेश दुआ
		तृतीय पुरस्कार	श्री सुनील कुमार, श्रीमती प्रोमिला वर्मा
कुशल सहायक कर्मचारी	सुलेख	प्रथम पुरस्कार	श्री अमन कुमार
		द्वितीय पुरस्कार	श्री हरिन्द्र कुमार
		तृतीय पुरस्कार	श्री सुरेश राम
सभी वर्ग	गीत गायन	प्रथम पुरस्कार	डॉ. रतन तिवारी
		द्वितीय पुरस्कार	श्री रमेश चंद
		तृतीय पुरस्कार	डॉ. सत्यवीर सिंह
		प्रोत्साहन पुरस्कार	श्री कृष्ण कुमार, सुश्री भारती पाण्डेय
सभी वर्ग	सामान्य ज्ञान	प्रथम पुरस्कार	डॉ. रतन तिवारी, श्री अभय नागर
		द्वितीय पुरस्कार	श्री राजेन्द्र कुमार, श्री गिरीश चन्द्र पाण्डेय
		तृतीय पुरस्कार	सुश्री भारती पाण्डेय, श्री कृष्ण कुमार, सुश्री ज्योति वार्ष्णेय, श्री देवेन्द्र अरोड़ा, डॉ. स्नेह नरवाल, डॉ. सोनिया, डॉ. अनीता मीणा, श्रीमती सुनीता जसवाल
		प्रोत्साहन पुरस्कार	श्री वी के सहगल, श्री यशपाल, सुश्री रजिता तुरन, सुश्री वंदिता मित्तल
सभी वर्ग	अंताक्षरी	प्रथम पुरस्कार	डॉ. रतन तिवारी, श्री राजेन्द्र कुमार, सुश्री भारती पाण्डेय, सुश्री ज्योति वार्ष्णेय
		द्वितीय पुरस्कार	डॉ. सुशीला कुण्डु, डॉ. सोनिया शोरान, डॉ. स्नेह नरवाल, श्रीमती सुनीता जसवाल
		तृतीय पुरस्कार	सुश्री नेहा जैन, सुश्री विनती राणा, सुश्री रजिता तुरन, श्रीमती वंदिता मित्तल
		प्रोत्साहन पुरस्कार	डॉ. सजय कुमार सिंह, डॉ. आर. के. शर्मा, डा. आर. एस छोकर, श्री राजेन्द्र सिंह
शोध सहायक	आशु भाषण	प्रथम पुरस्कार	सुश्री भारती पाण्डेय
		द्वितीय पुरस्कार	श्री पंकज कुमार सिंह
		तृतीय पुरस्कार	सुश्री ज्योति वार्ष्णेय
		प्रोत्साहन पुरस्कार	श्री यशपाल
संगणक कर्मी/ कुशल सहायक कर्मी	राजभाषा ज्ञान	प्रथम पुरस्कार	श्रीमती मीना कुमारी
		द्वितीय पुरस्कार	श्री बन्टी
		तृतीय पुरस्कार	श्रीमती नीतू वोहरा

4. राजभाषा के प्रचार–प्रसार के लिए चार वृत चित्र (सेतु, कलमकारी, गोपुरम, गांधी और गुलामी) खरीदे गए हैं।

5. विशेष हिन्दी सम्मेलन एवं कार्यशाला 11–13 जुलाई, 2012 को नैनीताल, उत्तराखंड में आयोजित हुई जिसमें निदेशालय के 02 कर्मचारियों ने भाग लिया।

6. 'गेहूँ एवं जौ स्वर्णिमा' का चतुर्थ अंक जो "कटाई उपरान्त प्रबंधन, भंडारण एवं मूल्य संवर्धन" विषय पर आधारित है का प्रकाशन किया जा चुका है।

7. प्रत्येक तिमाही की रिपोर्ट समयबद्ध एवं नियमित रुप से भारतीय कृषि अनुसंधान परिषद, कृषि भवन, नई दिल्ली को भेजी जा रही है।

8. 'गेहूँ एवं जौ संदेश' का प्रकाशन किया जा चुका है।

नराकास बैठकों का आयोजन

9. नराकास, करनाल की समीक्षा बैठक 27.06.2012 तथा 26.12.2012 को राष्ट्रीय डेरी अनुसंधान संस्थान, करनाल में आयोजित हुई जिसमें डॉ० अनुज कुमार (प्रभारी हिन्दी अनुभाग) ने भाग लिया।

10. नगर राजभाषा कार्यान्वयन समिति की 55वीं बैठक में गेहूं अनुसंधान, करनाल को वर्ष 2012 के दौरान अपने कार्य क्षेत्र में राजभाषा (हिन्दी) के उल्लेखनीय कार्य हेतु तृतीय पुरस्कार से सम्मानित किया गया।

राजभाषा में उल्लेखनीय कार्य के लिए तृतीय पुरस्कार

कार्यशाला का आयोजन

1. दिनांक 16 जून 2012 "आँखों एवं दांतों की देखभाल" विषय पर कार्यशाला का आयोजन किया गया।

2. दिनांक 21 सितंबर 2012 को ''सिमटते परिवार घटते नैतिक मूल्य'' विषय पर कार्यशाला का आयोजन किया गया।

हिन्दी दिवस

हिन्दी पखवाड़ा

17 PERSONNEL

Project Director

Indu Sharma, PhD

Crop Improvement

V Tiwari, PhD, Pr. Scientist
Ravish Chatrath, PhD, Pr. Scientist
Sushila Kundu, PhD, Pr. Scientist
Gyanendra Singh, PhD, Pr. Scientist
Ratan Tiwari, PhD, Pr. Scientist
BS Tyagi, PhD, Pr. Scientist
Arun Gupta, PhD, Pr. Scientist
Sindhu Sareen, PhD, Pr. Scientist
Raj Kumar, PhD, Sr. Scientist
SK Singh, PhD, Sr. Scientist
Pradeep Sharma, PhD, Sr. Scientist
Rajender Singh, PhD, Sr. Scientist
Rekha Malik, PhD, Scientist (SS)
Sonia Sheoran, PhD, Scientist (SS)
Satish Kumar, PhD, Scientist
Charan Singh, MSc, Scientist
Karnam Vanktesh, PhD, Scientist
CN Mishra, PhD, Scientist
HM Mamrutha, PhD, Scientist
Vikas Gupta, PhD, Scientist

Om Prakash, PhD, T-7-8
BK Meena, PhD, T-6
Ravinder Singh, BTech, T-6
Rajendra Kumar, MSc, T-6
Raj Kumar, T-5
Om Prakash, T-5
Rahul Singh, T-4
Suresh Kumar, T-4
Rajesh Kumar, T-3
Bhal Singh, T-3
Ronak Ram, T-3
Ramesh Pal, SSS
Aman Kumar, SSS

Crop Protection

AK Sharma, PhD, Pr. Scientist & PI (up to August, 2012)
DP Singh, PhD, Pr. Scientist (on deputation to ITEC assignment at Guyana)
AK Singh, PhD, Pr. Scientist (up to 31.5.2012)
MS Saharan, PhD, Pr. Scientist & PI (w.e.f. August 2012)
R Selvakumar, PhD, Sr. Scientist

Mangal Singh, MSc, T-6
Ishwar Singh, T-5
Lok Raj, T-3
Hem Lata, Stenographer
Nandan Singh, SSS

Resource Management

RK Sharma, PhD, Pr. Scientist & PI
SC Tripathi, PhD, Pr. Scientist
SC Gill, PhD, Pr. Scientist
RS Chhokar, PhD, Sr. Scientist
Raj Pal Meena, PhD, Scientist (SS)

Anita Meena, PhD Scientist
PHP Verma, MSc, T-6
Ram Kumar Singh, MSc, T-6
Rajinder Pal Sharma, T-4
Sukh Ram, T-2
Desh Raj, SSS

Quality and Basic Sciences

RK Gupta, PhD, Pr. Scientist & PI
Devender Mohan, PhD, Pr .Scientist
Sewa Ram, PhD, Pr. Scientist
Sneh Narwal, PhD, Sr. Scientist
OP Gupta, MSc, Scientist

VK Sehgal, MSc, T-6
Sunita Jaswal, T-5
Jamuna Devi, T-3
Ishwar Singh, T-3

Social Sciences

Randhir Singh, PhD, Pr. Scientist & PI
Satyavir Singh, PhD, Pr. Scientist
Anuj Kumar, PhD, Sr. Scientist
R Sendhil, PhD, Scientist

JK Pandey, MSc, T-7 -8
Rajender Singh, MSc, T-6
Ramesh Chand, PhD, T-6
Rajender Kumar Sharma, T-5
Paramjeet Singh, SSS

Barley Network

RPS Verma, PhD, Pr. Scientist & PI
AS Kharub, PhD, Pr. Scientist
Dinesh Kumar, PhD, Pr. Scientist
B Sarkar, PhD, Sr. Scientist (up to 31.08.2012)
Joginder Singh, PhD, Sr. Scientist (w.e.f. 6.02.2013)
Vishnu Kumar, PhD, Scientist

Sant Kumar, T-6
Yogesh Kumar, MSc, T-6
Madan Lal, T-5
Shanti Devi, SSS

Computer Science and Statistics

Ravish Chatrath, PhD, Pr. Scientist & Incharge
Ajay Verma, PhD, Sr. Scientist
Suman Lata, PhD, Sr. Scientist
Yogesh Sharma, MSc (CS), T-6
Surender Singh, T-6
P Chandrababu, PGDCA, T-6
Bhim Sen, SSS

Director's Cell

Gyan Aneja, PS to Project Director

Finance Management

Tara Chand Sharma, F&AO
Jagdish Chander, AF&AO
Ramesh Kumar, Asstt.
Krishan Pal, UDC
Suman Thapa, SSS
Ramu Shah, SSS

Administration

Ashok Mallick, Sr. AO (up to 31.08.2012)
Abhishek Srivastava, AO (w.e.f. 25.08.2012)
Roshan Lal, AAO (retired on 30.04.2012)
JS Pal, AAO (On deputation w.e.f. 26.11.2012)
Sher Singh, Asstt.
Promila Verma, Asstt.
Sunil Kumar, Asstt. (w.e.f. 08.06.2012)
Sh. Anil Kumar Sharma, Asstt. (On deputation w. e. f. 03.07.2012)
Smt. Usha Rani, Asstt. (On deputation w.e.f. 03.07.2012)
Anil Kumar, Stenographer
Sushila, UDC
Ramesh Kumar, UDC
Mahabir Singh, LDC
Yashwant Singh, SSS
Guman Singh, SSS

Library

Dinesh Kumar, PhD, Incharge
Abhay Nagar, M Lib. & Inf. Sci, T-6
Harender Kumar, SSS

Farm Section

Gyanendra Singh, PhD, Incharge
Surendra Singh, MSc, T-6
Amar Singh, Driver, T-3
Vinod Khokhar, Driver, T-1
Hari Prasad, SSS

Landscape Section

Rajender Kumar Sharma, T-5
Hawa Singh, SSG (Mali)
Raj Kumar, SSG (Mali)

Technical (Workshop Group)

Abhay Ram, Driver
Om Singh, Driver
Ram Jawari, Driver
Rajbir Singh, Driver
Rajbir Singh, Driver
Sunder Lal, Driver

Regional Station, Flowerdale, Shimla

SC Bhardwaj, PhD, Pr. Scientist & Incharge
Om Prakash Gangwar, PhD, Scientist
Promod Prasad PhD, Scientist
Hanif Khan, PhD, Scientist (w.e.f. 12.07.2012)
SB Singh, T-7
Subhodh Kumar, MSc, T-5
Baldev Singh, T-3
Udai Singh, T-3
Swroop Chand, T-1
Jaspal Singh, AAO
Shanti Devi, AAO
Roop Ram, Jr Stenographer
Chaman Lal ,SSS
Om Parkash, SSS
Sant Ram, SSS
Bhoop Ram Verma, SSS
Khem Chand, SSS
Bhoop Ram Thakur, SSS
Anil Kumar, SSS

Regional Station,Dalang Maidan, Lahaul & Spiti

Rajender Singh, PhD, Incharge
Nand Lal, T-2

18 STAFF POSITION & FINANCE

Staff Position as on March 31, 2013

Scientific cadre strength

Designation	Sanctioned	Filled	Vacant
DWR, Karnal			
Project Director	1	1	-
Principal Scientist	6	3	3
Senior Scientist	10	6	4
Scientist	30	31	-1
Barley Unit, Karnal			
Principal Scientist	1	1	-
Scientist	4	4	-
DWR Regional Station, Shimla			
Principal Scientists	1	-	1
Scientists	4	4	
Total	**56+1**	**49+1**	**8(-1)**

Administrative cadre strength

Designation	Sanctioned	Filled	Vacant
A. DWR, Karnal			
AO	1	1	-
AAO	1	1	-
FAO	1	1	-
AF&AO	1	1	-
Assistant	7	6	1
UDC	3	3	-
LDC	5	3	2
PS	1	1	-
PA	2	2	-
Total	**22**	**19**	**3**
B. DWR Regional Station, Shimla			
AAO	2	2	-
Steno Gr III	1	1	-
Total	**3**	**3**	**-**
Total (A+B)	**25**	**22**	**3**

Technical cadre strength

Designation	Sanctioned	Filled	Vacant
A. DWR, Karnal			
T-3 (Cat.II)	19	19	-
T-1 (Cat.I)	23	23	-
B. DWR Regional Station, Shimla			
T-3 (Cat.II)	2	2	-
T-1 (Cat.I)	3	3	-
C. DWR Regional Station, Dalang Maidan, Lahaul & Spiti			
T-3 (Cat.II)	-	-	-
T-1 (Cat.I)	2	1	1
Total (A+B+C)	**49**	**48**	**1**

Skilled supporting staff cadre strength

Station	Sanctioned	Filled	Vacant
DWR, Karnal	20	16	4
DWR Regional Station, Shimla	11	7	4
DWR Regional Station, Dalang Maidan, Lahaul & Spiti	3	-	3
Total (A+B+C)	**34**	**23**	**11**

Summary

Cadre	Sanctioned	Filled	Vacant
Project Director	1	1	
Scientific	56	49	7
Technical	49	48	1
Administrative	25	22	3
Skilled supporting staff	34	23	11
Total staff	**165**	**143**	**22**

Budget allocation and expenditure (Rupees Lakhs), 2012-13

Head	Allocation	Expenditure
Plan-DWR	530.00	529.58
Plan-AICW&BIP	1840	1840
Non Plan	1231.86	1204.63
Total	**3601.86**	**3574.21**

19 JOINING, PROMOTION, TRANSFER AND RETIREMENT

Joining

Sh. Sunil Kumar, Assistant	08.06.2012
Sh. Anil Sharma, Assistant	03.07.2012
Smt. Usha Arora, Assistant	03.07.2012
Dr. Hanif Khan, Scientist (Plant Breeding) at Shimla	12.07.2012
Sh. Abhishek Srivastava, Administrative Officer	25.08.2012
Sh. JS Paul, Asstt. Admn. Officer	26.11.2012
Dr. Joginder Singh, Sr. Scientist (Plant Breeding)	06.02.2013

Promotions

(From Sr. Scientist to Pr. Scientist)

Dr. BS Tyagi	w.e.f. 01.01.2009
Dr. Arun Gupta	w.e.f. 01.01.2009
Dr. MS Saharan	w.e.f. 01.01.2009
Dr. (Mrs.) Sindhu Sareen	w.e.f. 03.04.2010
Dr. Satyavir Singh	w.e.f. 27.07.2010
Dr. Subhash Chander	w.e.f. 19.12.2010

(From Scientist to Scientist SS)

Dr. RP Meena	w.e.f. 30.03.2009
Dr. (Mrs.) Sonia Sheoran	w.e.f. 07.01.2012

MACP granted

Sh. Sher Singh, Assistant (from Rs.4200 to Rs. 4600)	18.12.2012
Sh. Mahavir Singh, LDC (from Rs.1900 to Rs. 2000)	01.07.2012

Transfers

Dr. AK Singh, Pr. Scientist transferred to IARI New Delhi w.e.f. 31.05.2012

Dr. AK Sharma, Pr. Scientist was relieved from the Directorate on August 26, 2012 on his selection as Director, NBAIM, Mau (UP)

Sh. Ashok Mallick, Sr. Admn. Officer transferred to NDRI, Karnal w.e.f. 31.08.2012

Dr. B Sarkar, Sr. Scientist transferred to IIPR, Kanpur w.e.f. 31.08.2012

Retirement

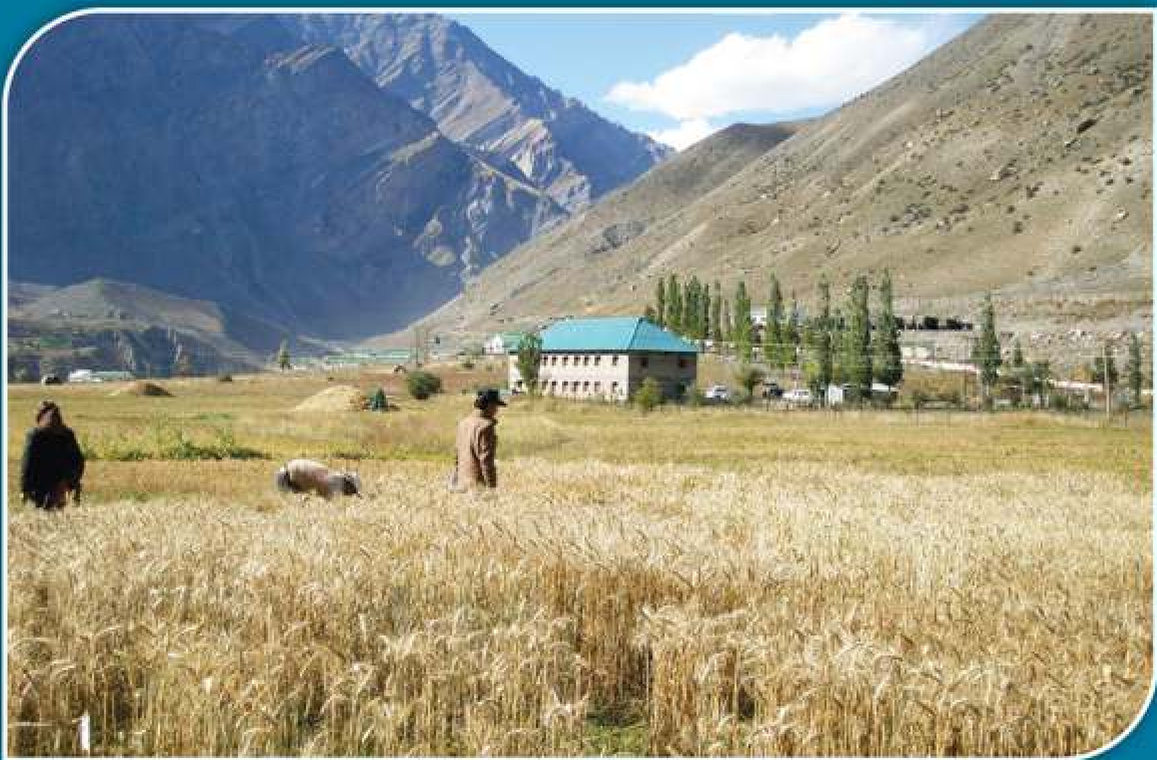
Sh. Ram Bhool, SSS-III, w.e.f. 31.03.2012.

Sh. Roshan Lal, Asstt. Admn. Officer w.e.f. 30.04.2012

Acknowledgement

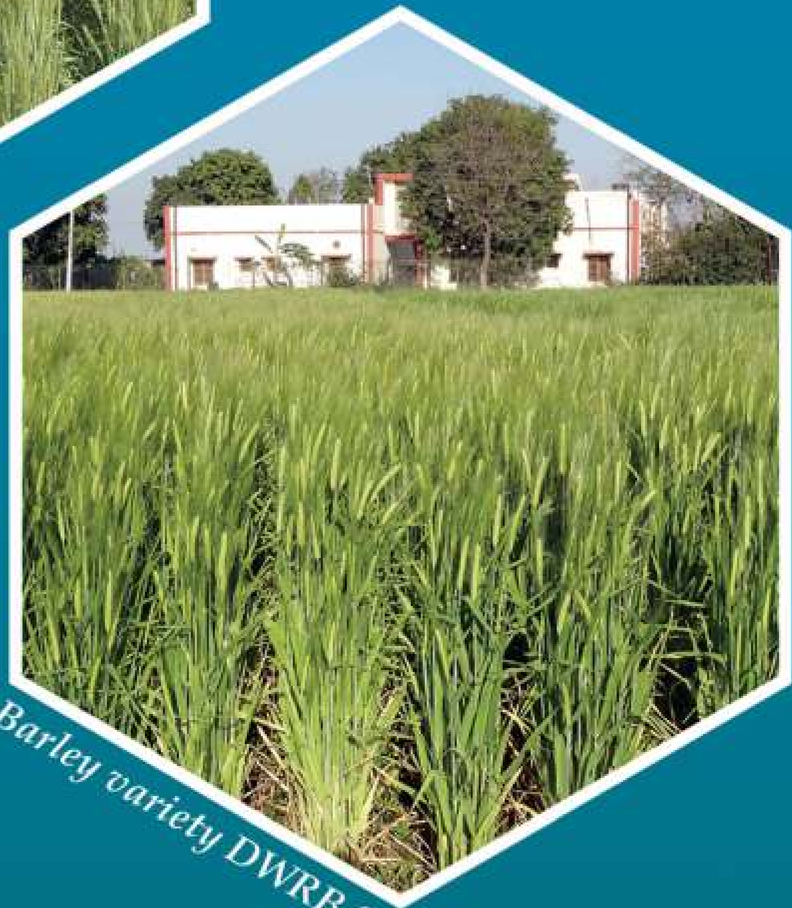
On behalf of the Directorate, the Project Director expresses her sincere thanks to Indian Council of Agricultural Research (ICAR), State Agricultural Universities and all the Cooperators for successfully executing the wheat research programme. The guidance and overwhelming support received from Dr. S Ayyappan, Secretary DARE & DG, ICAR, Dr. SK Datta, DDG (Crop Science) and Dr. RP Dua, ADG (FFC) are gratefully acknowledged. The combined efforts of all the Principal Investigators of the Directorate in publication of this report are appreciated. The contribution of scientists, technical, administrative, finance and supporting staff is acknowledged.

Greenhouses at Shimla



DWR Regional Station Dalang-Maidan

Wheat variety DBW 71



Barley variety DWRB 91

भाकृअनुप
ICAR

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भारतीय कृषि अनुसंधान परिषद

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