वार्षिक प्रतिवेदन

ANNUAL REPORT

2014-15

भा.कृ.अनु.प.- भारतीय गेहूँ एवं जौ अनुसंधान संस्थान

करनाल - 132001, भारत

ICAR- Indian Institute of Wheat and Barley Research

Karnal - 132001, India

MANDATE

- Organize, coordinate and monitor multi-locational and multi-disciplinary 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 organize nucleus and breeder seed production.
- Impart training/education related to wheat and barley improvement, production, protection, utilization and trade.

THE MISSION

Ensuring Food Security of India by Enhancing the Productivity and Profitability of Wheat and Barley on an Ecologically and Economically Sustainable Basis and making India the World Leader in Wheat Production.

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भा.कृ.अनु.प.- भारतीय गेहूँ एवं जौ अनुसंधान संस्थान
(भारतीय कृषि अनुसंधान परिषद)
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डा. (श्रीमती) इन्दु शर्मा
निदेशक
Dr. (Mrs.) Indu Sharma
DIRECTOR

PREFACE

It is my great privilege and pleasure to be a part of the organisation's historic journey from the All India Coordinated Wheat Improvement Programme in 1965 at New Delhi to a full-fledged Indian Institute of Wheat and Barley Research during 2014-15. I take this opportunity to thank all the present and past authorities in ICAR, past Project Directors of the Directorate of Wheat Research, and, all the co-operating centres and staffs who have contributed a lot in this glorious journey. On a personal note, this is a path laid to sustain more success in future for achieving national food and nutrition security.

Despite the track record of producing more than 93 mt of wheat continuously in the past three *Rabi* seasons, the country witnessed a decline in production from 95.85 mt in 2013-14 to 90.78 mt (3rd advance estimate) in 2014-15. *Inter alia,* unexpected hailstorms and unseasonal rains in the major wheat growing regions of the country during February-March 2015 hampered the wheat production by 5.29 per cent in comparison to the previous year record production.

Among all significant achievements in the current year, the highlight was the release of ten new wheat varieties by the CVRC comprising eight bread wheat varieties and one variety each in *durum* and *dicoccum* for cultivation in different wheat growing zones of the country. IIWBR also developed two new wheat varieties namely DBW107 for irrigated late sown conditions of North Eastern Plains Zone, and DBW110 for timely sown, restricted irrigation conditions of Peninsular Zone. To meet the demand of various public and private sector seed institutions, a total of 22492.21 q breeder seed of 156 varieties were produced by various cooperating centres. Crop protection group has been devising eco-friendly management techniques for the effective management of diseases and pests. Resource management team aims for increasing the total factor productivity by efficient utilization of resources through various resource conservation technologies. The quantum jump in wheat production during the past few years has offered opportunity for export. Hence, scientists from the quality and basic sciences division has been paying attention to meet the quality standards of international market through analysing large samples from the Food Corporation of India. The social sciences unit has conducted and coordinated 600 frontline demonstrations, and organised several capacity building programmes including trainings and providing advisory services to the farmers pertaining to wheat and barley production. Regional Research Station, Shimla has made sincere efforts to understand the epidemiology of wheat rusts. Cooperating centres across the country has utilized the off-season facility of Regional Station, Dalang Maidan. Demand for barley has been growing at a constant rate in the recent years and to meet the demand from brewing industries, the institute has developed a malt barley variety DWRB 101 suitable for cultivation in states like Punjab, Haryana and Rajasthan. Research farm at Hisar has become functional at very first year and has contributed a significant share to the Institute's resource generation.

Scientists from IIWBR have been recognised at national and international level through Awards/Grants like Panjabrao Deshmukh Outstanding Woman Scientist Award; Lal Bahadur Shastri Outstanding Young Scientist Award; Prof. Mahatim Singh Memorial Award; Dr. RK Arora Best Paper Award and LI-LMI Grant for the research ideas and contribution to wheat/barley improvement during the year.

Further, highlights of the research work and other activities organized at the institute during 2014-15 are reflected in this Annual Report.

24.6.2015

(Indu Sharma)

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EXECUTIVE SUMMARY

In India, the wheat research started in an organized manner exactly hundred and nine years ago during British period after joining of Sir Howards as the Imperial Botanist at Pusa (Bihar) in 1905. Later on with the establishment of the Indian Council of Agricultural Research, it became the main funding agency and promoter of wheat research in India and the Indian Agricultural Research Institute (IARI) played an important role for the wheat research related activities. An important milestone in this process was the establishment of the All India Coordinated Wheat Improvement Project (AICWIP) in 1965 by the ICAR. The AICWIP was elevated to the status of the Directorate of Wheat Research in 1978 and in 1990 it moved from IARI, New Delhi, to its present location at Karnal, 130 km north of Delhi along with two regional stations located at Flowerdale, Shimla and Dalang Maidan (Lahaul valley). In 2014, the council has upgraded the Directorate of Wheat Research to Indian Institute of Wheat and Barley Research, by doing so, ICAR has given more responsibility to the IIWBR in formulating strategies to ensure sustainable improvement in productivity of both wheat and barley crops.

The significant achievements made by the institute are presented below:

Crop Improvement

- Ten new wheat varieties including eight bread wheat varieties namely Pusa Kiran (HS 542), WH 1124, NW 5054, K 1006, Pusa Vatsala (HD 3118), DBW 107, DBW 110, MACS 6478 and one durum wheat variety, Pusa Anmol (HI 8737) and a dicoccum wheat variety Nilgiri Khapli (HW 1098) were released by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) for different production conditions and agro-ecological zones in the country.

- Two genetic stocks of wheat viz. HI 8708 (resistance to leaf rust) and UAS 334 (resistance to foot rot) were registered at NBPGR, New Delhi.

- Two varieties developed by the institute namely DBW 107 for irrigated late sown conditions in North Eastern Plains Zone (NEPZ) and DBW 110 for restricted irrigation, timely sown conditions in Central Zone (CZ) were released by the CVRC for commercial cultivation.

- The multi-location evaluation of wheat genotypes developed by breeders at centres across the nation was undertaken in which 508 entries along with 75 check varieties under 41 series of trials for yield, diseases, quality and agronomic characteristics spread all over the country. Out of 483 trials conducted at 131 centres, the data for 407 trials were found qualifying for reporting based on set norms.

- Among the 120 genotypes evaluated in various AVTs in coordinated trials conducted in different zones, 10 genotypes were found superior to the check varieties on the basis of yield and response to incidence of rusts.

- A total of 311 entries in different NIVTs, 36 in IVTs and 5 special trials on triticale, salinity/alkalinity, *dicoccum*, MABB/NIL and wheat biofortification were evaluated and 85 entries (50 of bread wheat and 35 of durum wheat) were found promising for yielding ability and disease resistance

- As part of international collaborations with CIMMYT and ICARDA, 135 sets of international nurseries and trials (130 from CIMMYT and 5 from ICARDA) comprising a total of 2050 lines were evaluated at various wheat breeding centres across the country.

- To meet the demand of breeder seed production in the country, a total of 22492.21q breeder seed involving 156 wheat varieties with a surplus production of 1381.14q over the indented quantity was produced at 31 seed production centres. In addition, 1762.45q nucleus seed of 143 varieties was also produced.

- Wheat and Barley field day was organized on March 27, 2015 at Karnal for making on the spot assessment and selection of the germplasm by the scientists from various cooperating centres.

- A total of 1344 accessions were supplied to various indenters within India during the period under report.

- Nine hundred five exotic accessions of wheat comprising 752 accessions of *T. aestivum*, 119 of *T. durum*, 17 of *T. dicoccum*, 07 of Triticale, 04 of *T. timopheevi* and 03 of *T. sphaerococcum* were evaluated and characterised as per DUS testing guidelines.

- 11,500 germplasm accessions were conserved in medium term storage module (4°C and RH 30-35%) at the institute and a safety duplicate comprising 9985 accessions is also being conserved under natural condition at IIWBR Regional Station, Dalang Maidan.

- The applications for registration of three new IIWBR varieties namely DBW 71, DBW 88 and DBW 90 were prepared and submitted to the PPV&FRA, New Delhi and the institute also facilitated in preparation and submission of application for registration of four farmers varieties namely *Mundal*, *Sharbati*, *Bansi* and *Pushkar plus* to the PPV&FRA, New Delhi.

- Around 400 accessions of 20 wild species were evaluated for stress tolerance and *T. dicoccum* and *T. sphaerococcum* were used for transfer of quality parameters while *T. urartu*, *Ae. tauschii* and *Ae. peregrina* were used as donors for disease resistance. A backcross breeding program was taken up involving the resistant stock Sumai # 3 and Frontana for transfer of head scab resistance to durum wheats.

- Different donors of stripe rust resistance genes were utilized for wheat improvement under high productive environments of Northern India. For incorporation of Ug99 resistance, FLW stocks were crossed as donors into superior backgrounds.

- Ten lines were identified as new sources to widen spot blotch resistance genetic base and abiotic stress tolerance in the research programme on eastern India. Thirty Seven fresh crosses were attempted to diversify base, improve tolerance against biotic/abiotic stresses and quality traits. Six sets of Shuttle Breeding Lines consisting 137 lines were shared with centres of NEPZ for selection and utilization. Three set of mapping populations were phenotyped for spot blotch resistance.

- A total of 238 new crosses including 12 double crosses were attempted to incorporate desirable traits. The segregating and advanced lines were shared with shuttle breeding centres in CZ and PZ for selection and utilization in target environments.

- In order to bring in new variability into spring wheats, a total of 347 crosses were made at Karnal during the season involving winter wheat and spring wheat parents under spring x winter wheat hybridization programme. Nine genotypes during 2013-14 crop season and six during 2014-15 crop season were tested in national coordinated varietal trials. Spring x Winter wheat Segregating Stock Nursery (SWSN) comprising 42 crosses in F_2 generation was shared with the five cooperating centres.

- Physiological screening of wheat germplasm lines and populations for abiotic stress tolerance involved maintenance of thirteen RIL populations developed for heat tolerance traits. Phenotyping was done in 7 cross-combinations to study the genetics of traits for heat stress. The RIL population (HD 2808/ HUW 510) comprising 253 lines were phenotyped for mapping studies. In addition, 37 indigenous and 32 exotic germplasm accessions and one hundred synthetic wheat derivatives were evaluated for drought and heat tolerance.

- In mapping QTLs for stripe rust resistance using separate biparental and association mapping populations, a total of 50 MTA's (marker trait associations) were obtained explaining 3.04 to 14.78% (R^2) of the phenotypic variation. Novel regions significantly associated with yellow rust were identified on chromosomes 2A and 5B.

- A marker assisted backcross breeding programme to transfer *Sr*39 gene from HR22Hartog using linked marker STS *Sr*39#22r into Indian wheat varieties like CBW38, DBW14, DBW71, DBW88, DBW107 and DBW110 was undertaken.

- A QTL for resistance to Karnal Bunt was mapped to the interval between markers Xwmc235 and Xbarc140 on chromosome 5B. In addition, genetic variability in *Tilletia indica* isolates using REP-PCR fingerprinting was carried out.

- In M_4 generation of TILLING population under development 10 lines (6 free and 4 flecking type) resistant to yellow rust were identified.

- In a study to see the effect of plant hormones in mitigating heat stress, the endogenous concentration of IAA in a set of heat tolerant and susceptible wheat genotypes was estimated ranging from 95.8 to 120.8 $\mu g\ g^{-1}$.

- An efficient regeneration protocol for Indian wheat genotypes was developed.

- Haploid production protocol in wheat was standardised using chromosome elimination technique through wheat x maize hybridization.

Crop Protection

- The sources of resistance (multiple disease/pest resistant sources) were identified through multi-location hot spot evaluation. A total of 41 entries known for confirmed sources of multiple disease and insect pest resistance were made available to the breeders through NGSN, which has helped in diversification and enhancement of resistance level. The most utilized entries at many centres were DBW 58, HD 3058, HI 1572, HPW 360, HS 534, HS 545, HUW 640, KRL 304, MACS 3828, MP 3288, MP 3304, NW 5013, PBW 648, PBW 658, RSP 561, UAS 320, VL 941 and WH 1095.

- Indian wheat advance lines (221) were evaluated at Kenya and Ethiopia for resistance against Ug99. Slow ruster lines were identified for stripe rust resistance at Karnal.

- This crop year was marked with the sporadic appearance of yellow (stripe) rust in some pockets of Northern India. Though the yellow rust was observed in early January 2014, however, due to the resistance in cultivated varieties as well as proactive steps for the management, it could be managed well. The Black (stem) rust of wheat was observed in May, 2014 on indigenous wheat material planted at Bhowali, Hawalbagh and Pantnagar (Uttarakhand) and in wheat fields from Nashik and Dhule districts of Maharashtra during 2nd fortnight of March, 2014. Except for the yellow rust in NHZ and NWPZ, the overall crop health status was satisfactory in the country.

- Out of 8900 grain samples analyzed for Karnal Bunt (KB), 32.20 per cent samples were found infected with KB. No sample from West Bengal, Gujarat (Vijapur), Maharashtra (Pune) and Karnataka (Dharwad) was found infected with KB.

- Out of 5717 grain samples analyzed for black point from different zones in the country, 78.95 per cent samples were found infected.

- Among AVT lines, none of the entry was resistant to shoot fly, aphids, root aphids and brown wheat mite. Genotypes, NW 3069, MACS 6221, VL 924, PDW 315, PDW 317, DBW 46, HPW 308, HPW 309, HI 8692 and WH 1076 have shown moderate resistance to brown wheat mite. Genotypes, NIAW 1994, NIAW 1885, K 1006, DBW 107, WH 1138, HD 2932+Lr19/Sr25, KB 2012-03, PBW 723, UAS 451 (Durum), PBW 692, HD 3128, VL 1004 and VL 3002 were found moderately resistant to root aphid.

- The genetic ratios of F_2 plants from the crosses HD 2967/Sumai-3 (120), HD 2967/Frontana and HD 2967/Aldan indicated a complex nature of resistance to head scab in all the three donors. Pathogenic variation among *Fusarium graminearum* isolates was studied on a set of wheat varieties under artificially inoculated conditions. Bioagents either used as seed treatment or spray resulted in head scab control as compared to untreated control.

- Thirty nine monosporidial lines were developed from single primary sporidia of *T. indica* infected grain of HD 2967 (Karnal). All lines were inoculated on two susceptible wheat genotypes, WL 711 and WH 542. Out of 39 monosporidial lines inoculated on above varieties, there was no infection with 17 lines.

- Imidacloprid 600 FS (Gaucho) @ 0.72 g a.i. /kg seed was quite effective for the control of termite damage. Propargite 57 SC (Omite) @ 1.5 ml/l of water was very effective for brown wheat mite management.

Resource Management

- In the long term experiment on various tillage options in rice-wheat system, it was observed that tillage in both rice and wheat had non-significant effect on wheat yield.

- In case of rice also, there was non-significant effect of tillage in wheat but no-tillage rice transplanting gave significantly lower yield compared to puddle and un-puddle transplanted rice.

- The wheat productivity was not significantly affected by different residue management practices and only nitrogen had significant effect.

- The yield of direct seeded rice variety Pusa 1509 was 30% lower than the puddled transplanted rice under various residue management options.

- The surface residue retention (>4 t/ha) improved the wheat productivity when only two irrigations were applied.

- The yield of direct seeded rice (varieties Pusa 1509 and NK 3325) was 25% lower than the puddled transplanted rice under various nitrogen management option.

- Relay planting of wheat in longer duration cotton gave 3-7% higher grain yield when power tiller was used either to drill or to mix the seed after broadcasting whereas yield reduction up to 7% was obseved when dry or soaked seed was broadcasted followed by immediate irrigation in the standing cotton.

- Application of FYM from 10 to 30 t/ha increased the productivity of high yielding wheat varieties significantly in comparision to control (No FYM and/or fertilizer) but remained significantly lower than recommended doses of chemical fertilizer.

- In the integrated nutrient managment experiment, the highest productivity was recorded with recommended NPK 150:60:40 kg/ha plus 15 t/ha FYM and the lowest productivity was observed in nitrogen omission treatment.

- Nitrogen application just before irrigation was better compared to when applied after irrigation.

- Irrigation scheduling at 60, 80 kPa or at critical growth stages of crop produced statistically similar yield.

- Matri-conditioning of seeds produced significantly higher grain yield over unprimed and pre-germinated seed.

- Significantly higher grain yield was obtained under drip + sprinkler method of irrigation followed by drip and sprinkler over check basins method of irrigation. However, maximum water use efficiency was obtained for sprinkler irrigation (1.61 kg m^{-3}) followed by drip + sprinkler (1.57 kg m^{-3}).

- Skipping of P application either in rice or wheat produced similar rice-wheat yield.

- Rice straw incorporation before wheat sowing require 25% more N than recommended dose.

- Raddish and turnip showed good performance in intercropping in furrows whereas cauliflower, cabbage, fenugreek and coriander performance was poor in furrows.

- Flufenacet can be effectively used for control of grassy weeds (*P. minor* and wild oat). This herbicide was also effective in controlling the multiple herbicide resistant populations of *P. minor*.

- Pyroxsulam at 18 g/ha with surfactant (Polyglycol) 1000 ml/ha is effective against grassy (*P. minor* and wild oat) and broad leaf weeds.

- *Rumex dentatus* has evolved metsulfuron resistance and showed the cross resistance to Atlantis (400 g/ha). However, the resistant population was effectively controlled by carfentrazone and 2,4-D.

Quality and Basic Sciences

- Several *T. aestivum* genotypes namely, WH 1129, MP 3382, C 306, K 8027, HD 2888, HD 2864, HD 2932, MP 3336, HI 1500, MACS 6478, HD 2932 and NIAW 1415 were found promising for chapatti quality scoring >8.0/10.0.

- Wheat genotypes viz. UAS 347, NIAW 1994, NW 2036, MACS 6222, HD 2932, Raj 4083, HD 3090, NI 5439 and NIAW 1415 were found suitable for bread quality recording 575 ml loaf volume.

- Only one genotype HS 490 was found good for biscuit recording >10.0 spread factor.

- Some of the *T. durum* wheat genotypes, HI 8736, HI 8737, UAS 446 were rated good for pasta products scoring 7.0/9.0 on hedonic scale.

- High molecular weight glutenin subunits were determined in all the AVT entries including checks at Glu A1, Glu B1 and Glu D1.

- 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 Raj 4376 from NIVT 1A for NWPZ, PBW 715 and HI 1603 from NIVT 2 for CZ and HD 3164 & HI 1603 from NIVT 2 for PZ.

- Quality Component Screening Nursery (QCSN) comprising of 52 test entries were evaluated at 15 locations and promising genotypes were identified.

- To improve the chapatti, 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 advance lines have been identified and promoted to NIVTs and AVTs.

- More than 350 new crosses and >500 back crosses were attempted and several hundred progenies belonging to different generations were advanced using summer nursery facilities to combine prominent quality traits related to chapatti, bread and biscuit with yield and disease resistance.

- Two entries, DBW 157 and DBW 162 were selected for NIVT 1A whereas DBW 168 and DBW 170 were found suitable for NIVT 2.

- Promising lines were identified from various nurseries viz. NGSN (103 lines), EIGN-I (92 lines) and EIGN-II (70 lines) grown at IIWBR Research Farm, Karnal and analysed for processing & nutritional quality parameters and also molecular characterization. Based on the quality data, promising lines were selected & used in crossing programme.

- Several wheat cultivars (240) were evaluated for glutenin subunits to understand their relationship with chemical and rheological quality traits.

- Variation in phytic acid content and inorganic phosphorus has been determined in the background population of PBW 502, PBW 343, PBW 373 and synthetic hexaploids.

- 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).

- Antioxidant activity of released barley varieties has been determined. Effect of barley blending on antioxidant activity and phenolic content of wheat flour and chapati has also been studied.

- More than 7500 wheat grain samples from Food Corporation of India (Punjab, Haryana and M.P.) have been analysed to facilitate the export of >6.0 million tonnes of wheat during last two years.

Social Sciences

- During the wheat crop season, 600 Wheat Front Line Demonstrations (WFLDs) of one hectare each were allotted to 63 cooperating centres of which 565 were conducted through 60 cooperating centers. These WFLDs covered 572.96 hectares area of 1147 farmers in 19 states.

- The yield gain due to improved varieties over regional was highest in CZ (48.34%) followed by NHZ (46.44%), NEPZ (30.72%), PZ (25.76%) and NWPZ (18.09%).

- FLDs on Bio-fertilizer showed that the yield gain was non-significant at most of the centers. Among RCTs, zero tillage gave a significant higher yield gain of 5.71% at Nawada center in NEPZ.

- In the case of improved durum varieties, HI 8713 gave a significant average yield of 58.00 q/ha at Udaipur centre. WHD 948 (d) gave a significant average yield of 41.63 q/ha at Niphad and MACS 2971 (*dicoccum*) gave a significant average yield of 40 q/ha at Parbhani centre in PZ.

- In NHZ, at Bajaura center, improved rainfed variety HPW 349 yielded 35.64 q/ha and in PZ, NIAW 1415 gave a significant average yield of 39.90 q/ha at Niphad.

- Yellow rust was the most serious constraint in the country followed by *Phalaris minor*, high cost of inputs, non-availability of seed of newly released variety and low price for wheat.

- During rabi 2014-15, twenty (20 hectares) wheat FLDs were conducted at 30 farmers' fields in Karnal district. In Rasulpur village, Muzaffarnagar district of UP, variety DBW 71 was demonstrated under late sown conditions. During rabi 2014-15, five (5 hectares) barley FLDs were conducted at five farmers' fields in Malkana village located in Bathinda district of Punjab state using variety DWRB 92. During Summer-2014, 2.6 hectares of Special wheat FLDs for HS 375 were also conducted at 20 farmers' fields in Lahaul & Spiti district of Himachal Pradesh.

- A significant difference in returns per rupee of investment was noticed between FLD and check plots across states, zones and technologies. Among wheat production and protection technologies, happy turbo seeder and chemical control of rust gave a good profit.

- The ICAR-IIWBR team accompanied by the experts from Ministry of Agriculture and the concerned centres, monitored the wheat and barley front line demonstration centres.

- In Agra district (UP), high cost of inputs, non-availability of seed of newly released variety, non-availability of labour, lack of knowledge among farmers about recent technologies, non-availability of electricity, erratic power supply, lack of knowledge about appropriate dose were the major factors limiting wheat production.

- In Bihar, *Phalaris minor*, *Chenopodium album* and *Cyprus rotundus* were the major weeds in order of importance across the rice-wheat, maize-wheat and sugarcane-wheat and vegetable wheat crop rotations. A majority (61.65 %) of the farmers had not applied any herbicide. 2,4-D and Isoproturon were the main herbicides used by the farmers.

- Most of the farmers reported positive impact of resource conservation technologies on yield in Panipat district (Haryana).

- During 1990's, with 1991-92 as the base year, the total factor productivity change was highest in 1992-93 owing to higher technological progress followed by efficiency change.

- Social Sciences division organised fourteen training programmes; foundation day; Rabi kisan mela; nine awareness programme on drought management, yellow rust management, PPV&FRA and barley management during 2014-15. Further, farmers' day was organized, participated in 12 exhibitions and coordinated 68 visits of more than 2741 students and entrepreneurs. Farmers were advised online and through SMS. Three TV/Radio Talk were delivered.

Regional Station, Flowerdale, Shimla

- During the year, there was no major outbreak of wheat rusts in India. However, sporadic occurrence of yellow rust of wheat was observed at some locations in Northern India. Yellow rust could be managed well as the area and diversity for yellow rust resistant varieties has increased. Moreover joint efforts of ICAR-IIWBR, SAUs and State Dept. of Agriculture led to the successful management of yellow rust.

- Black rust of wheat was reported on indigenous experimental wheat material planted in Uttarakhand and barley material in Karnataka. It was not observed on the present day cultivars. Indirectly it implies that inoculum of black rust exists in nature but the present day wheat material is able to resist it.

- During the year, 1625 samples of different rusts of wheat and barley were received/ collected for pathotype analyses. Analyses of more than 1374 samples revealed that the wheat rust population analyzed is avirulent to *Yr*5, *Yr*10, *Yr*11, *Yr*12, *Yr*13, *Yr*14, *Yr*15, *Yr*24, *Yr*26, *Yr*Sp and *Yr*Sk (yellow rust); to *Sr*26, *Sr*27, *Sr*31, *Sr*32, *Sr*35, *Sr*39, *Sr*40, *Sr*43, *Sr*Tt3 and *Sr*Tmp (black rust); to *Lr*24, *Lr*25, *Lr*29, *Lr*32, *Lr*39, *Lr*42, *Lr*45 and *Lr*47 (brown rust).

- Six new pathotypes; two each in black, brown rust and yellow rusts were identified. However, most of these are less virulent than the already described pathotypes in India. Virulence on *Sr*31 (Ug99 type of pathotypes) were not identified anywhere in India, Bangladesh, Bhutan and Nepal.

- The proportion of 46S119 has increased to 73.3% whereas that of 78S84 has reduced to 17.4% in *Puccinia striiformis* (yellow/stripe rust of wheat). In *Puccinia triticina* (brown/leaf rust of wheat) pathotype 77-5 (121R63-1) was the most predominant followed by pathotype 104-2 (21R55). In *Puccinia graminis tritici* (black/stem rust of wheat) pathotype 11 (79G31) was most predominant in Northern India followed by pathotype 40A (62G29) in Nilgiri hills.

- This year, 3552 lines of wheat and barley which includes AVT, NBDSN, EBDSN and breeder's material were evaluated for rust resistance. PBW 703 of AVT I was resistant to all the wheat rusts. Nine other lines were resistant to two of the rusts whereas 31 lines were resistant to one or the other rust.

- Rust resistance genes were characterized in AVT I and II wheat material. Proportion of lines with *Yr*9/*Lr*26/*Sr*31 has reduced drastically.

- Five *Yr* genes were characterized in 71 lines of AVT II and 4 in 76 lines of AVTI. Eleven *Sr* genes were inferred in 83 lines of AVT II whereas 12 *Sr* genes were postulated in 99 AVT I lines. 10 *Lr* genes were characterized in 77 and 87 lines of AVT II and I, respectively.

- More than 127 pathotypes were maintained as live cultures as well as cryo-preserved. Nucleus and bulk inocula were supplied to 56 scientists elsewhere in India.

- To develop rust resistant genetic stocks and study genetics of rust resistance, thirty one F1 cross combinations were generated using nineteen parents and advancement of generation for others was undertaken.

- Basic molecular studies on wheat rust pathotypes were undertaken.

Regional Station, Dalang Maidan, Lahaul & Spiti

- Around 49553 lines of wheat, barley and mustard were planted by 20 cooperators for generation advancement, disease screening and seed multiplication etc.

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

- Approximately 19,000 lines were screened for yellow rust and powdery mildew.

- Seven entries were evaluated in four replications under AVT-timely sown-Very high altitude 2013 trial.

Barley Network

- Multi-disciplinary experiments conducted across the barley growing zones both at funded and voluntary centres in the barley growing states, 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 traits.

- The research efforts are also going in malt, food and feed barley improvement, application of biotechnological tools in disease resistance and quality improvement, improvement of cultivation package and basic studies on pathogens, utilization of the new/ exotic genetic resources and creation of new variability.

- In addition, IIWBR also has linkages with international organizations like ICARDA, ICRISAT to facilitate the access to new germplasm of diverse origin for evaluation and utilization.

- A new malt barley variety (DWRB 101) identified and released by CVRC for commercial cultivation in NWPZ and two varieties RD 2849 (malt) and BH 959 (feed) were identified for NWPZ and CZ, respectively.

- 124 test entries contributed by 12 centres, were evaluated against 26 checks in the coordinated yield trials under rainfed (plains and hills), Irrigated (plains) and saline soils conditions under timely/late sown conditions. Seven promising genotypes were promoted in various barley coordinated trials. Ten new entries which performed better in station trials have been contributed to coordinated trials during 2014-15 crop season.

- The NBGSN includes 23 entries having traits of earliness, overall quality, higher test weight, good malting quality, grain plumpness, resistance to brown and black rust, resistance to brown and yellow rust, tolerance to saline/alkaline soils, grain and forage yield were evaluated at 11 centres. EIBGN was constituted with 45 genotypes selected from international trials/nurseries and evaluated at barley network centres. 582 germplasm accessions out of 8159 (conserved at IIWBR) were rejuvenated and characterised. Nine accessions of barley wild species were conserved in mid term storage facility. The 520 accessions of barley germplasm were conserved at Lahul Spiti in natural conditions.

- A total of 279 lines having diverse sources of yield, malting quality and resistance to diseases were grown and evaluated for various morphological and agronomic traits in malt barley crossing block. 116 new crosses were attempted for different traits. The breeding material in different generations (864 families representing 421 crosses involving several generations from F2 to F8) was grown and screened for stripe rust and leaf blights under artificial epiphytotic condition. Based on desirable grain score 648 single plant progenies representing 316 crosses were selected, for generation advancement.

- DWRB 127 (BK1222) is an high yielding, advance malt barley (two-row) yellow rust resistance genotype (DWR45/DWR46) and the proposal for registration has been submitted to PGRC, NBPGR.

- In feed barley, 280 different lines were included in the crossing block to identify superior parental lines. In order to incorporate yield, quality, disease/pest resistance, smooth awns, wide adaptation and early maturity in six rowed barley, 65 crosses were attempted.

- Naked barley comprising of 80 genotypes including 10 Indian released varieties, 21 land races and 49 exotic accessions were screened at seed and research farm, Hisar. Promising entries were identified for various traits.

- Promising genotypes for grain beta glucan, protein content and thousand grain weight were identified after evaluation at different locations. The genotypes 20th IBON 3, BCU 554, DWR 30 and DWRUB 76 for higher beta glucan content, BCU

2030, BCU 277, SLOOP SA WL 3167 and SLOOP VIC VB 9953 for lower beta glucan content, BCU 4966, BK 303 and BK 306 for higher protein content coupled with good bold grain percentage and BK 1127 for high thousand grain weight.

- Naked barley genotypes were evaluated for beta glucans and other grain traits. Dolma had significantly higher content of beta glucans (6.8% dwb) along with reasonably good protein content percentage (14.1%). BH S352 is good for blending with the wheat for multi gain flour as the reduction in the chapatti score is much less.

- A set of 26 varieties was evaluated for grain starch, protein and beta glucan content. There were significant differences in relation to beta glucan and protein contents. The lowest beta glucan content in Alfa 93 (3.1% dwb) and the highest was obtained in BHS 352 and RD 2624 (6% or more). Higher values of protein were obtained in HBL 276 and DWRB 92 (>11.0%). There was negative correlation between starch and protein content and also between starch and beta glucan content.

- Five barley cultivars grown at six locations were evaluated for grain and malt quality to study the location effect. Beta glucan and protein content of grain was influenced both by genotype and growing location, however in case of amylose content only location effect was significant.

- Promising entries were identified for individual malting quality trait-test Weight (DWR 101, RD 2849, BH 968, DWRB 118), protein content (PL 874), husk content (RD 2849, BH 968), malt friability (PL 874, RD 2849), beta glucan % (≤ 4.0 %) (BH 968), kolbach Index (DWRB 101).

- A total of 821 feed grain samples from various trials and grown at different locations were analysed for physical parameters and protein content. The entries having highest test weight; crude protein and thousand grain weight were identified.

- The test entry VLB 130 and best check HBL 276 were statistically at par at all N levels in NHZ and responded up to 80 kg N/ha. The checks BH 902 and BH 946 were superior to the new entry RD 2832 under normal sown conditions in NWPZ. The test entries DWRB 101 and RD 2849 were superior to two row checks in yield and malt quality. Test entry BH 959 and the checks PL 751 and RD 2786 were at par in yield in CZ.

- Sole crop of mustard recorded highest total equivalent yield followed by barley + mustard. Sole crop of barley and dual purpose barley were at par in total equivalent yield and closely followed by intercropping of mustard in barley.

- Four varieties were evaluated against four dates of sowing (starting from last week of October to last week of November, 10 days interval) to fine-tune the sowing dates under changing agro climatic conditions. First and second dates of sowing were at par and thereafter a significant decrease in yield of all varieties except BH 902 in NWPZ. Under late sown situations, there was significant decrease in yield of all varieties as the sowing date advanced. In NEPZ, sowing between 15-24 November was found superior to other dates of sowing. In NHZ, the yield increased up to second date of sowing (10-24 November) and after that the yield decreased as the date advanced.

- Sprinkler irrigation initially 20 days after sowing and thereafter at 30 days interval and flood irrigation recorded the better yield as compared to other options.

- S application increased the productivity of all varieties up to 30kg S/ha but results were at par at 20 kg S/ha.

- Higher yield levels were obtained at 40 kg of phosphorus and 40 kg of potash per ha in NHZ.

- Metsulfuron+Carfentrazone 25g+ NIS 0.2% showed better results compared to other options of weed management for broad leaved weeds. In another experiment, the best results were of Pinoxoden 40g+Carfentrazone 20g for broad and narrow leaved weeds.

- To mitigate the adverse effect of changing climate and sustainable production, conservation agriculture experiment was initiated and zero till sown barley with rice residue retention @ 6 t or 4t/ha after direct seeded and un-puddled transplanted rice resulted in significantly higher yield of malt and feed barley. Preliminary studies on sowing of barley in standing cotton shown promising results.

- In barley, stripe rust pathotype 1S0 (M) was most frequent followed by pathotype 0S0 (57). In stem rust (*P. graminis f.* sp. *tritici*), pathotype 79G31 (11) was encountered in all samples. In NBDSN, sixteen lines viz., VLB 140, UPB 1038, BH 902, RD 2833, BH 902, RD 2860, RD 2889, RD 2890, RD 2887, DWRB 127, RD 2875, RD 2552 (C), RD 2786 (C), KB 1369, RD 2883, RD 2882 were found resistant to brown and yellow rusts. In EBDSN, VLB 132 and RD 2786 were resistant to all the rusts.

- In APR, 41 entries of IBDSN were found to be resistant (ACI <10) to stripe rust and 137 entries have ACI less than 10. For stem rust, 73 entries were found to be having HS <10 out of these, 48 were free from stem rust (HS=0). In case of leaf blight screening, 12 entries were found to fall between average score of 23 and highest score of 57 against leaf blight. In case of 91 entries screened under EBDSN, 17 entries were confirmed for resistance (ACI = 0)

- Chemical control of barley foliar blight was achieved by seed treatment with Vitavax @ 3g/Kg followed by spraying with Tilt / Folicur @ 0.1%. For chemical control of stripe rust, spraying with Tilt @0.1% and Bayleton @0.1% recorded lower disease severity and higher yield was found to be effective.

- For chemical control of foliage aphids (*Rhopalosiphum maidis*), clothianidin 50 WDG @ 15 g.a.i./ha(1.27) was found to be promising in reducing aphid population.

- RIL population (RD2503 X BCU76) screened with previously identified closely linked molecular markers (Bmac213 and ABG59) to validate the applicability these identified markers for leaf blight resistance. Molecular marker Bmac213 was found closely linked with Rcs-qtl-1H-1 at proximal end (0.0 cM) on IH chromosome of barley.

- Barley genotypes identified in barley quality screening nursery (BQSN) for low and high beta glucan content were characterized with gene specific/closely linked SSR and CAPS molecular markers. SSR marker Bmag382 and HvBKVS1were found closely linked with high beta glucan content in barley. These genotypes were screened with gene specific/closely linked molecular markers for quality traits (Protein and starch content). Marker HvBKVS1and HvWaxyG were found efficient to discriminate BQSN entries for low protein and high starch content.

- Awareness programmes for extension of new technologies to the end users were undertaken in Haryana, Rajasthan and Madhya Pradesh.

- Work was initiated in collaboration with private industry for feasibility of barley based biscuits.

Seed Farm, Hisar

- Experimental trials were sown on 68 acres (wheat (43 acres) and barley (25 acres)) of land.

- Green manuring was conducted in 28 acres of land.

Other Institutional Activities

- ICAR-IIWBR and Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur jointly organized the 53rd All India Wheat and Barley Research Workers' Meet and one day International Seminar on "Enhancing Wheat & Barley Production with special emphasis on Nutritional Security" at Jabalpur during August 22-25, 2014.

- During 2013-14, ICAR-ICARDA Regional Information Workshop and Meeting on Benchmarking Varieties of Important Agricultural and Horticultural crops in India was organized by the institute.

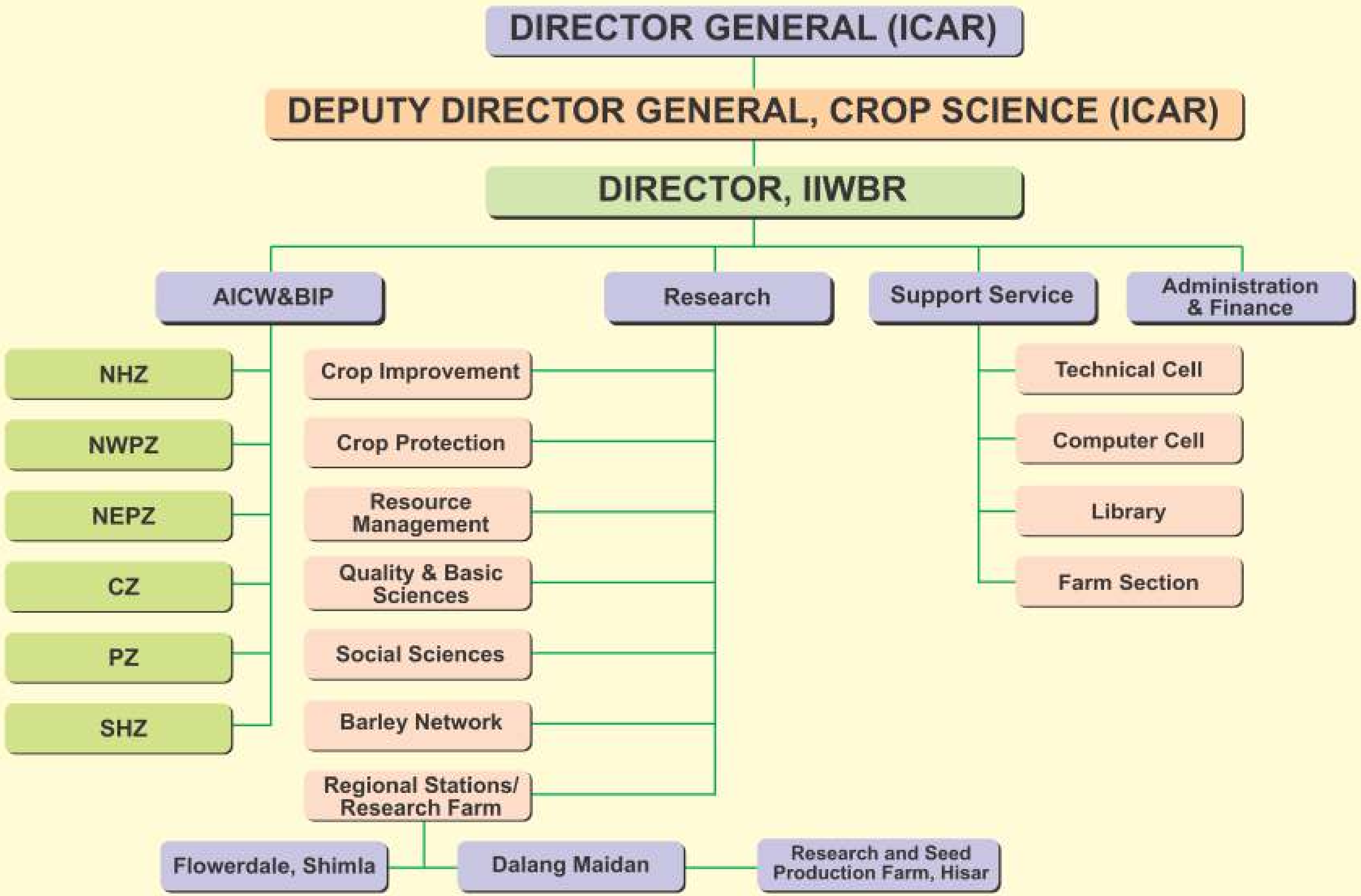
- World Food Prize winner Dr. Surinder Kumar Vasal delivered the Dr. MV Rao Lecture at the institute on December 15, 2014.

- The scientists of the institute published 79 research papers in various national and international journals, 11 book chapters and 14 progress reports/annual report besides 43 papers were presented in seminar/symposia/workshops.

- The scientists of the institute received various awards including Panjabrao Deshmukh Outstanding Woman Scientist Award; Lal Bhahadur Shastri Outstanding Young Scientist Award; Prof. Mahatim Singh Memorial Award, Dr. RK Arora Best Paper Award and LI-LMI Grant for the research ideas and contribution to wheat/barley improvement beside fellow of various societies.

- The institute has organized various programmes for the promotion of Hindi.

ORGANOGRAM



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1. CROP IMPROVEMENT

Wheat production during the crop season 2013-14 in the country stood at 95.85 million tonnes, which was an increase of over 2.3 million tonnes above the production of 93.51 million tonnes recorded during the preceding year 2012-13. The overall weather conditions during the crop season were quite favourable throughout the country with well distributed and spaced rains particularly during the grain filling stage. However, the rains caused delay in maturity in many parts of Himachal Pradesh, Uttarakhand, Punjab and Haryana. Further, loss in yield was reported due to hailstorm in some parts of Madhya Pradesh and Maharashtra.

A summary of the work done and significant achievements made during the crop season 2013-14 in Crop Improvement is presented in the ensuing pages.

Release of new wheat varieties

On the basis of Varietal Identification Committee recommendations, the Central Sub-Committee on Crops Standards, Notification and Releases of Varieties for Agricultural Crops (CVRC) recommended the varieties of bread wheat namely, Pusa Kiran (HS 542), WH 1124, NW 5054, K 1006, Pusa Vatsala (HD 3118), DBW 107, DBW 110 and MACS 6478; durum wheat Pusa Anmol (HI 8737) and dicoccum wheat Nilgiri Khapli (HW 1098) for notification and release for cultivation in different production conditions during 2014-15 (Table 1.1).

Genetic stocks registered

Registration of genetic stocks at NBPGR is based on the novelty and uniqueness of the stock for traits such as yield contributing traits, resistance against various diseases, abiotic stresses, quality attributes, etc. The basic purpose of the registration is to provide an easy access of the materials thereby facilitating its use in the research and development programme related to wheat breeding. The genetic resources unit of the IIWBR, Karnal multiplies the seeds of the registered genetic stock and makes them available to wheat breeders within country. During the year 2014-2015, one durum wheat genotype for resistance to leaf rust and another for foot rot disease was registered as genetic stock at NBPGR (Table 1.2).

Table. 1.1. Wheat varieties released by CVRC during 2014-15

SN	Variety name and parentage	Production condition	Area of adaptation	Developed by	Grain yield (t/ha) Average	Grain yield (t/ha) Potential
Bread Wheat						
1.	**Pusa Kiran (HS 542)** (MILAN/KAUZ//PRINIA/3/BABAX)	Rainfed, Early sown	NHZ	IARI RS, Shimla	3.29	4.48
2.	**WH 1124** (MUNIA/CHTO/AMSEL)	Irrigated, Late sown	NWPZ	CCSHAU, Hisar	4.27	5.61
3.	**NW 5054** (THELIN//2*ATTILA*2/PASTOR)	Irrigated, Timely sown	NEPZ	NDUA&T, Faizabad	4.70	6.42
4.	**K 1006** (PBW343/HP1731)	Irrigated, Timely sown	NEPZ	CSAUA&T, Kanpur	4.70	6.54
5.	**Pusa Vatsala (HD 3118)** (ATTILA*2/PBW65//WBLL1*2/TUKURU)	Irrigated, Late sown	NEPZ	IARI, N. Delhi	4.17	6.64
6.	**DBW 107** (TUKURU/INQLAB)	Irrigated, Late sown	NEPZ	IIWBR, Karnal	4.13	6.87
7.	**DBW 110** (KIRITAT/4/2*SERI*2/3/KAUZ*2/BOW//KAUZ)	Restricted irrigation, Timely sown	CZ	IIWBR, Karnal	3.9	5.05
8.	**MACS 6478** (CS/TH.SC//3*PVN/3MIRLO/BUC/4/ MILAN/5/TILHI)	Irrigated, Timely sown	PZ	ARI, Pune	4.50	6.57
Durum Wheat						
9.	**Pusa Anmol (HI 8737)** (HI8177/HI8158//HI8498)	Irrigated, Timely sown	CZ	IARI RS, Indore	5.34	8.10
Dicoccum Wheat						
10.	**Nilgiri Khapli (HW 1098)** (NP 201 Mutant developed through 20 Kr irradiation)	Irrigated, Timely sown	All dicoccum growing areas	IARI RS, Wellington	4.55	5.90

Table 1.2. Genetic Stock Registered during 2014-15

SN	Name	Registration number	National ID number	Developing centre	Trait
1	HI 8708	INGR14042	IC0611303	IARI, Indore	Resistance to leaf rust
2	UAS 334	INGR 14027	IC0599612	UAS, Dharwad	Resistance to foot rot

Significant results from coordinated yield trials

Conduction of coordinated trials

During the crop season 2013-14, 41 series of trials comprising 508 test entries and 75 check varieties were constituted. In all, 483 trial sets were supplied to 131 centres spread across six wheat zones in the country out of which 470 trials were actually conducted under four major production conditions *viz.* timely sown irrigated, late sown irrigated, timely sown rainfed and timely sown restricted irrigation condition. The conduction of trials was 100% in North Western Plains Zone and Peninsular Zone, while it was over 92% in Northern Hills Zone, 97% in Central Zone and 87% in Southern Hills Zone.

Out of 483 trials which were conducted during 2013-14, the data on 407 trials were found qualifying for reporting based on set norms. Out of the 63 trials which were not reported as many as 26 trials were rejected by the monitoring teams in various zones (Table 1.3). 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).

Table 1.3. Breakup of yield trials during 2013-14

Zone	Proposed	Conducted	Not Conducted	Reported	Not Reported
NHZ	54	50	4	45	5
NWPZ	143	143	0	126	17
NEPZ	88	84	4	75	9
CZ	98	95	3	81	14
PZ	85	85	0	69	16
SHZ	15	13	2	11	2
Total	**483**	**470**	**13**	**407**	**63**

This year there was a marked improvement in the reporting of trials over the preceding year, 87% as compared to 80% during 2012-13. There was significant improvement in reporting of data particularly from the NHZ, 90% as compared to 71% during 2012-13 and SHZ, 85% as compared to 62% in 2012-13 (Table 1.4).

Table 1.4. Percent success in trial conduction and reporting during 2013-14

Zone	% conduction of proposed trials	% reporting of conducted trials	Trials Rejected by Monitoring teams
NHZ	92.6	90.0	0
NWPZ	100.0	88.1	12
NEPZ	95.5	89.3	0
CZ	96.9	85.3	8
PZ	100.0	81.2	6
SHZ	86.7	84.6	0
Total	97.3	86.6	26

Varieties in final year of testing

During the year under report, there were 23 varieties in final year of yield testing in AVTs in different zones. Among them the variety WH1142 was evaluated in two zones NWPZ and CZ for RI/RF condition (Table 1.5). The proposal for identification of the varieties would be placed for consideration by the Varietal Identification Committee.

Table 1.5. Varieties in final year of testing during 2013-14

	Trial	Final year entries
Northern Hills zone		
(i)	AVT-RF-ES-TAS	HPW376
(ii)	AVT-TS- RF/IR-TAS	VL967
Northern Western Plains Zone		
(i)	AVT-IR-TS-TAS	PBW681, WH1138, HUW666
(ii)	AVT-IR-LS-TAS	WH1129
(iii)	AVT-RI-TS-TAS	WH1142
Northern Eastern Plains Zone		
(ii)	AVT-IR-LS-TAS	HD3118, DBW107, K1114
(iii)	AVT-RF-TS-TAS	BRW3723
Central Zone		
(i)	AVT-IR-TS-TAD	MP3382, HI8736(d), HI8737(d)
(ii)	AVT-RF-TS-TAD	NIAW1885, PBW689, WH1142
(iii)	AVT-RI-TS-TAD	DBW110
Peninsular Zone		
(i)	AVT-RF-TS-TAD	UAS347, NIAW1994, UAS446(d)
Special Trial		
(i)	SPL-DIC-IR-TS	MACS5022, DDK1042

Promising varieties in Advanced Varietal Trials

Among the 120 genotypes evaluated in various AVTs conducted in different zones during the crop season, only 10 genotypes were identified to be superior on the basis of yield performance with respect to the check varieties and response to the incidence of rusts. This revealed that the gain in yield enhancement over the check varieties by the new genotypes is quite less. Among the AVT entries, as many as 5 entries were found promising under timely sown irrigated condition out of which 3 were durum entries. There were 2 promising entries under rainfed condition, while under restricted irrigation condition there were 3 entries (Table 1.6).

Table 1.6. Most promising entries in AVTs during 2013-14

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Rainfed	Timely sown, Restricted irrigation
NHZ	HS562	-	HS562	-
NWPZ	HD4730(d)	-	WH1164	MP1277, DBW129
NEPZ	-	-	-	-
CZ	GW451, HD4730(d), HD4728(d)	-	-	-
PZ	-	-	-	-
SHZ	-	-	-	MACS6507

Promising varieties in NIVTs, IVTs and Special Trials

Among the total of 311 entries evaluated for their performance in different NIVTs and 36 in IVTs, as many as 80 entries were found promising for high yielding ability and disease resistance. Out of these 80 promising entries, 45 were of bread wheat and 35 of durum wheat. Thirty-two entries were observed to be promising in timely sown irrigated condition, 10 in late sown irrigated condition, 23 in rainfed and 18 in restricted irrigation condition.

From among the 41 genotypes evaluated in five special trials on triticale, salinity/alkalinity, *dicoccum*, MABB/NIL and Wheat Biofortification, four genotypes were found promising (Table 1.7).

Evaluation of National and International Nurseries/Trials

National Nurseries

During the crop season 2013-14, eight nurseries and two segregating stock nurseries (Table 1.8), were constituted by the institute and supplied to different cooperating centres located across various zones of the country for evaluation and utilization as per their requirement.

The salient features observed in various national nurseries are given below:

(1) National Genetic Stock Nursery (NGSN): It comprised elite lines, confirmed genetic stocks for yield traits, disease resistance and quality traits and was supplied to breeding centres as a suggested crossing block. During 2013-14, 90 lines were provided to 31 centres. Pooled analysis of data was done for identification of promising lines (Table 1.9). The promising genotypes in NGSN showing resistances

Table 1.7. Most promising entries in NIVTs, IVTs and Special Trials during 2013-14

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Rainfed	Timely sown, Restricted irrigation
NIVTs/IVTs				
	HS583	-	HS583	-
NHZ				
NWPZ	PBW707, PBW709, NW6029, NW6036, HD3159, HD3160 DDW32(d), DDW31(d), MACS3949(d), MACS4024(d), UAS452(d)	DBW147, HD3165, PBW716, WH1179	K1317, HD3174, HI1605, HD3172, NW6035, DBW153	NW6035, HD3171, BRW3753, PBW721
NEPZ	-	-	HD3171, K1317, WH1167	-
CZ	GW463, HI1603, NIAW2313, HI8759(d)	CG1015, PBW718	HUW689, HI1605, JAUW621, HI8764(d), GW1316(d), GW1315(d), MACS4020(d), HI8765(d)	K1317, RKD268(d), DDW33(d), DDW34(d), MACS4020(d), GW1314(d), HI8766(d), HI8763(d)
PZ	UAS361, UAS360, HD3164, HI8759(d), MACS3949(d), UAS453(d), MACS4024(d), WHD955(d), HI8757(d), HI8761(d), GW1309(d), GW1311(d), UAS452(d)	UAS364, HI1604, HI8756(d),	PBW721, K1315, HD3174, HI8765(d), GW1315(d)	HI1605, JWS712, MACS3970(d), HI8762(d), MACS3972(d)
SHZ	-	-	-	HW5801
Special Trials				
Triticale	-	-	-	-
Dicoccum	-	-	-	-
Sal/Alk	-	-	-	
MABB/NIL	NWPZ: PBW723	NEPZ: MMBL283	-	-
WBiofort.	NWPZ: HPBW 01, WB 1	-	-	-

Table 1.8. Nurseries shared with co-operators during 2013-14

SN	Nurseries	Genotypes + Checks #	Cooperating centres #
National Nurseries			
1	National Genetic Stock Nursery (NGSN)	90 + 3	31
2	Yield Components Screening Nursery (YCSN)	103 + 5	25
3	Salinity-alkalinity Tolerance Screening Nursery (SATSN)	65 + 4	10
4	Short Duration Screening Nursery (SDSN)	44 + 5	18
5	Drought Tolerance Screening Nursery (DTSN)	46 + 3	12
6	Quality Component Screening Nursery (QCSN)	52 + 3	12
7	Elite International Germplasm Nursery – breadwheat (EIGN-I)	83	20
8	Elite International Germplasm Nursery – durum wheat (EIGN-II)	60	20
Segregating stock nurseries			
1	Segregating Stock Nursery (SSN)	93 F_1 & F_2	15
2	Spring x Winter Segregating Stock Nursery (SWSN)	42 F_2	5

Table 1.9. Promising lines identified for yield component traits in NGSN during 2013-14

Characteristics	Promising genotypes	Best check
Tillers/m (>110)	MP3288 (116), JWS134 (114), Raj4390 (111)	Sonalika (105)
Grains /spike (>50)	HPW355 (56), HUW640 (55), TL2969(t), RSP561, PHS1107, HPW360, DBW58 (54), KRL304, VW921, WH1080, NW5013, UP2797(53), HD3058, PBW658, PHS1104, NWL09-7, HI8715(d), HI8713(d), LBPY2010-24, J07-40 (52), UAS320, VW916, TL 2968(t), VL941, PHS1106 (51)	HI8498 (48)
1000-grains weight (>50 g)	PHS1108, Lok Bold (55), PHS1103, PHS1109 (54), PHS1101, PHS1102, DL1063(53), PHS1104, PHS1105, MACS3744, MACS3828, DL1012 (51), PHS1106, PHS1107, WSM41, DBPY08-4(d) (50)	HI8498 (48)

under field conditions across the locations are listed in Table 1.10. On the basis of utilization report received from 22 locations, it was found that over 20% genotypes of NGSN were either directly used for selection or utilized in hybridization as parents.

Table 1.10. Genotypes showing resistance to diseases in NGSN under field conditions

Diseases	Resistant lines
Black rust	TL2968(t), DDK1041(dic), HI8713(d)
Brown rust	HI8703(d), TL2969(t), HI8713(d), MACS2997(dic), Raj4389, MACS5012(dic), DDK1041(dic), WHD946(d), PBW640, HI8713(d)
Yellow rust	TL2968(t)
Leaf blight	KRL304, HD3058, UP2797

t: Triticale; d: *Durum*; Dic: *Dicoccum*

(2) Yield Component Screening Nursery **:** The 26th Yield Component Screening Nursery (YCSN) consisting of 103 (53 bread wheat + 50 durum wheat) was supplied to 25 centres. On the basis of superior performance for specific traits from among the three major yield components continuously for three years across locations, the trait specific entries were identified as promising genetic resources (Table 1.11).

(3) Short Duration Screening Nursery **:** The 27th Short Duration Screening Nursery (SDSN) comprising 44 entries was conducted at 18. Early maturing genotypes

Table 1.11. Promising lines of YCSN for different traits identified after three years evaluation (2012-2014)

Traits	Promising genetic resources (in order of merit)
Tillers/metre (>86)	DBPY 11-2(d), GW-2010-272, GW-2010-281, GW-2010-286(d), KLY-1035, KLY-1082, RAJ 4265, VW-20145
Grains per spike (>56)	AKAW-4731, AKAW-4739, DBPY 11-1(d), GW-2010-279(d), GW-2010-287, GW-2010-288, GW-2010-291, KLY-1082, KLY-1090
1000-grain weight (>47g for bread wheat)	GW-2010-272, GW-2010-281, GW-2010-288, VW-20167, VW-20168
1000-grain weight (>50g for durum wheat)	GW2010-275, GW2010-277, GW2010-278, GW2010-282, GW2010-284, GW2010-285, GW-2010-298, NIDW 760, VW-20169

tolerant to high temperature during grain filling period under late sown conditions were identified. The entries showing consistently superior performance during the last 3 years as compared to checks are given in Table 1.12.

Table 1.12. Promising lines for grain yield identified from SDSN

Zone	Germplasm lines	Best check
NWPZ	RAJ4274 (521g)	DBW14 (476g)
PZ	RAJ4274 (382g), DL1058 (426g)	HD2285 (336g)

(4) Drought Tolerance Screening Nursery (DTSN) **:** The 26[th] DTSN having 49 test entries including three checks (C306, AKAW3717 and NI5439) was supplied to 12 research centres. Pooled analysis was done for finding the best performing genotype for different zones and also across the zones. The genotype WH1126 was maintaining stability in yield both under drought and irrigated treatments across the centres (Table 1.13).

Table 1.13. Superior genotypes for drought tolerance (DTI >1.0)

Zone	Genotypes
NEPZ	NIAW 1994, DTW 2011- 83, WH1126, Raj 4356
CZ	PBW 674, DBW74, Raj 4356, WH1126
PZ	PBW 675, WH 1098, WH1126, GW 2010-345
Pooled across zones	WH1126

(5) Salinity-Alkalinity Tolerance Screening Nursery (SATSN) **:** The nursery comprising 65 test entries and four checks viz., Kharchia 65, HD 4530, KRL 19 and KRL 210 was evaluated at 10 locations in 4 states in augmented design. Nine entries WH1309, WS 1301, LBP 2013-24, KRS 1301, KRS1303, KLP 1221, RWP 2013-18, WA 1304 and WS 1305 were identified as high yielding along with resistance for all the three rusts (stem, leaf and yellow rust). These genotypes would be tested special trial for salinity/alkalinity conditions (Table 1.14).

Table 1.14. Promising test entries in SATSN

SN	Genotype	Grain yield/plot (g)
1	WH 1309	558.9
2	WS 1301	463.7
3	LBP 2013-24	453.5
4	KRS 1301	444.1
5	KRS 1303	441.7
6	KLP 1221	424.9
7	RWP 2013-18	421.0
8	WS 1304	414.1
9	WS 1305	403.9
	Mean	406.6
	Range	558.9-384.8
1	Kharchia 65(C)	290.6
2	HD 4530(C)	304.4
3	KRL 19(C)	339.7
4	KRL 210(C)	373.5

(6) Quality Component Screening Nursery (QCSN) **:** The nursery conducted at 12 centres comprised 52 test entries which were compared with three checks to identify new genetic resource for quality improvement (Table 1.15).

(7) Elite International Germplasm Nurseries (EIGN) **:** The promising entries from the international germplasm nurseries and trials which are evaluated in India every year are utilized for constituting two nurseries for distribution as Elite International Germplasm Nurseries for bread wheat (EIGN-I) and durum wheat (EIGN-II). The EIGNs are constituted every year and shared with cooperating centres with the objective to provide them with elite exotic germplasm. During 2013-14, 20 sets each of EIGN-I (83 entries) and EIGN-II (65 entries) were supplied to wheat breeding centres. Promising entries were identified for plant height,

Table 1.15. Promising genotypes for individual quality traits

Component	Range	Genotypes
Protein content (%) (At 14% grain moisture)	14.0-14.3	GW 2010-385(d), GW 07-112(d), QLD 11, KLM 1005(d), WSM24(d), GW 09-232(d), 2010-305(d)
Protein yield (g/m^2)	52-56	GW 2010-389, QLD 28, QLD 40, QLD 50, QLD 31, BW 5838
Sedimentation value (ml)	49-55	GW 2010-389, QLD 49, QLD 53
Grain hardness index	85-89	GW 2010-304(d), GW 2009-246(d), MASS 499(d), GW2010-395(d), GW 2009-239(d), GW 2010-305(d), GW 2010-393(d), RAJ 3307(d), GW 2010-318(d)
	15-25	QLD 28, QLD 49, QLD 54, QBP 12-8, QBP 12-9, QBP 12-10, QBP 12-11
Test weight (kg/ml)	80-81	GW 2009-246(d), GW 07-182(d), QLD 51, QLD 58, RAJ 3307, RAJ 4138
1000 grain weight (g)	50-52	WSM 24(d), GW 2009-245(d), KLM 1008
Grain appearance score	6.5-6.9	QLD 46, GW 2009-245(d), GW 2010-385(d), KLM 1006, KLM 1008, GW 2007-182(d)

d: *Durum;*

1000-grains weight and grain yield/plot (Tables 1.16 & 1.17). A total of 163 and 136 selections were made by different centres for further use by the cooperating centres in EIGN-I and EIGN II, respectively.

Table 1.16. Trait-wise promising entries from EIGN-I

Trait	Entry number
Plant height (<83cm)	45th IBWSN 1134
Heading days (< 79 days)	45th IBWSN 1134,30th SAWSN 3085, 45th IBWSN 1018, 20th SAWYT 331, 45th IBWSN 1122, 33rd ESWYT 119, 45th IBWSN 1287, 20th SAWYT 350, 45th IBWSN 1282, 45th IBWSN 1294
1000-grains weight (g) (> 47g)	7th STEMRRSN 6111, 7th STEMRRSN 6067, 33rd ESWYT 124, 22nd ISEPTON 6219, 30th SAWSN 3029, 45th IBWSN 1287, 45th IBWSN 1121
Grain Yield/plot (>570g)	23rd HRWSN 2007, 23rd HRWSN 2015, 23rd HRWSN 2108, 20th HRWYT 214

Table 1.17. Trait-wise promising entries from EIGN-II

Trait	Entry number
Nos. of tillers/m (>109)	44th IDYN-29, 44th IDSN-83
Thousand grains weight (g) (>49)	44th IDSN-87, 44th IDSN-117
Black rust (Free or tR)	44th IDSN-71, 44th IDSN-77,
Brown rust (Free or tR)	44th IDSN-143, 44th IDYN-30, 44th IDYN-33, 44th IDYN-41, 44th IDSN-22, 44th IDSN-77, 44th IDSN-117,
Yellow rust (Free or tR)	44th IDYN-19, 44th IDYN-36, 44th IDYN-42, 44th IDSN-36, 44th IDSN-57, 44th IDSN-84, 44th IDSN-85, 44th IDSN-87, 44th IDSN-93, 44th IDSN-117

Segregating stock nurseries

(i) Segregating Stock Nursery : The 17th Segregating Stock Nursery (SSN) was constituted for sharing segregating material with upcoming wheat breeding centres of the AICW&BIP to enable them to develop breeding lines as per the breeding requirement of the prevailing agroclimatic conditions at the centres. The nursery consisted of 93 segregating populations (F_2/F_3) and supplied to 15 wheat breeding centres. All the segregating populations were utilized by one or the other centre and total of 3624 plants were selected (Table 1.18).

(ii) Spring x Winter Wheat Segregating Stock Nursery: The Spring x Winterwheat Segregating Stock Nursery (SWSN) comprising F_2 generations from 42 crosses was shared with five cooperating centres, namely GBPUA&T-Pantnagar, NDUAT-Faizabad, RAU-Sabour, JNKV-ZARC-Powarkheda and SDAU-Vijapur. The maximum number of 285 single plants was selected at Powarkheda followed by Faizabad (137) and BAU-Sabour (128). Promising cross-combinations in advance generations along with their characteristics are given in Table 1.19.

Table 1.19. Promising cross-combinations in F_6/F_7 generations

SN	Cross Combination	Characteristics
1.	F81.513/MILAN2//HW30 67	High tillering, medium late maturity, long spikes
2.	90ZHONG65/UP2572//H RWYT28	High tillering, medium late maturity and bold grains with good grain appearance
3.	90ZHONG65/UP2572//U P2556/WUGENG8025	High tillering, medium late maturity and long spikes with good grain appearance
4.	UP2425/CENTURK/PHR 1010	High tillering, strong culm and bold grains
5.	PHR1014/ZANDER33	High tillering, medium late maturity and long spikes

International Nurseries and Trials

During the crop season 2013-14, 135 sets (130 from CIMMYT and 5 from ICARDA) comprising a total 2050 lines were evaluated at various wheat breeding centres across the zones in the country. It included 106 sets of bread wheat comprising 1620 lines and 29 sets of durum wheat comprising 430 lines. The best performing lines from these nurseries would be utilized to constitute the Elite International Germplasm Nurseries for bread wheat (EIGN-I) and durum (EIGN-II) and supplied to cooperating centres for evaluation and utilization in wheat improvement. The promising genotypes identified from these nurseries are given in Table 1.20.

During 2014-15 crop season, sets of nurseries and trials were also planted at IIWBR, Karnal in order to evaluate, multiply seeds and facilitate large number of wheat breeders from different centres for exercising *in-situ* selection during the field day. The Wheat Field Day was organized on 27th March, 2015 at Karnal.

Table 1.18. Utilization pattern of segregating populations in 17th SSN

Breeding Programme	Segregating populations	Frequency of utilization	Utilization %	Plants selected
Warmer area	25	116	58.0	987 (27.23%)
Rice-Wheat	30	134	55.8	1516 (41.83%)
Leaf Blight	28	129	57.6	1022 (28.20%)
Durum	10	19	23.8	99 (2.74%)
Total	**93**	**398**	**53.49**	**3624**

Table 1.20. Promising lines identified for various traits in CIMMYT trials/nurseries

Trial/Nursery	Grain yield	1000-grains weight	Resistance to yellow rust
Bread wheat			
21st SAWYT	(>48q/ha) 307,310, 312, 331, 349	(>43g) 320, 324, 344, 348, 349, 350	(≤10S) 308, 314, 315, 316, 317, 320, 321, 322, 330, 331, 334, 335, 336, 342, 346, 349, 350
33rd ESWYT	(>47q/ha)109, 111, 124, 131, 139, 142, 145, 147, 148	(>44g) 109,117,125,126,150	(≤10S) 116, 127, 131, 135
8th EBWYT	(>48q/ha) 503, 507, 509, 510, 512, 514, 518, 528, 529	(>42g) 503, 505, 521, 523, 526, 527	(≤5S) 507, 508, 509, 513, 514, 518, 519, 520, 527, 528, 529, 530
21st HRWYT	(>40q/ha) 202, 211, 222, 224, 230, 231, 233, 235	(>45g) 202, 207, 216, 220, 221, 225, 226, 231, 236	-
46th IBWSN	-	(>44g) 1149, 1198, 1253, 1259, 1274, 1322, 1324	(IMR or 0) 1013, 1069, 1116, 1122, 1123, 1124, 1143, 1152, 1154, 1189, 1190, 1194, 1202, 1203, 1227, 1247, 1248, 1249, 1252, 1273, 1274, 1283, 1290, 1299, 1308, 1311
31st SAWSN	-	(>45g) 3024, 3038, 3049, 3181, 3189, 3202, 3204	-
8th HTWSN	-	(>45g) 4409, 4416, 4421, 4426, 4471, 4479, 4481, 4484, 4504, 4506	-
8thSTEMRRSN	-	(>42g) 6053, 6061, 6062, 6083, 6088, 6149, 6153, 6185, 6187	6010, 6037, 6043, 6198
24th HRWSN	-	(>46g) 2011, 2021, 2030, 2036, 2067, 2075, 2076, 2079, 2095, 2098, 2099, 2101, 2107	-
Durum			
45th IDYN	(>51q/ha) 710,711, 717,721,724,727, 730,734,736,742	(>45g) 702, 703, 708, 711, 716, 717, 734, 738, 739, 748	(Free or tR) 718, 719, 720, 724, 727, 728, 729, 734, 735, 736, 737, 738, 739, 740, 744, 745, 746
45th IDSN	-	(>45g) 7008, 7011, 7016, 7017, 7038, 7048, 7060, 7064, 7084, 7089, 7090, 7104, 7110, 7136, 7144	(Free or tR) 7018, 7019, 7029, 7044, 7059, 7096, 7103, 7107, 7108, 7109, 7110, 7115, 7123, 7126, 7143, 7151

From ICARDA, Syria five nurseries and trials were received. The best performing lines for grain yield in ICARDA nurseries and trials are mentioned in Table 1.21.

Table 1.21. Promising lines identified for grain yield in ICARDA nurseries/trials

Trial/Nursery	Grain yield
21st FAWWON-SA	(>45q/ha) 203, 210, 250, 262, 269, 299, 302, 303, 304
21st FAWWON-IR	(>60q/ha) 7, 32, 35, 45, 47, 48, 51, 54, 57, 61, 62, 70, 73
13th DSBWYT	(50q/ha) 8, 18
13th SBWON	(300g/plot) 3, 6, 26, 27, 47
36th IDON-MR	(500g/plot) 7, 52, 67, 69, 79, 170

Breeder and nucleus seed production

Breeder seed production

A total quantity of 21111.07q breeder seed production target for 156 varieties was received during the production year 2013-14 from DAC and Director Agriculture, HP. HD2967 was the highest indented variety with target of 1313.88q (Table 1.22). The highest indented varieties in NWPZ besides HD2967 were DBW 17, PBW 550, HD 3043, Raj 4037, DPW 621-50 and HD 2851. Raj 4120, K 0307 and HD 2733 were the highly indented varieties of NEPZ. In Central Zone, variety GW 322 was highest indented followed by GW 366, GW 273, HD 2932, MP 4010, HD 2864. In Peninsular Zone, Raj 4037 was the most indented variety. HPW 236, HPW 349 & HPW 155 were the highest indented varieties of NHZ (Table 1.23).

Table 1.22. Most popular wheat varieties in breeder seed indent and production during 2013-14

SN	Variety	Indent (q)	Production (q)
1.	HD 2967	1313.88	1946.70
2.	GW 322	1162.20	1177.50
3.	DBW 17	1010.98	1076.50
4.	GW 366	833.95	861.10
5.	PBW 550	757.30	804.00
6.	GW 273	750.00	798.60
7.	Lok 1	729.30	760.80
8.	HD 3043	689.60	138.30
9.	RAJ 4037	648.00	717.60
10.	DPW 621-50	621.37	1047.15

A total quantity of 19880.47q breeder seed was allocated against indent of 21111.07q for production at 31 breeder seed production centres during production year 2013-14. Against these targets, a total production

Table 1.23. Most popular wheat varieties indented for breeder seed production

S.No.	Variety	Indent 2012-13	2013-14
NWPZ			
1.	HD 2967	230.80	1313.88
2.	DBW 17	781.80	1010.98
3.	PBW 550	1186.40	757.30
4.	HD 3043	160.00	689.60
5.	DPW 621-50	412.80	621.37
NEPZ			
1.	Raj 4120	258.40	557.60
2.	K 0307	336.20	374.00
3.	PBW 343	552.20	367.40
4.	HD 2733	639.40	250.70
CZ			
1.	GW 322	1291.20	1162.20
2.	GW 366	988.05	833.95
3.	GW 273	798.00	750.00
4.	Lok 1	731.20	729.30
5.	Raj 4037	613.60	648.00
PZ			
1.	GW 322	1291.20	1162.20
2.	Raj 4037	613.60	648.00
3.	HD 2932	357.70	350.10
4.	HD 2189	370.70	209.20
NHZ			
1.	HPW 236	20.00	150.00
2.	HPW 349	0.00	90.00
3.	HPW 249	10.00	60.00
4.	HPW 155	20.00	50.00
5.	HS 507	56.00	40.00

of 22492.21q breeder seed was reported. Thus, a surplus production of 1381.14q over the indented quantity of breeder seed was recorded. At the Kanpur wheat workshop it was also decided not to produce breeder seed of old varieties which were indented e.g., DL153-2, DL788-2, DL803-3, HD2285, HD2329, HS240, HUW12, JWS17, UP2003, UP2382, UP2425.

The maximum breeder seed was produced at PAU-Ludhiana (3004q) followed by GBPUAT-Pantnagar (2899q), MPUA&T-Kota (2447.85q), SKRAU-Bikaner (1893q), CSAUAT-Kanpur (1847q), IARI-Indore (1667q), and SDAU-Vijapur (990.80q).

Nucleus seed production & Test stock multiplication

A total 1762.45q nucleus seed of 143 varieties was produced. The maximum nucleus seed was produced for GW322 followed by Lok1, GW273, GW366, GW496, HI8498, HD2967, MP1544, MP4106, HD2932, DPW621-50, MP3211, PBW343, MP3288, HI8663, PBW502 and DBW17. The maximum nucleus seed production was reported from JNKVV-Jabalpur centre followed by IARI-Indore, SDAU-Vijapur, MPUA&T-Kota, GBPUAT-Pantnagar, PAU-Ludhiana, RVSKVV-Gwalior and SKRAU-Bikaner.

Test stock multiplication of newly identified eight bread wheat varieties *i.e.* DBW88, DBW90, DBW93, HD3090, HS542, MACS6478, PBW660, WH1124 was taken up at SFCI farms. A total production of 580.80q test stock seed of these varieties was reported by SFCI, New Delhi.

Seed production at IIWBR

Breeder seed of wheat varieties DBW 14, DBW 17, CBW 38, DBW 39, DPW 621-50 and DBW 71 amounting to 171.86q was produced during 2013-14 crop season. During the production year 2014-15 breeder seed production target of 1326.4q for varieties DBW 14, DBW 16, DBW 17, CBW 38, DBW 39, DPW 621-50, DBW 71, DBW 88, DBW 90 and HD 2967 was taken up at Karnal and Hisar farms.

Germplasm exchange, evaluation, characterization, conservation and documentation

Germplasm exchange

94 accessions were received from various cooperating centres for conservation at IIWBR, Karnal and institute supplied 1344 accessions to various indenters within country.

Characterisation

During 2013-14, nine hundred five exotic accessions of wheat mainly received from Turkey, Uruguay, USDA and selection from various CIMMYT nurseries were evaluated and characterised as per DUS testing guidelines. These accessions includes 752 accessions of *T. aestivum*, 119 of *T. durum*, 17 of *T. dicoccum*, 7 of Triticale, 4 of *Timopheevi* and 3 of *T. sphaerococcum*.

Days to heading and maturity: Thirteen accessions had early heading (82-88days) and matured in and around 145-150 days. These accessions were UPO 31, PI 322245, NEPAL 4, NEPAL 10, NEPAL 17, NP 857, PI 324480, PI 348983, PI 383908, PI 383908 A, PI 383909, DT 2706 and E 1860.

Plant height: One accession (PI 376071) carrying triple dwarf gene and had plant height less than 40 cm, whereas twelve accessions namely TURKEY(97-98) 9, TURKEY(97-98) 10, TURKEY(97-98) 11, TURKEY(97-98) 12, TURKEY(97-98) 22, TURKEY(97-98) 26, TURKEY(97-98) 39, TURKEY(97-98) 42, PI 376841, CPAN 6249, DLRRL 60 and E 3226 had plant height ranging from 60-75 cm. 35 accessions were tall and had plant height more than 150 cm.

Spike length: Twenty accessions namely TURKEY(97-98) 3, URU(97-98) 52, URU(97-98) 69, URU(97-98) 89, BW 46, NP 837, PI 338446, PI 343434, PI 430005, PI 430063, DT 8 (Trit.), UPT 78274(Trit.), E 292, E 671, E 976, E 3038, E 3142, E 3863, E 4769 and E 4914 had more than 14cm spike length.

Spikelets/ spike: Six accessions namely URU(97-98) 89, PI 338446, PI 348981(all aestivum), DT 8, DT 33, E 3142 (all triticale) had more than or equal to 26 Spikelets/spike.

Grain number/ spike: Twenty seven accessions namely PI 519975, PI 520082, PLATA 16 (dur.), PLATA 18 (dur.), SAWSN(14th)21, URU(97-98) 1, URU(97-98) 24, URU(97-98) 65, URU(97-98) 72, URU(97-98) 83, URU(97-98) 87, BW 46, BW/SH 22, BW/SH 30, BW/SH 36, PI 348981, PI 430107, PI 430111, PI 430125, CPAN 4141, CPAN 4151, CPAN 4217, CPAN 6225 (dur.), DT 8 (Trit.), DT 33 (Trit.), DTS 977 (Trit.) and E 401514 had more than 70 grains per spike.

Grain weight/ spike: Ten accessions had more than 3.2 g per spike weight. These were DT 8(3.66g) (Trit.), PATIN-2/PLATA(3.58g) (dur.), URU(97-98) 87(3.46g), PI 338446(3.44g), URU(97-98) 1(3.42g), PI 348981(3.40g), BW/SH 23(3.38g), BW/SH 55(3.28g), BW/SH 64(3.23g) and E 3068(3.22g)

Thousand grains weight: Thousand grain weight were more than 50g in accessions namely RS 628, BW/SH 57, BW/SH 61, BW/SH 64, NEPAL 7, NEPAL 8 and NEPAL 12 (all aestivum) and PI 422293, RD 179, URU(97-98) 58, CPAN 6235 and UPD 64 (all *durum*).

Protein: Forty three accessions had grain protein more than 15%. Some of the accessions (PI 520128 (dur.), NP 880, E 2176, E 2914, E 3008, E 3487 (dur.), E 3555, E 3579, E 3712, E 4026, E 4071 and E 8620) had 1000 grains weight more than 35g and grain protein more than 15%.

Number of tillers: Tillers ranged from 40-195 per meter row length and accessions PI 520097, PLATA 16, SCA'S', TURKEY(97-98) 6, TURKEY(97-98) 14, TURKEY(97-98) 16, TURKEY(97-98) 18, TURKEY(97-98) 29, TURKEY(97-98) 30,TURKEY(97-98) 31, TURKEY(97-98) 33, TURKEY(97-98) 35, URU(97-98) 27, URU(97-98) 29, URU(97-98) 51, URU(97-98) 53, URU(97-98) 54, URU(97-98) 62, URU(97-98) 63, URU(97-98) 64, URU(97-98) 66, URU(97-98) 67, PI 322224, PI 338446, PI 351571, PI 376840, PI 383909, PI 427274, PI 430038, PI 430051, PI 430058 (AL), PI 430094, PI 430113, PI 430115, PI 352498, CPAN 4135, E 2582, E 3902, E 4064, E 4104, E 4178 and E 4392, recorded more than 160 tillers/metre.

Grain hardness index: Grains of 153 accessions were soft (Hardness index <40) and 221 accessions were hard (HI 75-100) in nature.

Multiple yield contributing traits: Germplasm SAWSN (14th) 10, PATIN-2/PLATA (*durum*), PI 519975, PKD 4 (dur.), PLATA 16 (dur.), SAWSN (14th) 21, SAWSN (14th) 192, SAWSN (14th) 274, URU(97-98) 1, URU(97-98) 40, URU(97-98) 57, URU(97-98) 58 (dur.), URU(97-98) 60 (dur.), URU(97-98) 72, URU(97-98) 87, URU(97-98) 88, BW/SH 23, BW/SH 55, BW/SH 64 were found promising for multiple yield contributing traits.

Conservation

At IIWBR around 11,500 accessions of wheat that includes released varieties, AVT material, registered genetic stock, exotic and indigenous collection are conserved in germplasm repository under medium term storage module (4°C and RH 30-35%). A total of 9985 safety duplicate accessions (including 1090 accessions stored this year) are conserved at IIWBR Regional Station, Dalang Maidan under natural condition.

Registration of wheat varieties under PPV& FRA and DUS testing

The institute submitted the registration proposal of three new wheat varieties namely DBW 71, DBW 88 and DBW 90 for registration with PPV&FRA. The germplasm resource unit of the institute facilitated farmers to submit registration proposal of their varieties *Mundal, Sharbati, Bansi and Pushkar plus* for registration with PPV&FRA.

DUS testing

During 2013-14, 3 trials were sown and 9 candidate varieties (Ajeet 110, Ajeet 111, Kharchia, GG 04, GG 24, GG 39, HDCSW 16, HDCSW 18 and Sanjeevani) were tested against 23 reference varieties, while in 2014-15 29 candidate varieties (AJEET110, AJEET 111, WH 1105, JP 151, JP 197, JP 209, PUSHKAR PLUS, MUNDAL, ASTHA GOLD, JP 8661, SHARBATI, GG 04, BANSI LOCAL, SANJIVANI, JEEVAN, M.K.KRANTI, TIPOYA, GEHUN, MAH.KI. VARDAN, JHARANA, BHAGAT, JP 164, JP 157, JP 133, JP 153, JP 168, GG 24, GG 39, W07NV037) are being tested against 85 reference varieties.

Pre-Breeding for Wheat Improvement

Pre-breeding Material

Wheat family provides untapped reservoir of genetic variation for biotic as well as abiotic traits. Out of this gene pool only few of wild sources, synthetic hexaploid wheats and land races have been used to improve the resistance to rusts and abiotic stresses. In this regard sources with unknown genes were crossed with promising and agronomic base genotypes to introgress the desired traits. Pre-breeding is a requisite to transfer the desired genes from primary and tertiary gene pool to well adapted varieties. Around 400 accessions of 20 wild species including *T. baeoticum, T. monococcum, T. urartu, Ae. speltoides, Ae. squarrossa, Ae. tauschii, T. dicoccum, T. sphaerococcum, T. vavilovii, Ae. longissima and Ae. sharonensis* were evaluated for stress tolerance and cell membrane stability (CMS) is given in Fig. 1.1.

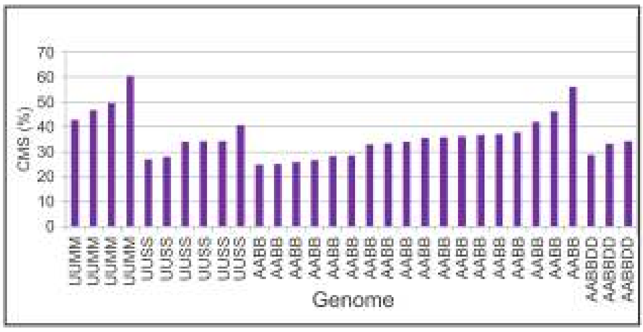


Fig. 1.1. Cell membrane stability (CMS) in tetraploid and hexaploid accessions

Evaluation of wild species for chlorophyll fluorescence and content: Chlorophyll fluorescence and chlorophyll content was determined in 282 accessions of wild species. The accessions of *Aegilops tauschii* had maximum variability in chlorophyll fluorescence followed by *Triticum compactum* and *Ae. ovata* The accessions of *T. monococcum* had maximum variability for chlorophyll content followed by *Ae. tauschii, Ae. peregrina* and *Ae. ovata*.

Crosses using wild species

Sixty-two accessions of wild species namely, *T. sphaerococcum, T. urartu, Ae. tauschii, Ae. kotschyi, Ae. peregrina, T. dicoccoides and Ae. polonicum* were used in crossing programme to transfer the desired traits into varieties/ advanced breeding lines with good agronomic base. (Table 1.24)

Table 1.24. Crosses attempted using wild species for heat tolerance

Cross Name	Cross Name
T. dicoccum(102)/HD 2932	*Ae. peregrina* (PI266822)/PBW 677
T. sphaerococcum/HD 3118	*Ae. peregrina* (PI603931)/IC 118737 (HALBERD)
T. urartu (81)/HD 2967	*Ae. peregrina* (PI603931)/SUNSTAR
T. dicoccum (103)/HD 2932	*Ae. peregrina* (PI604145)/IC 532653
Ae. tauschii (3758)/SUN STAR	*Ae. peregrina* (PI604145)/ DHARWAR DRY
Ae. tauschii (3758)/SUN STAR	*Ae. peregrina* (PI604147)/IC 532653
Ae. tauschii (3758)/IC532653	*Ae. peregrina* (PI604147)/IC 532653
Ae. tauschii (3759)/NIAW 34	*Ae. peregrina* (PI604147)/IC 532653
Ae. tauschii (3769)/PBW 702	*Ae. peregrina* (PI604149)/HD 3128
Ae. tauschii (3784)/HS 277	*Ae. peregrina* (PI604162)/IC 532653
Ae. tauschii (3806)/HD 2967	*Ae. peregrina* (PI604162)/IC 532653
Ae. tauschii (89809)/HI 1563	*Ae. peregrina* (PI604162)/HD 2967
Ae. tauschii (9785)/PBW 693	*Ae. peregrina* (PI604168)/DBW 107
Ae. tauschii (9787)/IC-118737 (Halberd)	*Ae. peregrina* (PI604169)/HS 277
Ae. tauschii (9787)/HS 277	*Ae. peregrina* (PI604169)/IC 118737 (HALBERD)
Ae. tauschii (9795)/HS 277	*Ae. peregrina* (PI604169)/HS 277
Ae. tauschii (9795)/NIAW 34	*Ae. peregrina* (PI 604189)/HD 2932
Ae. tauschii (9803)/HS 277	*Ae. peregrina*(PI 604192)/HS 277
Ae. tauschii (9803)/HD 2967	*Ae. peregrina*(PI 604192)/NIAW 34
Ae. tauschii (9803)/DBW 14	*Ae. peregrina*(PI 604192)/HD 2967
Ae. tauschii (13762)	*Ae. peregrina* (PI 604192)/HD 3118
Ae. tauschii (14325)/HD 3127	*Ae. peregrina* (PI 604192)/SALEMBO
Ae. tauschii (14338)/DHARWAR DRY	*Ae. peregrina* (PI266822)/PBW 677
Ae. tauschii (14338)/IC 532653	*T. dicoccoides* (4821)/
Ae.tauschii (3761)/IC 532653	*T. dicoccoides* (7132)/HD-2967
Ae. kotschyi (3774)/DBW 107	*T. urartu* 78/STT 68/HD 3117
Ae. kotschyi (402242)/IC 532653	*Ae. squarrosa* 13/ STT 71/HD 2967

The promising accessions were selected and crossed to introgress genes into released high yielding varieties / genotypes. Based on the quality traits *T. dicoccum* and *T. sphaerococcum* were used, while *T. urartu, Ae. tauschii* and *Ae. peregrina accessions* for disease resistance were crossed with bread wheat varieties (Table 1.25).

Table1.25. F_1s planted for advancing generation and to attempt backcrosses

Cross Name	Cross Name	Cross Name
T. dicoccum (102)/HD 2932	*Ae. kotschyi* (3774)/DBW 107	*Ae. peregrina* (PI604169)/HS 277
T. sphaerococcum/HD 3118	*Ae. tauschii* (9803)/HS 277	*Ae. peregrina* (PI604169)/IC 118737 (HALBERD)
T. urartu (81)/HD 2967	*Ae. tauschii* (9787)/IC-118737 (Halberd)	*Ae. peregrina* (PI604169)/HS 277
T. dicoccum (103)/HD 2932	*Ae. kotschyi* (3774)/DBW 107	*Ae. peregrina* (PI 604189)/HD 2932
Ae. tauschii (3758)/SUN STAR	*Ae. kotschyi* (402242)/IC 532653	*Ae. peregrina* (PI 604192)/HS 277
Ae. tauschii (3758)/SUN STAR	*Ae. tauschii* (9787)/IC-118737 (Halberd)	*T. dicoccoides* (4821)/
Ae. tauschii (3758)/IC532653		*T. dicoccoides* (7132)/HD-2967
Ae. tauschii (3759)/NIAW 34		*T. urartu* 78/STT 68/HD 3117

Similarly, F_2s were also advanced which involved synthetics, wild species bread wheat genotypes and *durum* wheat genotypes for making the new synthetics at IIWBR, Karnal. These are being selected on single plant basis against diseases. These synthetics were having the higher tiller number and also tolerance to late heat (Table 1.26).

Table 1.26. F_2s involving wild species and synthetics with agronomic base varieties

Cross Name	Cross Name
T. urartu / PDW 291	PDW 291 / *T. ventricosa*
Agropyron / UP 2425 // PBW 343	PDW 291 / *T. umbellulata*
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
SYN 143/ DPW 621-50	SYN 242/ HD 3010
SYN 176/ GW 322	SYN 432/ DBW 14
SYN 187/ HD 2967	SYN 233/ Dharwar dry

From pre-breeding programme some elite lines were selected and tested in IPPSN for diseases and also in preliminary yield trial (PYT). The disease score of entries is given in Table 1.27 along with yield levels.

Table 1.27. Genotypes being evaluated for resistance to biotic stress in IPPSN and for yield in PYT

Pedigree	Brown rust / Yellow rust	Pedigree	Brown rust/Yellow rust
Urartu/ NIAW 34/ NIAW 34	00/00	PBS 10-01/ FKW 3// DM 6/ PBW 550	00/TMS
Synthetic 26/ PBW 502// PBW 502	00/00	NP 846/ DBW 17/ DBW 17	TMS/20MS
Synth 126/ PBW 502// PBW 502	tS/ TMR	New Synth 202/ DBW 17	00/10S
Synth 160/ DBW 17/ DBW 17	00/10MS	New Synth 207/ PBW 502//PBW 502/C 306	00/00
NP 846/DBW17// PBS-10-01/ FKW 3	00/00	Synth 98/PBW 343// Synth 99/ UP 2425/ Lok 1	00/TMS

Evaluation of material developed through pre-breeding

Two genotypes, developed through pre- breeding approach were included into the DWR station trial during previous crop season. The pedigree of two genotypes included synthetic hexaploid wheat. The main objective was to incorporate the yellow rust resistance from non conventional sources to an agronomic base variety. The two genotypes selected last year from PYT were evaluated here in DWR station trials alongwith checks. These showed high degree of resistance to the rusts particularly the yellow rust. However these were not the best yielders and thus could not be promoted to national trials.

Developing head scab resistance in bread and durum wheats

Indian varieties are highly susceptible to head scab disease particularly in North West India. A set of 100 released varieties including *durum* and bread wheats, were evaluated for head scab but none showed resistance against this disease. To develop head scab resistance (*Fusarium head blight)* resistant wheat varieties, the back cross programme was taken up involving the resistant stocks Sumai#3 and Frontana. The crosses available now are Sumai#3/DBW16, Sumai#3/ PBW502, Sumai#3/Frontana, Sumai#3/ PDW274, PBW502/Frontana, Sumai#3/ PDW291 and Frontana/ DBW16 (Table 1.28).

Table 1.28. Elite crosses showing complete resistance to head scab

Name	Bread wheat	Name	Durum wheat
HSRBW-1	Sumai#3/PBW 502	HSRDW-1	Sumai#3/PDW 274
HSRBW-2	Sumai#3/HD 2967	HSRDW-2	Sumai#3/PDW 291
HSRBW-3	Sumai#3/DPW 621-50		
HSRBW-4	Frontana/Sumai#3	HSRDW-3	Frontana/PDW 233
HSRBW-5	Frontana/PBW 502	HSRDW-4	Frontana/HI 8498

Durum Breeding

Hybridization

About 310 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 against brown & yellow rusts. The artificial epiphytotic was developed through spraying mixture of races. The Table 1.29 shows number of crosses attempted and the progenies in different generations during 2013-14.

Table 1.29. Crosses and their progenies evaluated and advanced

Generation	No. of Crosses (Progenies)
F_1	75
F_2	60
F_3	50 (150)
F_4	40 (160)
F_5	5 (180)
F_6	35 (140)
F_7	30(130)

Evaluation of genotypes under national coordinated trials

Two advance durum lines DDW 31, DDW 32 were evaluated in national coordinated trials (NIVT 4) while other two DDW 33 and DDW 34 in rainfed durum trial NIVT -5B during 2013-14 (Table 1.30 & 1.31). In another evaluation experiment, DDW 27 (AVT-TS in PZ) and DDW 30 (AVT-RF in CZ) were evaluated in AVT trials.

Ten entries of durum are being evaluated in DWR-ST-A+D.

Table 1.30 Promising genotypes tested in coordinated trials

SN	Genotype		Rank in Zone
1	DDW 32	Promoted to AVT in NWPZ	1st in first NS
2	DDW 31	Promoted to AVT in NWPZ	4th and in first NS
3	PDW 314(Check)		7th
4	HD 2967 (Check)		13th

Table 1.31. Quality parameters of promising durum entries evaluated in coordinated yield trials

Genotypes	Yellow berry (%)	Yellow pigment (ppm)	Protein content (%)	Test wt.	Grain appearance score
DDW 30	21	6.1	12.6	83.3	7.0
DDW 27	21	6.0	12.3	82.8	7.8
DDW 33	20	7.8	12.1	84.6	5.4
DDW 34	3.1	6.3	13.4	82.3	6.9
HI 8713 (C)	8.8	5.0	13.0	80.0	5.5

Sharing of material with centres for quality traits

In the Yield Component Nursery which was evaluated at 25 centers for three years, 8 genotypes of durum wheat were shared. Three genotypes DBPY-11-2, DBPY-13-4 and DBPY-12-5 were identified as the genetic stocks for tillers/meter; three genotypes DBPY-11-1, DBPY-12-5, DBPY-12-7 and DBPY-13-3 for grains per spike and two genotypes DBPY 11-1 and DBPY-12-2 for thousand grains weight (Table 1.32). Many of these are having more than one yield component traits. The feedback reports suggested that breeders used them extensively in the hybridization program for yield and TKW.

Table 1.32 Genotypes identified as the genetic stocks for different traits

Trait	Genotype
Tillers/ meter	DBPY-11-2, DBPY-13-4, DBPY-12-5
Grains/ spike	DBPY-11-1, DBPY-12-5, DBPY-12-7, DBPY-13-3
TGW (g)	DBPY 11-1, DBPY-12-2

Similarly five advance durum lines were shared through NGSN to 20 centres and reports shows 6.4% utilization by the cooperating centres. Ten F_2 segregating populations were shared through SSN besides 10 more F_2 populations and 10 advance fixed lines shared with Jabalpur and Niphad centres.

Wheat improvement for high productive environments of Northern India

Contribution to coordinated trials/nurseries

DWR station trial: A total of 16 entries were contributed to DWR station trial (7 for timely, 7 for late sown) and 2 for A+D which were conducted at 2 locations of NWPZ (Karnal, Hisar), 4 locations of NEPZ (Faizabad, Kalyani, Patna and Coochbehar) and 3 locations of A+D trials (Vijapur, Junagadh and Niphad). From the station trial, three promising genotypes namely DBW 158(NIVT-1A), DBW 164 and DBW 165 (NIVT-1B), DBW 173 (NIVT-3A), DBW 175 (NIVT-3B), DBW 178 (NIVT-5A) and DBW 183 (Spl. Sal./Alk. trial) were promoted to respective trials.

National Initial Varietal Trial: Based on the performance of entries in DWR station trials the following entries were promoted to NIVTs. The performance of these entries in different NIVTs is given in Table 1.33.

Table 1.33. Performance of entries in different NIVTs

Entry	Pedigree	Yield (q/ha)			
		NWPZ	NEPZ	CZ	PZ
DBW 137 (NIVT 1A)	HP 1761/ DBW 343// DBW 15	51.8	50.5	-	-
*DBW 147 NIVT 3)	PBN 142/DBW 30	50.5	40.4	45.9	43.6
DBW 154 (SAL/ALK)	KIRITATI//2* SERI/RAYON		Zonal	39.2	

* Entry promoted to AVT-IR-LS-TAS

Advance Varietal Trial: DBW 95 and DBW 128 were tested in AVT-I year (2013-14) for timely sown and late sown conditions of NWPZ. The performance of entries in timely and late sown conditions of NWPZ is mentioned in Table 1.34.

Table 1.34. Performance of entries in different AVTs

Entry	Pedigree	AVT- I	Yield (q/ha)
DBW 95	K 9908/PBW 534	AVT-IR-TS-NWPZ	54.5
DBW 128	SITE/MO//PASTOR /3/TILHI	AVT-IR-LS-TAS-NWPZ	42.9

Hybridization and generation advancement

About 337 cross combinations were made during rabi 2013-14 involving agronomically superior varieties and donors for different traits like heat tolerance, disease resistance, salinity tolerance, quality traits and good plant type. The breeding material in different segregating generations was planted in the field. The material includes 270 F_1, 578 F_2, 126 F_3, 139 F_4, 47 F_5 and advance lines were bulked and tested in preliminary yield trial. A total of 1200, 520, 630 and 320single spikes from F_2 to F_5 generations were selected. At Dalang Maidan, 30 new crosses were attempted using donors for different traits. Out of 337 F_1, 45 F_3, 22 F_4 and 20 F_6 327 F_1s, 300 F_3 (single spikes), 200 F_4/F_5 (single spikes) and 12 F_6(bulks) were selected and planted at Karnal.

Breeding for stripe rust resistance

Donors having different resistance genes for stripe rust like *Yr4, Yr5, Yr10, Yr 15, Yr 17, Yr18* and *Yr24* were procured and have been utilized in the crossing programme (Table1.35). The donors have been used in crossing programme and material in different generations is screened for stripe rust resistance against the prevalent races of stripe rust. The crosses in different generations *viz.*, 125 F_2, 17 F_3, 20 F_4 and7 F_5 will be advanced further for yield and resistance evaluation.

Table 1.35. Donor genotypes used for incorporating yellow rust resistance genes

SN	Cultivar	SN	Cultivar	SN	Cultivar
1	Gladius	14	ELLISON	27	SK 371
2	Sunco/tasman #93	15	FRAME	28	SK 701
3	QUAL 2000	16	JANZ	29	SK 818
4	SUNLAND	17	HUME	30	HSB 2398
5	RUBRIC	18	RUBY	31	HSB 2398
6	GOLDMARK	19	WYALKETCHEM	32	HSB 2408
7	BABBLER	20	C80.1/3*Sr2 Batavia	33	HSB 2527
8	BINNU	21	Yr10Yr17/ Tincurrin	34	HSB 2944
9	BRAEWOOD	22	Sunco/Tasman # 61	35	HSB 2949
10	CARINYA	23	Sunco/Tasman #93	36	HSB 2955
11	CASTLEROCK	24	Sunco/Tasman #12	37	HSB 3176
12	CLEARFIELD	25	Sunco/Tasman # 35	38	HSB 3178
13	DERRIMUT	26	SK 118	39	HSB 2801

Targeted programme for resistance against Ug99

During *rabi* 2013-14, 09 cross combinations have been made with FLW 2, 3, 6, 8, 9, 11, 12, 13, 20 and 24 as donor parents for incorporating resistance to Ug99 in advanced genotypes. The breeding material in different generations generated earlier was evaluated and single spike selections were made based on plant type and maturity.

Contribution in 28th Short Duration cum late heat tolerance nursery

Ten entries were contributed to 28th Short Duration cum Late Heat Tolerance Screening nursery during the crop season 2014-15. Three new entries RWP 2013-2, RWP 2013-9 and RWP 2013-10 were contributed to the 28th SDSN. In addition to this, 4 entries RWP 2011-15, RWP 2011-17, DBW 74 & DBW 125 were retained for evaluation over locations in NWPZ. One entry RWP 2011-15 was retained for evaluation over locations in NEPZ. Entries RWP-2011-15, RWP- 2011-17, DBW 74, DBW 113 and DBW 118 retained for evaluation in CZ. RWP 2011-17, DBW74 & DBW 125 retained for evaluation in PZ. Two entries RWP 2011-18 and DBW 113 retained in NHZ for further evaluation. All these entries were retained based on yield and agronomic traits.

Contribution to Segregating Stock Nursery (SSN)

25 F_3 cross combinations were contributed to the 18th SSN. 30 F_3 cross combinations were contributed to 17th segregating stock nursery which was sent to 15 centers across the country. The material developed through the programme has the utilization of 55.80 %.

Wheat improvement for Eastern and Far-Eastern parts of the country

New sources identified

A new set of 250 lines was evaluated under field conditions for yield, resistance and other agronomic traits. Based on their performance, total 10 promising lines were identified as new sources to be utilized in hybridization programme to widen genetic base for various traits including yield attributes, spot blotch resistance and abiotic stress tolerance.

Hybridization programme

Total 37 fresh crosses were attempted to diversify base, improve tolerance against biotic / abiotic stresses and quality traits (Table 1.36).

Table 1.36. List of F_1 combinations attempted during 2013-14 and advanced at summer nursery

SN	Cross Combination	SN	Cross Combination
1	DBW 71/ KRL-1-4	20	KRL 210 / BH 1146
2	DBW 88 / KRL 210	21	KRL 210 / HD 2009
3	DBW 88/ KH 65	22	KRL-1-4/ BH 1146
4	DBW 88/ KRL-1-4	23	KRL-1-4/ HD 2009
5	DPW 621-50/ KH 65	24	PBW 550 / KH 65
6	DPW 621-50 / KRL 210	25	PBW 550 / KRL 210
7	HD 2009 / KRL 210	26	PBW 550/ KRL-1-4
8	HD 2009/ KRL-1-4	27	WH 1105 / KRL 210
9	HD 2329/ KH 65	28	WH 1105/ KH 65
10	HD 2329/ KRL-1-4	29	WH 1105/ KRL-1-4
11	HD 2932 / KRL 210	30	WR 544/ DBW 71
12	HD 2932/ KH 65	31	WR 544/ HALNA
13	HD 2932/ KRL-1-4	32	WR 544/ HD 3086
14	HD 2967 / KH 65	33	WR 544/ HI 1563
15	HD 2967 / KRL 210	34	WR 544/ PBW 550
16	HD 2967/ KRL-1-4	35	WR 544/ RAJ 3765
17	HUW 638 / DBW 39	36	WR 544/ RAJ 4238
18	KH 65 / BH 1146	37	WR 544/ WH 1021
19	KH 65 / HD 2009		

The material at F_1 generation was sent for advancing generation at Dalang Maidan and subsequently F_2 generation of above material was planted at IIWBR, Karnal during 2014-15 and observations have been recorded. The promising combinations will be advanced based on overall performance.

Contribution to AVT and NIVTs

On the basis of performance assessed under PYT, 15 entries were contributed to DWR Station Trials (for timely, late and A+D trials). Based on performance as compared to respective checks in DWR station trials entries were contributed to different NIVTs and details are presented in Table 1.37 and 1.38.

Table 1.37. Promotion from NIVT to AVTs - 2014-15

Entry	Trial	Yield (Q/ha)	Rank	Ramarks
DBW 135	NIVT-1A	51.6	5	Not considered
DBW 143	NIVT-1B	49.9	2	Not considered
DBW 149	NIVT-3	42.0	26	Not considered
DBW 150	NIVT-3	42.6	25	Promoted to AVT-IR-LS-NWPZ

Table 1.38. Promotion from station trial to different NIVTs during 2014-15

Sn	Entry	Plant height	1000-gr. weight	Heading (days)	Yield (Q/ha)	Remarks
1	LBP 2013-05	86	41.0	76	46.5	DBW 156- NIVT-1A
2	LBP 2013-11	92	41.0	78	48.1	DBW 163- NIVT-1A
3	LBP 2013-12	101	46.0	100	45.7	DBW 169- NIVT 2
4	LBP 2013-14	98	40.9	84	50.8	DBW 176-NIVT-3B
5	LBP 2013-16	85	43.6	87	53.2	DBW 171- NIVT 3A
6	LBP 2013-24	93	38.0	85	39.0	DBW 182- SPL-AST

Contributions to national nurseries

The project has contributed a total of 13 entries for testing under yield component screening nursery (YCSN) for different traits.

Contribution to SSN

During period under report, 27 segregating bulks from this programme were also contributed to segregating stocks nursery (SSN). Pedigree details showing diversity among the parents in their pedigree in the lines contributed to SSN during last three crop seasons are given in Table 1.39.

Table 1.39. Pedigree details of entries contributed to SSN during 2014-15

Entry ID	Pedigree	Entry ID	Pedigree
LBPSSN-14-1	HD 2967/ HD 2932	LBPSSN-14-15	DBW 50/ DBW 39
LBPSSN-14-2	C 306/ PBW 550	LBPSSN-14-16	RAJ 4120/ CHIRYA 7
LBPSSN-14-3	C 306 / WH 730	LBPSSN-14-17	PBW 550/ HD 2932
LBPSSN-14-4	HD 2967/ YM#6	LBPSSN-14-18	RAJ 3765/ HD 2967
LBPSSN-14-5	DBW 39/ CHIRYA 3	LBPSSN-14-19	RAJ 3765/ PBW 550
LBPSSN-14-6	DBW 39/ HD 2985	LBPSSN-14-20	RAJ 4120/ PBW 550
LBPSSN-14-7	DBW 50/ BH 1146	LBPSSN-14-21	WH 147/ NI 5439
LBPSSN-14-8	Dharwad Dry / HD 2967	LBPSSN-14-22	WH 147/ PBW 550
LBPSSN-14-9	DBW 39/ GW 322	LBPSSN-14-23	WH 147/ RAJ 3765
LBPSSN-14-10	HD 2932/ RAJ 3765	LBPSSN-14-24	WH 730/ HD 2967
LBPSSN-14-11	HD 2967/ BH 1146	LBPSSN-14-25	WH 730/ PBW 550
LBPSSN-14-12	HD 2967/ DBW 50	LBPSSN-14-26	WH 730/ RAJ 3765
LBPSSN-14-13	HD 2967/ DBW 39	LBPSSN-14-27	WH 730/ RAJ 4120
LBPSSN-14-14	HD 2967/ PBW 550		

Sharing of DSBL lines for evaluation and utilization in NEPZ

During 2013-14, six sets of DSBL (Directorate Shuttle Breeding Lines) consisting 137 lines were supplied to Shillongani, Ranchi, Sabour, Faizabad, Patna and Coochbehar centres for evaluation under irrigated timely sown conditions. Data was recorded on days to heading, days to maturity, plant height, 1000 grain weight, grain yields and leaf blight score at appropriate stage. The data supplied by the centres was compiled to have an idea about the performance and suitability of material at these centres. Three varieties (DBW 39, NW 1014, DBW 14) released for north eastern plains zone (NEPZ) and one genetic stock (DBW 46) were used as checks for making comparison and identifying suitable genotypes for each trait and location. The location wise range and mean of entries for five metric traits is presented in Table 1.40.

Table 1.40. Location wise range and mean of DSBL entries for agronomic traits during 2013-14

Centre	Days to heading		Days to maturity		Plant height		1000 grain weight		Grain yield	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Shillongani	60-75	67	121-138	129	76-130	97	26-57	44	778-1753	1255
Ranchi	64-88	77	105-127	118	82-147	110	40-59	49	622-1986	1340
Faizabad	60-75	67	94-114	101	57-110	79	25-53	35	600-1980	1102
Sabour	68-90	78	120-132	127	76-146	101	30-48	39	640-1990	1534
Coochbehar	56-88	69	120-132	127	72-138	95	31-52	41	415-1093	797
Patna	67-94	81	108-131	120	82-153	110	32-51	42	710-1910	1319

A perusal of Table 1.40 revealed that Patna centre has longer duration (81 days) while Shillongani centre recorded maximum duration for maturity (129 days) followed by Sabour and Coochbehar. In case of plant height the performance of material ranged between 79-110 mean values for different locations. Whereas, for 1000 grain weight Ranchi centre had highest estimate of site mean followed by Shillongani. The site mean for grain yield ranged between 797g (Coochbehar) to 1340g (Ranchi). During 2014-15, fresh set of 200 lines was supplied to 6 centres namely Coochbehar, Shillongani, Faizabad, Ranchi, Sabour and Patna for evaluation and site specific selections. Across locations, promising genotypes were identified for each traits. For early maturity 9 lines namely, DSBL-13-06 (LBP-2013-08), 32 (LBP-2012-11), 35, 54, 81 (DBW 117), 84, 95, 114, 136; 8 lines namely DSBL-13-02 (LBP-2013-02), 5 (LBP-2013-07) , 37, 95, 96, 100, 130 for bold grain; 9 genotypes identified for high grain yield included DSBL-13-04, (LBP-2013-06), 17 (LBP-2013-20), 24 (DBW 135), 88, 100, 117, 129, 133, 137 and only 4 genotypes namely DSBL-13-09 (LBP-2013-11), 45, 80 (DBW 51) and 107 performed better for spot blotch resistance having average leaf blight score of lower than 13 on double digit scale, thereby, meaning that these lines possess high degree of resistance to leaf blight even under hot spot conditions and thus could be used as donor in hybridization programmes.

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

In this project, three sets of mapping populations made for spot blotch resistance in wheat viz. Sonalika / BH1146 (set-I), Kanchan / Chirya1 (set-II) and HUW 234 / YM#6 (set- III) were utilized for phenotyping at DWR (Karnal), BCKV (Coochbehar) and UBKV (Kalyani) under natural conditions and in polyhouse under epiphytotic conditions at DWR, Karnal.

Phenotyping: The above mapping populations were phenotyped at three different plant growth stages at three centres viz. Karnal, Coochbehar and Kalyani. The resistant and susceptible parental lines exhibited contrasting phenotypes for spot blotch disease severity (DS) during all the three years (2011-2014) and RILs showed large phenotypic variations. Based on multilocation and multiyear evaluation, potential donors from two sets of RILs along with parental lines are presented in Table 1.41 and Table 1.42.

Table 1.41. Leaf blight score (double digit) of potential donors from RIL population (Sonalika/BH 1146) evaluated under field conditions at three locations and also under polyhouse (Karnal) during 2012-13 and 2013-14

RIL No.	Karnal		Coochbehar		Kalyani		Polyhouse	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
LBRIL 3	03	03	13	13	13	13	23	23
LBRIL 8	03	03	12	12	12	12	24	24
LBRIL 18	03	03	13	13	13	13	23	23
LBRIL 46	03	03	13	13	12	12	23	23
LBRIL 61	03	03	13	13	12	12	13	13
LBRIL 102	03	03	13	13	02	02	13	13
LBRIL 142	03	03	13	13	12	12	24	24
Sonalika ©	79	79	89	89	89	89	99	99
BH 1146 ©	12	12	24	24	24	24	35	35

Table 1.42. Leaf blight score (double digit) of potential donors from RIL population (Kanchan/Chirya 1) evaluated under field conditions at three locations and also under polyhouse (Karnal) during 2012-13 and 2013-14

RIL No.	Karnal		Coochbehar		Kalyani		Polyhouse	
	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
LBRIL 6	24	02	24	13	23	13	13	13
LBRIL 37	12	03	24	13	23	13	13	13
LBRIL 38	12	02	23	13	13	13	23	23
LBRIL 54	13	12	23	23	23	13	24	13
LBRIL 118	13	12	23	13	23	13	13	13
LBRIL 143	24	12	23	13	24	13	13	13
LBRIL 189	13	02	23	13	13	13	13	13
Kanchan ©	57	35	89	89	89	89	89	89
Chirya-1 ©	23	02	13	13	13	12	13	13

Genotyping Set-I: Sonalika/BH1146: In this population, about 900 Simple Sequence Repeats (SSR) markers have been used to screen parental lines. A total of 120 SSR markers were found polymorphic between the parents, Sonalika and BH1146. Maximum frequency of marker polymorphism was observed on B genome (42.5%) followed by A genome (33.0%) and D genome (24.5%). Three linkage groups were co-segregating with mean percent disease severity for spot blotch across the location and over the years chromosomal region explaining 6.4 to 11.6 percent variation was identified on chromosome 7B.

Set-II: Kanchan/Chirya#1: In this mapping population, 140 markers were found polymorphic after screening of parental lines with 900 SSR markers. Maximum polymorphic markers were observed on B genome (45%) followed by D (28%) and A (27%) genome and four linkage groups were obtained. LOD score of 7.4 was obtained with mean percent disease severity for spot blotch across the location and over the years on chromosome 7B explaining phenotypic variation 10.5 percent. Few more markers are required to further saturate the detected linkage groups to identify new QTLs. There is need to further validate the flanking markers of the identified QTLs in the set of genotypes phenotyped for spot blotch.

Biochemical estimation of different genotype: The biochemical parameters viz. Phenol, Peroxidase activity and lignin content associated with disease resistance were estimated in 7 genotypes of Set-1, 7 genotypes of Set-2 and 5 genotypes of Set-3 along with Sonalika as Check. The plants were inoculated at 28 days after sowing with virulent strain of *Bipolaris sorokiniana* and leaves were collected after 4 days of inoculation. The results indicated that all the parameters were higher in the resistant RILs as compared to susceptible check, Sonalika following infection. The resistant plants with higher levels of protection against *Bipolaris* infection also recorded significant increases in the levels of phenols, peroxidase as well as Lignin content with minor variations.

RILs for heat and drought tolerance

The work of development of RILs for heat and drought tolerance in wheat was carried forward and the material developed at IIWBR, Karnal was shared with two centres namely GBPUA&T, Pantnagar (drought) and ARI, Pune (heat) for multiplication and preliminary phenotyping. However, the detailed phenotyping of this material with more traits will be taken up after receiving financial support.

Wheat improvement for water logging, salinity and element toxicities

The salient achievements made under this Indo-Australian Collaborative project at DWR, Karnal over last four crop seasons are summarized below.

- Experiments on divergence analysis of 108 bread wheat accessions from India and Australia indicated that maximum number of genotypes was grouped into the cluster IV (26) followed by cluster VI (22) and cluster II (12). The genotypes in diverse clusters i.e. Perenjori, KRL261 and KRL283 of cluster X, Gutha of cluster IX may be used as potential donors for hybridization programme to develop water logging tolerant genotypes with high grain yield.
- Phenotyping of SSD populations was taken at DWR, Karnal and NDUA&T, Faizabad during 2014-15 crop season and observations have been recorded.
- Based on experiment with 160 genotypes planted under normal and water logged conditions promising lines were selected based on geometric mean productivity (GMP), stress tolerance index (STI), mean productivity (MP), harmonic mean

(HM), and stress tolerance score (STS) and have been rated as highly waterlogging tolerant. The lines thus selected were namely; BH 1146, DBW 39, DBW 52, NW 1014, NW 1067, NW 4081, PBW 621, PBW 631, PBW 590, RW 3684, HD 2967, HD 2997 and NW 4083. However, the lines that were shortlisted based on stress susceptible index (SSI) and tolerance (TOL) only could be classified suitable for normal and waterlogged conditions. The lines thus identified included; Perenjori, PBW 343, PBW 636, KRL 268, RAJ 4201, RAJ 4205 and WH 1094.

- It is anticipated that results obtained will be very useful in identifying and utilizing donors for incorporation of waterlogging tolerance. The research findings also imply that tolerant lines eventually would lead to higher production and productivity under situations, where heavy rainfall and stagnant water for prolonged period adversely affect the wheat crop.

New initiative for creating repository of mapping populations of wheat at GRU

The IIWBR has initiated a new activity to safely maintain the mapping populations developed for different traits under various projects/programmes. During 2014-15 crop season, about 50 g seed of each line (packed in sealed aluminium envelopes) of following mapping populations was submitted alongwith passport details and the cross details etc. for medium term storage and also for making these material available for further studies following terms and conditions laid for this purpose (Table 1.43).

Table 1.43: Details of mapping population developed

S. No	Pedigree	Number of lines	Trait name
1.	Sonalika / BH 1146	219	Spot blotch
2.	Kanchan / Chirya 1	215	Spot blotch
3.	HUW 234/ YM# 6	292	Spot blotch
4.	DBW 17 / BH 1146	327	Waterlogging/ salinity
5.	DBW 16 / BH 1146	362	Waterlogging/ salinity
6.	PBW 550/ Chirya 1	450	Waterlogging/ salinity
7.	C 306 / HD 2967	346	Drought Tolerance
8.	Dharwad Dry / HUW 468	334	Drought Tolerance
9.	NP 846 / DBW 17	237	Drought Tolerance
10.	NP 846/ HUW 468	219	Drought Tolerance
11.	NP 846/ HUW 234	167	Drought Tolerance
12.	NI 5439/ MACS 2496	240	Heat Tolerance
13.	WH 730 / MACS 2496	271	Heat Tolerance
14.	WH 147/ HD 2967	106	Heat Tolerance
15.	RAJ 3765/ UP 2382	125	Heat Tolerance

Wheat Improvement for warmer areas

Release of new bread wheat varieties

DBW 110 : Wheat variety DBW 110 was released by the Central Sub-Committee on Crop Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) for timely sown, restricted irrigation condition of Central zone comprising states of Madhya Pradesh, Chhattisgarh, Gujarat, Kota & Udaipur divisions of Rajasthan and Jhansi division of Uttar Pradesh (Fig. 1.2). This variety recorded mean yield of 39.0q/ha in yield evaluation trials of AICW&BIP under timely sown restricted irrigation conditions of the central zone which was significantly higher than the check varieties HI 1500 (20.0%) and MP 3288 (5.4%). DBW 110 had maximum yield potential of 50.5q/ha. It significantly out-yielded check varieties in agronomical trials and showed 41.7% and 60.3% yield superiority over rainfed crop in the availability of one and two irrigations, respectively. DBW 110 is highly resistant to brown (ACI-4.1) and black (ACI-7.3) rusts and Karnal bunt (Av score 2.0). This variety has better chapati and bread making qualities with 12.2% protein, 54.0ml sedimentation value and 81.3kg/hl test weight. It also had better nutritional qualities as it possesses 38.2ppm Fe, 41.3ppm Zn and 3.94ppm yellow pigment.

Fig. 1.2. Wheat variety DBW 110 released for timely sown, restricted irrigation condition of Central zone

DBW 107 : Wheat variety DBW 107 was released by the CVRC for late sown, irrigated condition of North Eastern Plains zone (NEPZ) comprising Eastern Uttar Pradesh, Bihar, Jharkhand, W. Bengal and plains of Assam state (Fig.1.3). This variety recorded mean yield of 41.3q/ha in yield evaluation trials of AICW&BIP under late sown irrigated conditions of the NEPZ which was 4.8% higher than the best check variety DBW 14. DBW 107 had highest yield potential of 68.7q/ha. DBW 107 was categorized as resistant to heat stress (0.99heat susceptibility index). DBW 107 was highly resistant to brown rust (ACI-3.7) and leaf blight (AV. score: 24 in natural, 36 in artificial). This variety

Fig. 1.3. Wheat variety DBW 107 released for late sown, irrigated condition of NEPZ

Fig. 1.4. Wheat variety DBW 93 released for timely sown, restricted irrigation condition of PZ.

had better chapati and bread making qualities with 12.8% protein and better nutritional qualities as it possesses 44.6 ppm Fe, 35.7 ppm Zn and 4.15 ppm yellow pigment.

DBW 93: Wheat variety DBW 93 was released by the CVRC for timely sown, restricted irrigation condition of peninsular zone comprising states of Maharashtra and Karnataka (Fig. 1.4). This variety recorded mean yield of 29.3q/ha in yield evaluation trials of AICW&BIP under timely sown restricted irrigation conditions of the peninsular zone which was significantly higher than the check varieties NI5439 (19.1%) and NIAW 1415(11.0%). DBW 93 had yield potential of 39.0q/ha. It showed highest yield response (34.5%) at application of single irrigation under restricted irrigation conditions. DBW 93 was highly resistant to black (ACI-3.2) and brown (ACI-10.3) rusts and Karnal bunt (Av score 3.5). DBW 93 is premium quality wheat variety as it contains high contents of protein (14.6%) and dry gluten (11.4%) & possesses higher rate of flour recovery (71.5%) and hectoliter weight (80.3kg/hl). Perfect 10/10 score for high molecular weight (HMW) subunits and the presence of 5+10 subunits of GluD-1 reflects its higher gluten strength. It also had better nutritional qualities as it possesses 50.9 ppm Fe, 46.0 ppm Zn and 3.7 ppm yellow pigment.

New cross combinations and their evaluation

A total of 238 new cross combinations including 12 double-crosses were attempted during the crop season which included diverse genotypes as parents with the objective to incorporate the desirable traits for warmer areas. These crosses involved synthetics, Chinese germplasm, and elite material from national and international nurseries/trials as parents for broadening the genetic base of the material. 358 F_1s made in 2012-13 were evaluated for yield and component traits alongwith 9 check varieties namely HD 2967, DBW 17 & DBW 16 of NWPZ; K 0307, CBW 38 & DBW 14 of NEPZ; GW 322 of CZ and NIAW917 & NIAW 34 of PZ. The promising combinations for higher yield were identified for more precise evaluation in next generations.

Table 1.44. Variability observed in PYT entries for yield and component traits under different irrigation levels

Traits	Irrigated		Restricted irrigation		Rainfed	
	Range	Mean	Range	Mean	Range	Mean
Days to heading	87-110	98	74-111	91	76-117	93
Days to maturity	135-149	143	135-149	141	137-154	143
Plant height	77-112	99	79-114	96	53-110	95
Tillers/m	46-98	69	60-220	157	60-260	135
Spikelets/spike	14-25	20	13-24	18	15-24	20
Spike length (cm)	9-14	11	9-14	11	10-15	12
CT	17.8-25.2	20.5	15.3-23.1	20.2	13.6-20.5	18.5
1000-gr. weight (g)	26-55	41	26-54	38	25-51	38
Grain yield (g)	168-426	304	296-804	529	354-903	634
Biomass yield (g)	623-1207	921	1050-2400	1674	1040-2173	1660
Harvest index (%)	21.2-44.2	33.0	20.5-39.6	31.7	30.2-44.4	38.2

Evaluation of advanced bulks in PYT

109 advanced bulks were evaluated for various yield traits along with 11 checks, namely, DBW17, HD 2967, HD 3086, DBW16, DBW14, DBW 71, CBW38, K0307, GW322, NIAW34 and NIAW917 in six row plot of 6m length in 2 replications. Besides, same set was also evaluated under restricted irrigation and rainfed conditions in double row plot of 2.5m length spaced 20cm apart. A wide range was observed for various traits under three different irrigation conditions (Table 1.44 & 1.45).

Table 1.45 PYT entries promoted to DWR station trials based on the superior yield and disease reactions

Entry	Yield (q/ha)	Days to heading	Days to maturity	Pl. height (cm)	1000-gr weight (g)	Yellow rust	Promotion
PYT 2013-101	51.6	108	147	110	47	10MR	DWR-ST-TS
PYT 2013-33	49.6	110	147	100	37	0	
PYT 2013-117	48.9	100	142	110	54	0	
PYT 2013-13	47.8	96	139	98	41	20MR	
PYT 2013-12	45.4	100	142	104	42	0	
PYT 2013-97	46.6	95	144	88	35	0	
HD 2967 (C)	45.2	98	141	107	47	0	
PYT 2013 - 35	53.2	106	147	99	43	0	DWR-ST-LS
PYT 2013 - 26	49.4	96	139	100	37	0	
PYT 2013 - 60	49.3	97	142	97	55	0	
PYT 2013 - 76	48.7	103	144	97	39	10MR	
PYT 2013 - 17	46.5	98	147	101	36	10MR	
PYT 2013 - 86	47.3	97	139	89	42	10MR	
DBW 16 (C)	46.0	99	142	95	42	10MR	
DBW 71 (C)	48.9	88	138	100	45	0	
PYT 2013 - 96	44.4	96	144	86	33	0	DWR-ST-A+D
PYT 2013 - 66	46.1	100	142	99	40	10MR	
PYT 2013 - 62	45.3	105	147	93	39	10MR	
GW 322 ©	36.2	95	144	96	43	10MS	

Table 1.46. Entries contributed to national coordinated yield trials

Entry	Yield (q/ha)	Rust reaction			Promotion
		Yellow rust	Leaf rust	Stem rust	
DWR-ST-TS-NWPZ (Karnal)					
DWAP 1304	44.5	40S (11.3)	TR (0.1)	-	DBW 159 (NIVT 1A)
DWAP 1305	42.7	30S (11.3)	10S (5.0)	-	DBW 161 (NIVT 1A)
HD 2967 (C)	36.4				
DWR - ST – TS- NEPZ (Faizabad, Kalyani)					
DWAP 1303	45.9	30S (9.8)	TS (0.5)	-	DBW 167 (NIVT 1B)
DBW 39(C)	45.5				
DWR - ST – LS- NEPZ (Patna, Coochbehar)					
DWAP 1310	66.6	40S (12.7)	10S (5.0)	-	DBW 172 (NIVT 3A)
DWAP 1311	58.1	40S (13.8)	30S (15.0)	-	DBW 174 (NIVT 3A)
DBW 14(C)	49.1	-	-	-	-
DWR - ST – LS- National (Karnal, Patna, Coochbehar)					
DWAP 1306	46.3	-	TMS (0.2)	20S (5.2)	DBW 177 (NIVT 3B)
DBW 14(C)	43.6	-	-	-	-
DWR - ST – TS- A+D - National (Karnal, Junagarh, Vijapur, Niphad)					
DWAP 1316	48.2	-	40S*(8.6)	-	DBW 179 (NIVT 5A)
GW 322(C)	47.2	-	-	-	-

Contribution to station trials

During 2013-14, sixteen entries were contributed to DWR station trial (5 in timely sown, 7 in late sown, 4 in A+D) out of which seven entries were promoted to NIVT 1A (DBW 159, DBW 161), NIVT 1B (DBW 167), NIVT 3A (DBW172, DBW 174), NIVT 3B (DBW 177) and NIVT 5A (DBW 179) during 2014-15 (Table 1.46). In addition one entry DBW 186 has been contributed to SPL-VLS-NWPZ/NEPZ.

Contribution to coordinated trials

During 2013-14, two genotypes namely DBW 148 and DBW 151 were contributed in NIVT 3 out of which DBW 148 has been promoted to AVT-I-IR-LS-NWPZ for crop season 2014-15 (Table 1.47).

Table 1.47. Entries promoted to AVTs

Entry	Yield (q/ha)	*Yr*(ACI)	*Lr*(ACI)	Promotion
DBW 148	45.8	60S (11.2)	20MS (5.2)	AVT-LS-IR-NWPZ
DBW 151	43.9	60S (23.3)	20S (7.6)	
HI 1563(C)	40.4			

Two genotypes namely DBW 126 (AVT-IR-LS-NEPZ) and DBW 129 (AVT-TS-RI-NWPZ) were evaluated in AVT I. In addition, wheat genotypes DBW 107 (AVT IR-LS-NEPZ) and DBW 110 were evaluated in final year and both the entries were identified and released in respective production conditions.

Sharing and multilocational evaluation of breeding material

During 2014-15, total of 9 genetic stocks were contributed in NGSN and shared with 31 cooperating centres. The data from 22 centres was pooled which indicated 20.1% utilization. Based on the pooled mean, the promising genotypes that showed better performance than the best check were identified. PHS 1101, PHS 1104, PHS 1106 and PHS 1107 showed excellent performance for more than 2 traits in combination compared to the respective best checks. In addition, a total of 50 segregating populations were contributed in the Segregating Stock Nursery (SSN) and National Hybridization programme. These were shared with 20 wheat breeding centers reported 58.0% utilization (Table 1.48).

Shuttle breeding under warmer area programme

The segregating and advanced lines were shared with shuttle breeding centres of CZ and PZ under warmer area programme. Out of 128 F_2 crosses shared with Dharwad, Akola, Vijapur and Jabalpur, 523 single plant selections were made by the centres. 572 F_3 lines were shared with Dharwad, Niphad, Jabalpur and Powarkheda out of which more than 2500 single plant selections were made. 103 advanced lines of PYT were sent to Dharwad, Akola, Jabalpur, Junagarh and Bilaspur for evaluation under irrigated, rainfed as well as restricted irrigation conditions. A wide range was observed for various traits and promising entries were retained by centres for evaluation in respective PYTs. 17 entries were promoted to station trials by Dharwad centre. In addition to these, 108 elite durum lines were shared with Dharwad out of which 46 were selected for SYT of the station during coming season.

Table 1.48. Superior genotypes for yield component traits in NGSN during 2013-14

Traits	Criteria	Promising Genotypes
Days to heading	<71	PHS1104 (69), PHS1107, PHS1101 (70)
Days to maturity	<123	PHS1104 (122)
Grains /spike	>50	PHS1107 (54), PHS1104 (52) , PHS1106 (51)
1000-gr weight (g)	>50	PHS1108 (55), PHS1103, PHS1109 (54), PHS1101, PHS1102 (53), PHS1104, PHS1105 (51), PHS1106, PHS1107 (50)
Spike length (cm)	>10	PHS1103, PHS1108, PHS1105, PHS1109 (12), PHS1102, PHS1101, PHS1104, PHS1106 (11)
Quality		
Protein content	> 14.0	PHS1103, PHS1108, PHS1109, PHS1102, PHS1101
Fe (ppm)	> 45.0	PHS 1101, PHS1103, PHS1107, PHS1108, DBW 71
Zn (ppm)	> 40.0	PHS 1107

Note: Value in parenthesis indicates the values of the traits

Marker studies for leaf rust

Leaf rust is a worldwide and yield-limiting disease of wheat. To integrate durable leaf rust resistance in the crop, there is a need to stack new resistance genes into the best available germplasm. Diversification of leaf rust resistance requires efficient genetic marker strategies. Closely linked markers for leaf rust resistant genes *Lr*32 and *Lr*42 were evaluated in 120 PYT lines. The markers that mapped closest to *Lr*32 were *Xwmc43* and *Xbarc135*, which co-segregated 0.6 cM proximal to *Lr*32. Out of 120 lines tested with *Xwmc43*, a single line possesses a diagnostic fragment for *Lr*32 was sized at ~346 bp whereas *Xbarc135*, did not yielded any amplicon in the tested lines. The closest marker, *Xwmc432*, is about 0.8 cM from *Lr*42. The *Lr*42 has not been widely deployed in wheat breeding programmes. Among 120 accessions, five lines possessing 204/211-bp banding pattern for marker *Xwmc432* as tested while 3 lines carried the 220-bp fragment for marker *Xcfd15* (Fig. 1.5).

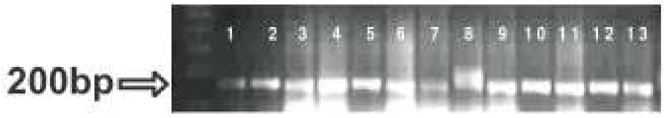


Fig. 1.5. PCR profile of representative 13 PYT lines with xcfd marker

Outreach activities for popularization of new wheat varieties in western UP

A three-pronged activity for popularization of new wheat varieties in western UP was initiated in 2013-14 through research scientists at SVBPUA&T, Modipuram and its RRS, scientists from 13 KVKs, seed producing companies and more than 20 progressive farmers. In this, a varietal cafeteria of six latest varieties of timely sown conditions and late sown conditions of NWPZ was planted at main campus, 13 KVKs, 3RRSs and 3 seed growers for exposure of new varieties to the farmers and farmers meeting at these sites were encouraged. 10 kg seed of DBW 71 was also planted at all these sites for popularization among farmers, seed multiplication and distribution to farmers in coming season. Large scale multiplication was also facilitated with seed production unit of the SVBPUA&T and three seed growers. This activity was also supported by Dy. Cane Commissioner, Meerut, Govt. of UP. In this activity more than 1000 farmers visited crop cafeteria and observed performance of latest cultivars. Feedback from 16 farmers indicated wide range for yield of new variety DBW 71 with maximum mean yield when sown in January. It produced 36.0q/ha under very late sown condition even when sown on 26th January.

Spring x Winter wheat hybridization

Winter wheats are endowed with novel features which serve as a source for introducing new variability in the spring wheats. The spring x winter wheat hybridization programme aims to enhance yielding ability and resistance to biotic and abiotic stresses in spring wheat. One of the objectives of the project is also to develop materials suitable for early planting in NWPZ. In NWPZ early planting of wheat is done around end October or first week of November. In the past farmers have tried many varieties for early sowing which did not perform very well due to lack of adaptability features in them. The derivatives from winter x spring wheat hybridization are naturally endowed with longer vegetative growth period which is a necessary characteristic for early sowing. The materials being selected for early planting are having longer vegetative phase, but are similar in total crop duration to the popular varieties in the zone, and also better disease resistance and higher yield.

Sharing of segregating material

During the crop season 2013-14 the material generated in the programme was provided to five centres in three major wheat growing zones (NWPZ, NEPZ and CZ) of the country for selection under different biotic and abiotic stresses and diverse agro-ecological conditions. The collaborating centres under the programme are GBPUA&T-Pantnagar, NDUAT-Faizabad, BAU-Sabour, JNKV-ZARC-Powarkheda and SDAU-Vijapur.

The Spring x Winter wheat Segregating Stock Nursery (SWSN) comprising 42 crosses in F_2 generation was shared with the five cooperating centres. The segregating material was subjected to natural biotic and abiotic stresses at different centres. There was occurrence of yellow rust and powdery mildew at Pantnagar, stem and leaf rust at Vijapur, and Powarkheda and leaf blight and loose smut at Sabour and leaf blight at Faizabad. Regarding abiotic stresses the material was subjected to early heat stress at Vijapur and sodic soils at Faizabad and terminal heat at all centres. The utilization report from cooperating centres showed that the percent utilization of the spring x winter crosses varied from 36% (Vijapur) to 100% (Powarkheda). The maximum number of 285 single plants were selected at Powarkheda followed by Faizabad (137) and BAU-Sabour (128) as shown in Table 1.49.

Table 1.49. Utilization report from cooperating centres

Centre	Crosses utilized #	Utilization %	Plants selected #	Characteristics for which utilized
GBPUA&T-Pantnagar	25	60	56	Disease resistance and yield components
NDUAT-Faizabad	22	52	137	Yield components, disease resistance, morphological and seed characteristics
BAU-Sabour	28	67	128	Yield components, disease resistance and seed characteristics.
JNKV-ZARC-Powarkheda	42	100	285	Yield components, disease resistance morphological traits and seed characteristics
SDAU-Vijapur	15	36	19	Yield components, disease resistance and morphological traits

The majority selections across the cooperating centres were done in the crosses with pedigree AGRI/NAC//ATTILA/HS507, AGRI/NAC //ATTILA/VL907, PHS 0928/EC 582228//VL 829,

VL404/CTK/VEE// KAUZ// VL829, VL 404/EC 582228//VL829, C 81-13=TORK-15/VL 892, NESSER/SAULES KU32/MACS6240 and VL892/F81513/ KAUZ//VL892. The utilization of SWSSN at the cooperating centres was very encouraging and it reflected the usefulness of winter wheats in spring wheat improvement.

During the crop season 2014-15, 45 cross-combinations were shared with six cooperating centres including IIWBR Regional Station, Shimla for on-site selection and utilization of the material.

Evaluation of breeding materials

The derivatives from winter x spring wheat hybridization are naturally endowed with required characteristics for longer vegetative growth period, and hence one of the objectives of the project is to develop breeding material suitable for early planting in NWPZ. The materials selected are similar in heading and maturity, disease resistance with higher yield *per se* to the popular varieties in the zone. During this year, 193 F_2 crosses, and families in filial generations numbering 533 F_3, 188 F_4, 193 F_5 were evaluated in field and plants were selected on the basis of rust resistance and yield characteristics. Further, advance generation lines comprising 87 F_6, 59 F_7 and 19 F_8 families were evaluated. Some of the promising cross-combinations in advance generations along with their characteristics are given in Table 1.50 and promising lines having high yield and desirable plant type with rust resistance were tested in DWR Station Trial are presented in Table 1.51. During the crop season about 1600 breeding lines were sown at DWR-RS, Dalang Maidan for generation advancement and recording the disease reactions.

Table 1.50. Promising cross-combinations in F_6/F_7 generations

Cross Combination	Characteristics
F81.513/Milan2//HW3067	High tillering, medium-late maturity, longer spikes
90Zhong65/UP2572//HRWYT28	High tillering, medium-late maturity and bold grains with good appearance
90Zhong65/UP2572//UP2556/ Wugeng8025	High tillering, medium-late maturity and longer spikes with good appearance
KYZ9712/Wugeng8025//IGPSN 149	High tillering, longer spikes and bold grains with good appearance
UP2425/Centurk/PHR1010	High tillering, strong stem and bold grains
PHR1014/Zander33	High tillering, medium-late maturity and longer spikes

During the crop season 2014-15, two PYTs with 72 entries were sown for yield evaluation. The breeding materials sown during the season for evaluation and selection included 469 F_1s and 297 F_2 crosses, and filial generation families numbering 483 in F_3, 194 in F_4, 102 in F_5, 95 in F_6, 64 in F_7 and 18 in F_8 generation.

Table 1.51. Promising cross-combinations in preliminary yield trials

Cross Combination	Characteristics
UP2572/WUGENG8025	Resistance to leaf rust (ACI=0.0) and stem rust (ACI= 6.5)
UP2425/SPARTANKA-KAK-HORI-DOLI// PHR1010	Resistance to leaf rust (ACI=0.0) and stem rust (ACI= 5.6) and bold seeded
90ZHONG65/UP2572	Resistance to leaf rust (ACI=5.0), high tillering and high thousand grains weight
UP 2556/Mv231-98	Resistant to leaf rust (Score=0) and bold seeds

New spring x winter wheat crosses

Sixty-one winter wheat lines alongwith 7 F_1s of winter x winter crosses were grown under natural photoperiod conditions during last week of October 2014 which headed during March 2015. 469 F_1s were also grown for making further introgression via top or double crosses. A total of 347 crosses were made at Karnal during the season involving winter and spring parents.

Contribution of entries to coordinated trials

During 2013-14, nine genotypes were tested in coordinated varietal trials out of which 4 entries were tested in NIVT-1A (DBW 134, DBW 136, DBW 138 and DBW 140), two entries in NIVT-1B (DBW 141, DBW 144), two entries in NIVT-5A (DBW 152, DBW 153) and one entry (DBW 155) in Salanity/Alkalinity trial.

In 2014-15 crop season, a total of six entries were contributed to national trials, viz., DBW 160 in NIVT-1A, DBW 166 in NIVT-1B. DBW 180 in NIVT-5A and DBW 181, DBW 184 and DBW 185 to Salanity/Alkalinity trial.

Genetic studies on heat stress tolerance in wheat

In order to study inheritance of various traits under heat stress using six generation means, P_1, P_2, F_1, BC_1, BC_2, F_2 of 7 crosses namely, K7903/RAJ4088, K7903/PI1632, HD2808/PI1632, HD2808/HUW510, K7903/RAJ4014, HD2808/RAJ4014 and WH730/HUW510, were raised under timely and late sown conditions for the second year to validate the results. Data recorded confirmed that the traits, grain weight/spike, thousand grain weight and photosynthetic efficiency were governed by additive dominant model. New direct and back crosses were attempted and generations were raised for further studies.

Thirteen RIL populations developed for heat tolerance traits were advanced to next generation; 3 populations from F_4 to F_5, 2 populations F_5 to F_6, 2 populations F_6 to F_7, 3 F_7 to F_8 and 3 F_8 to F_9.

Phenotyping of RILs population

RIL population (HD2808/HUW510) consisting of 253 lines was phenotyped along with parents under normal (timely) and stress (late) environments for terminal heat tolerance. The minimum temperature during grain filling ranged between 2.8°C to 17.0°C under normal conditions and from 7.5°C to 19.0°C under late sown conditions. The maximum temperature during this period ranged between 13.0°C to 34.5°C under normal conditions and from 22.8°C to 37.0°C under late sown conditions. Average minimum and maximum temperature during grain filling period was 10.6°C and 24.2°C and 13.3°C and 28.4°C under normal and late sown conditions. It clearly shows that the late sowing was heat stressed. Analysis of variance revealed that RILs differed significantly for days to heading, days to maturity, plant height, grain yield, grain weight/spike and 1000 grains weight whereas sowing conditions for all traits except plant height (Table 1.52).

HD 2808 suffered 12.4% reduction under stress conditions whereas genotype HUW 510 suffered significant reduction of 34% under stress conditions. The reduction in grain weight ranged from -25% to 66% among RILs. Thirty-six percent RILs registered less reduction than in HD 2808 where as 22% registered more reduction than HUW 510 (Fig.1.6). The distribution of reduction in grain weight in RILs showed normal curve. About 32% progenies had significant reduction in grain weight under late sown condition whereas 21% progenies had no reduction.

Parental screening with SSR markers: Parents HD 2808 and HUW 510 were screened with 342 microsatellite markers such as 81(GWM), 109 (WMC), 41(CFD), 38 (BARC), 7(CFA), 3(GDM and 1(GPW). Out of these tested markers 87 (25.4%) were found to be polymorphic.

Evaluating genotypes under drought and heat stress conditions: Forty entries comprising of wheat cultivars, advanced breeding material and indigenous and exotic germplasm collections were evaluated for terminal heat stress by sowing under late and very late sown conditions. The average temperature during grain filling period ranged from 12.0 to 32.6°C under late sowing and from 17.0 to 32.6°C under very late sown conditions. The mean minimum and maximum temperature was higher by 1.4 and 2.0°C under very late sown conditions. Genotypes HS277, IC-118737, RAJ4037, Giza 155, SALEMBO, IC 32586, Bacanora 88, REDFIFE, IEPACA RABE, SUNSTAR and Sonora 64 Dwarf suffered non-significant reduction in biomass; Bacanora 88, TEPOKO, SALEMBO, IC 32586, K7903, Giza 155, Barkare, Sonora 64 Dwarf, REDFIFE and ARIANA 66 in grain yield and BABAX, SERI 82, IC-118737, BWL-1793, IC532653, Bacanora 88, PBN-51, WH730 and REDFIFE in grain growth duration. The Heat sensitivity index of genotypes CHIRYA-3, ARIANA 66, REDFIFE, Sonora 64 Dwarf, Giza 155, Barkare, BWL-0924, Bacanora 88, TEPOKO, RAJ4037, BWL-9022, CUS/79/PRULLA, IEPACA RABE, K7903, IC 32586, RAJ4083, DBW14 and HS277 was less than 1.0 (Fig. 1.7).

Table 1.52. Mean sum of squares for genotypes, conditions and genotype x conditions for various traits

Source of variation	DF	DH	DM	GFD	CTD	PHT	GY	GW	GFR	TGW
Genotype	254	52.53*	11.52*	6.45	4.01	155.56*	7009.05*	0.19*	0.02	30.72*
Cond	1	223.07*	80349.6**	30734.2**	123.12**	246.41	493468**	20.51*	18.16*	117.49*
Genotype*cond	254	52.62*	10.11	6.70	3.81	170.99**	7800.37**	0.20	0.03*	33.65*
Residual	510	42.54	9.54	7.09	4.68	127.71	5507.46	0.18	0.02	27.96
Total (corrected)		47.72	89.02	36.99	4.41	145.56	6926.75	0.20	0.04	30.10

*, **Significant at P = 0.05 and P = 0.01, respectively

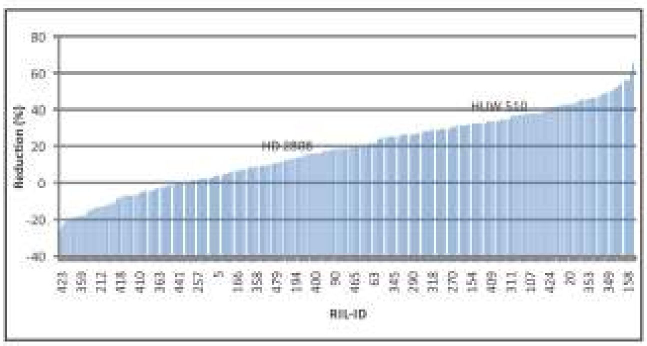


Fig. 1.6. Reduction in grain weight in RIL population including parents under late sown stress conditions

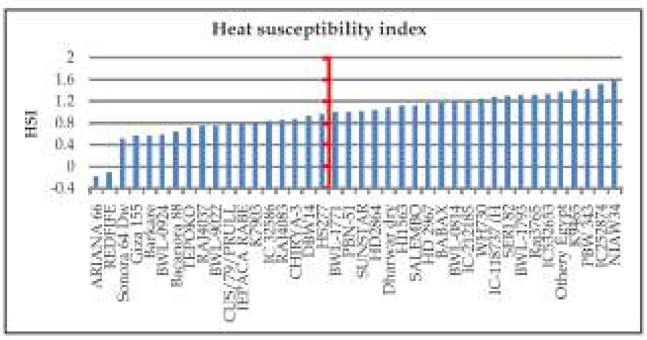


Fig. 1.7. Heat susceptibility index for grain yield in forty genotypes evaluated under late and very late sown conditions

Evaluating genotypes for heat tolerance under late sown and temperature controlled phenotyping facility: 94 genotypes along with two checks were sown under timely conditions in field and phenotyping facility and late sown conditions in field. Under controlled conditions, heat stress of 5°C was applied for 4days weekly after anthesis for 3 weeks. Data was recorded under three sets of sowing and it was found that the reduction in all the traits was more under controlled temperature conditions as compared to stress under late sown conditions (Fig. 1.8).

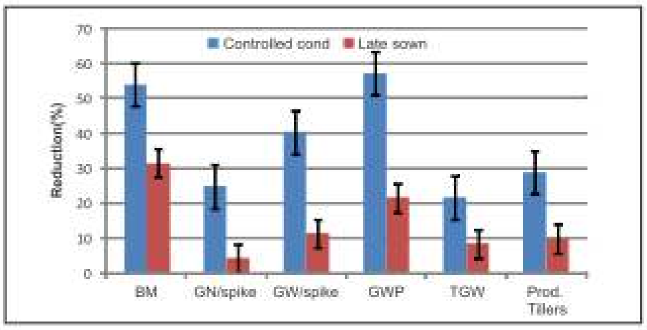


Fig. 1.8. Reduction in grain yield components under temperature controlled and late sown conditions

The heat sensitivity index for grain yield /plant was less than 1.0 in 37 genotypes under controlled stress conditions and 53 under late sown field conditions. Of these only 18 (Table 1.53) were tolerant under both conditions.

Table 1.53. Genotypes with heat susceptibility index less than 1.0 under temperature controlled and late sown conditions.

C 306	DBW 14	NI 5439	NIAW 1994	HD 2327
HW 2045	K 1114	DL 788-2	HD 3119	MP 3379
HD 3116	HI 1563	GW 173	WH 1128	UP 2845
HD 3117	K 9465	MP 3304		

Evaluating indigenous germplasm accessions for drought and heat tolerance: Thirty-seven indigenous germplasm accessions along with checks were evaluated for drought tolerance under field conditions and for heat tolerance under controlled temperature conditions. For dought tolerance irrigated and rainfed trials were conducted. For heat tolerance timely and late sowing was done in two parallel chambers of the temperature controlled glasshouse. The temperature in the late sown chamber was increased by 2.0°C during post heading period. Genotypes IC 128342, IC 28692A, IC 55707B, IC 57889B, IC 59579A, IC 78764A and IC 78924 were less sensitive to both drought and heat conditions. Genotypes IC 28661, IC 78856, IC 55701A, IC 55707B, IC 28692A, IC 78869A, IC 57889B, IC 41504, IC 28664A, IC 28938B, IC 128335, IC 128342, IC 59579A, IC 28904B, IC 78924, IC 138904B, IC 78764A and IC 28599 were less sensitive to high temperature conditions. Genotypes IC 57985, IC 28658, IC 36761A, IC 28665, IC 59128B, IC 59575A, IC 55707B, IC 78753B, IC 57586, IC 128342, IC 57889B, IC 78762B, IC 78872, IC 30276A, IC 78764A, IC 28692A, IC 59579A and IC 78924 were less sensitive to drought conditions.

Evaluating exotic germplasm accessions for drought and heat tolerance: Twenty-two germplasm accessions were evaluated for drought tolerance under rainfed conditions during crop season 2013-14. There was 171mm rainfall during the crop season; the rainfed crop received 104mm rainfall during grain growth period. Based on the drought susceptibility index, five genotypes namely LGM 118, HY 127, LGM 150, LGM 117 and JNIT for highly tolerant, LGM 147 and LGM 159 were moderately tolerant and GL 23, GL 25 and GL 39 were highly susceptible (Fig. 1.9).

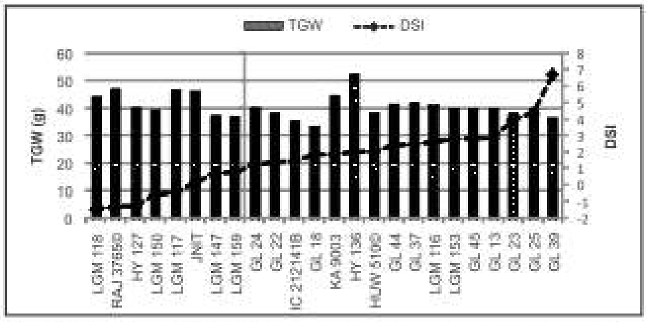


Fig. 1.9. DSI and TGW of germplasm accessions screened for drought tolerance

Evalluation of hexaploid wheat synthetic lines for heat tolerance: One hundred synthetic wheat lines were evaluated for heat tolerance under polyhouse and field conditions. The post heading average maximum and minimum temperatures under late sown field conditions were higher by 3.7°C and 2.7°C. Under temperature controlled conditions, the post heading temperature was maintained from 30°C to 40°C. Synthetic lines 149, 150, 196, 200, 202, 209, 210, 223, 231, 232 and 234 had less than 10% reduction in grain number/ spike (Fig.1.10).

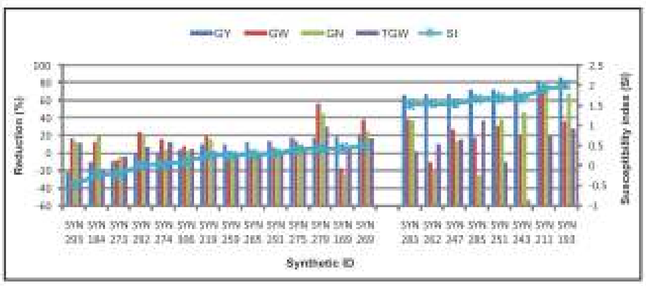


Fig. 1.10. Reduction in grain yield, grain weight/spike, grain number/spike, 1000 grain weight and susceptibility index in some synthetic hexaploid wheat lines

Synthetic lines 148, 150, 153, 170,176,187, 192,196, 210, 239 and 254 had lesser reduction in 1000 grain weight than their counterparts under non stress conditions. Based on heat sensitivity index for thousand grain weight, synthetic lines 148, 150,153,170,187,196, 210,239 and 254 were less sensitive under stress conditions. The synthetic line 432 had significantly higher reduction in grain filling duration under stress conditions; lines 135, 136, 237 and 466 had more than 25% reduction in grain weight/spike and lines 183 had more than 25% reduction in thousand grain weight and lines 183, 212 and 241 were more sensitive to high temperature conditions.

Elucidating the role of indole acetic acid under terminal heat tolerance in wheat

Hormones play an important role in the interplay of plant's adaptability to stresses. Hormonal homeostasis, stability, content, compartmentalization and biosynthesis are altered under heat stress. Indole-3-acetic acid (IAA) is an important auxin in most plants and regulates cell division, elongation and differentiation. IAA has been shown to have a role in heat tolerance in barley and other crops under controlled conditions. Hence, in the present study an attempt has been made to estimate the endogenous concentration of IAA in a set of heat tolerant and susceptible wheat genotypes under late sown condition in field.

Colorimetric method by Gordon and Weber (1951) was followed for IAA estimation and was standardized for wheat with some modifications. Generally in many of the crops, reproductive tissue is largely used for IAA accumulation studies. In order to identify a representative tissue for IAA accumulation studies in wheat a preliminary screening was conducted by quantifying IAA accumulated in tissue samples from different vegetative and reproductive parts and it was found that maximum quantifiable amount of IAA was extracted from flag leaf compared to all other tissues tested. Twenty four wheat genotypes namely, DBW14, DBW17, DPW 621-50, Halna, HD2864, HD2932, HD2967, HI1563, HD2329, HS277, HUW468, HW2004, P11632, NI5439, NIAW34, PBW343, PBW373, PBW590, Raj3765, Raj4037, Raj4083, UP2425, WH147 and WH730 were sown in three replications under late sown conditions to enable them to be exposed to terminal heat stress. The tissue samples of flag leaf from each genotype was collected at GS75 in Zadoks scale and was used for quantifying the differential ability of genotypes for IAA accumulation. An equal quantity of tissue from flag leaf (0.5 g FW) were ground in 5.0 ml distilled water and centrifuged at 6,000g at room temperature for 10 min. The supernatant was collected and IAA was determined in 1.0 ml aliquot with modified Salowski reagent (1.0 ml of 0.5 M $FeCl_3$ in 50 ml 35% perchloric acid). In 1.0 ml aqueous aliquot, 2.0 ml Salowski reagent was added. The development of pink colour was measured after 1h at 530 nm and the results were expressed as μg g−1 FW. The experiment was repeated for two years.

Genotypic variation exists for IAA accumulation and the values ranged from 95.8 to 120.8 μg g−1 FW of leaf (Fig. 1.11). The lowest IAA concentration was observed in HD2932 (95.8 μg g−1FW) and maximum concentration was in WH147 (120.8 μg g−1FW) followed by WH730 (118.9 μg g−1 FW). The reported heat tolerant genotypes like Halna, Raj3765, WH147, and WH730 showed relatively higher concentration of IAA compared to others. Hence IAA accumulated may have some role under terminal heat tolerance. However the precise quantification of IAA using ELISA in large number of genotypes may further confirm the role of this hormone in heat tolerance in wheat.

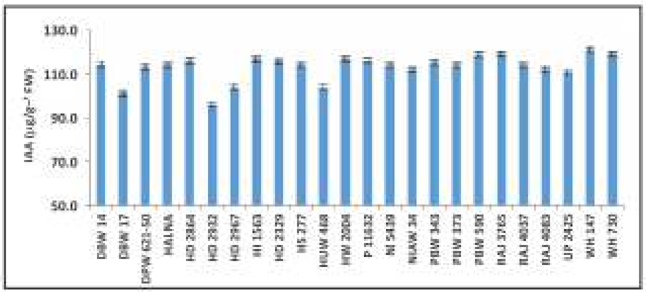


Fig. 1.11. Genotypic variation in IAA concentration under late sown condition

Biotechnological interventions

Identification of QTLs using separate biparental and association mapping populations

Stripe rust disease caused by *Puccinia striiformis* f. sp. *tritici* is most important and devastating disease of wheat worldwide, which strongly affects the grain yield, quality and nutrition. Identification of quantitative trait loci (QTL) generally relies on segregating populations upon which polymorphic markers are evaluated and subsequently associated with a phenotypic trait of interest. Association mapping (AM) is an alternative strategy to identify marker-trait associations and has been used extensively in human and animal genetic experiments. Both these approaches were carried out using biparental population in one study and an AM population to identify marker-trait associations for stripe rust resistance.

For association mapping a total of 319 genotypes were taken that represented released varieties, elite wheat genotypes from Indian wheat programme. Out of 30 markers applied, 50 polymorphic fragments from 16 polymorphic primers were selected for diversity studies. After diversity analysis on the basis of SSR markers and pedigree analysis, a total of 120 genotypes were selected for association studies. For phenotypic traits, genotypes were planted in three replications in lattice design in two consecutive crop seasons, 2012-13 and 2013-14. A total of ten phenotypic traits were selected for present study. For genotypic analysis, genotypes were screened with 150 SSR markers, out of which 63 polymorphic markers distributed across all wheat chromosomes were selected for further analysis. Structure analysis revealed that the genotypes can be categorized into three sub-groups. This was followed by linkage dis-equilibrium analysis using software GGT 2.0 and TASSEL 4.0. LD decay scatter plot of synteric r^2 vs genetic distance (cM) was generated. As the inter-locus distance increased, r^2 value decreased and the plot showed an LD decay distance extended maximally upto 15cM.

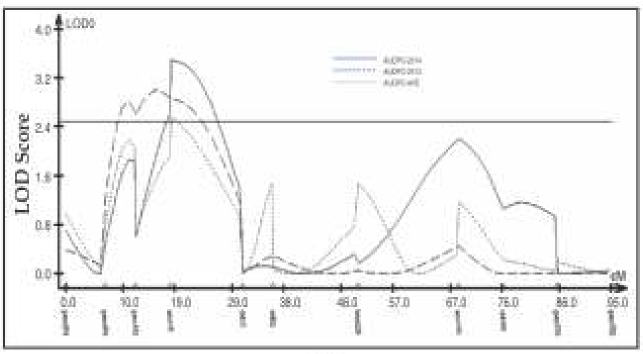
A total number of 50 marker trait associations (MTA's) were obtained for yellow rust across two years that explained 3.04 to 14.78% (R^2) of the phenotypic variation at three different levels of significance. Chromosomes 2A, 2D, 3D, 2B, 3B and 6A were detected as most significantly associated. Six of the mapped markers namely Xgwm261, Xgwm120, Xwmc332, Xgwm639, Xbarc176, Xgwm46 and Xgwm389 reported in the present study coincide with the earlier reports. However, some of the markers; Xgwm374, Xwmc817, Xgwm484, Xgwm341, Xwmc146, Xwmc748 and Xgwm111 were found to be very close to the already reported markers. In addition to the above results, novel regions were identified on chromosomes 2A and 5B that were significantly associated with yellow rust. Out of the total MTA, only four markers; Xgwm335, Xgwm484 and Xgwm639 were found to be consistently associated across both criteria of environment and General Linear Model (GLM) and Mixed Linear Model (MLM) analysis (Table 1.54).

Table 1.54. Association of SSR markers with yellow rust resistance across two years

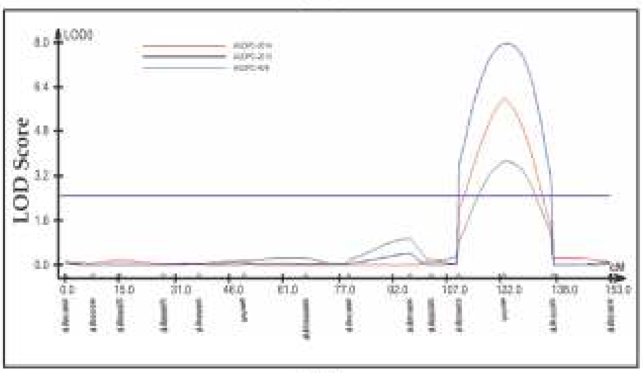
Marker	GLM RESULTS		MLM RESULTS	
	2013-14 %R^2	2012-13 %R^2	2013-14 %R^2	2012-13 %R^2
Xgwm335	12.48***	12***	9.99***	11.91***
Xgwm484	14.78***	10.8**	9.57**	9.38**
Xgwm639	9.31***	7.39**	6.29**	5.79**
Xwmc332	8.72***	11.49***	7.58**	11.7***

In another study, to elucidate the genetic basis of resistance in a recombinant inbred line (RIL) population developed from a cross between resistant Cappelle-Desprez and susceptible cultivar PBW343 map construction and QTL analysis was completed with 1,012 polymorphic (DArT and SSR) markers. Screenings for stripe rust disease were carried out in field condition for two consecutive crop seasons (2012-13 and 2013-14). Susceptible parent (PBW343) achieved a significant level of disease i.e., 100 percent in both the years. The production of consistent severe disease epidemics resulted in high heritability (0.82) across the years for stripe rust. The relative area under the disease progress curve (rAUDPC) data showed continuous distributions, indicating that trait was controlled multigenically. In present investigation resistance in Capelle-Desprez was found stable and response to the rust ranged from 0-1.5 percent over the years.

Subsequent QTL analysis in the mapping population led to the identification of two QTLs QYr.iiwbr-5B and QYr.iiwbr-2D (Figure 1.12) which were detected separately for both the years i.e., 2012- 13 and 2013-2014 and also with mean values of rAUDPC). The LOD value ranged from 3.0 to 3.8 and 3.5 to 6.0 respectively their corresponding phenotypic variation explained (PVE) ranged from 13.9 to 31.8 % and 24.0 to 27.0% respectively. QYr.iiwbr-5B conferring with maximum contribution to stripe rust resistance was flanked by DArT markers 1376633 |F|0-1207571 |F|0 peaks located with XWmc745 marker. A minor QTL effect showed on the short arm of chromosome 2D (QYr.iiwbr-2D) to stripe rust with flanking marker loci Xgwm484-Xcfd73.



(A)



(B)

Fig. 1.12. Composite interval mapping of stripe rust severity at adult plant stage in the Cappelle-Desprez/PBW343 mapping population based on stripe rust screening for 2014 and 2013. QTLs were detected on chromosome 2D (A) and 5B (B) with significant LOD scores.

Introgression of *Sr* genes in Indian wheat varieties

Crosses attempted using prominent Indian wheat genotypes to introgress *Sr39* gene from exotic source HR22Hartog were advanced during off season nursery, Dalang maidan. BC_1F_2 are sown in crop season 2014-15. STS *Sr39*#22r is a dominant marker that amplifies a single 487-bp band linked to the *A. speltoides* translocation containing *Sr39*. The parental lines along with donor HR22Hartog were confirmed for *Sr39* gene using this marker to confirm the presence/absence of this gene at molecular level. In our studies, its presence was confirmed in donor parent HR22 Hartog whereas the recipient parents did not amplify diagnostic band fragment marking the absence of *Sr39* in Indian genotypes (Fig. 1.13). Along with this, new crosses were attempted to introgress Sr genes like *Sr22*, *Sr33*, *Sr36* and *Sr39* in Indian wheat varieties like CBW38, DBW14, DBW71, DBW88, DBW107 and DBW110.

Fig. 1.13. Introgression of Sr genes in Indian Wheat

Legend: M (100 bp ladder); R (recipient lines PBW343, HUW206, HW517, K9107, DBW17 and HUW510)

In an effort to identify new genomic regions for rust resistance, mapping populations ($F_1/F_2/F_3$) of 35 crosses developed for stem rust studies were advanced and screened for adult plant resistance under high disease incidences. Resistant and susceptible bulks of 18 F_2 populations were identified on the basis of adult plant resistance for yellow and brown rusts for bulk segregant analysis studies to localize genomic areas conferring resistance for these two rusts.

Yellow rust resistant bread wheat lines identified through mutagenesis

Exploiting natural or induced genetic variability is an important proven strategy in the improvement of all major food crops including wheat. Mutagenesis is an important tool in crop improvement to generate a vast amount of genetic variability for identification of improved or novel phenotypes that can be exploited in conventional plant breeding programmes and genetic studies. A chemically induced mutant genetic resource for detecting novel variations has been developed in bread wheat cultivar DPW621-50. A population comprising of 1910 mutant lines (M_4 generation) was evaluated for field resistance to yellow rust under artificially created epiphytotic conditions during 2013-14 crop season (Fig. 1.14). Stripe rust epidemic was initiated by inoculating 3 week old plants of spreader rows with urediniospore collected from infected plants from farmers' fields in Yamunanagar area of Haryana. Out of 1910 lines screened, 1087 lines were found to be highly susceptible and 812 lines showed susceptible reactions to stripe rust. There were 6 lines (DWM1820, DWM1822, DWM1977, DWM2017, DWM2182 and DWM3140) free from any rust pustule and five lines showed only flecking type reactions indicating these lines can be effectively utilized in breeding programme as a source for stripe rust resistance.

Fig. 1.14. Yellow rust resistant lines of bread wheat developed through EMS mutagenesis

Identification of QTL conferring karnal bunt resistance in bread wheat

Karnal bunt (KB) caused by *Tilletia indica* is an important disease of wheat (*Triticum aestivum* L.) with implications for wheat quality and trade. Identification of PCR-based markers linked to Karnal bunt resistance offers prospect of using marker-assisted selection schemes in developing resistant wheat cultivars. A set of 75 wheat recombinant inbred lines (RILs) developed from a cross between susceptible (WH542) and resistant (ALDAN) genotypes to Karnal bunt were screened for two years with the pathogen populations prevalent in northern India. Parental genotypes were screened with 330 SSR markers out of which 16% showed polymorphism. Analysis of variance revealed significant ($p \leq 0.001$) differences of the disease severity among RILs (G), years and G x E interaction over the two years (2012-13 and 2013-14). The present study detected one consistent QTL (*Qkb.dwr-5BL.1)* across two years which was mapped in the interval *Xwmc235* and *Xbarc140* on chromosome 5B accounting up to 16.9–18.0% of phenotypic variation (Fig. 1.15).

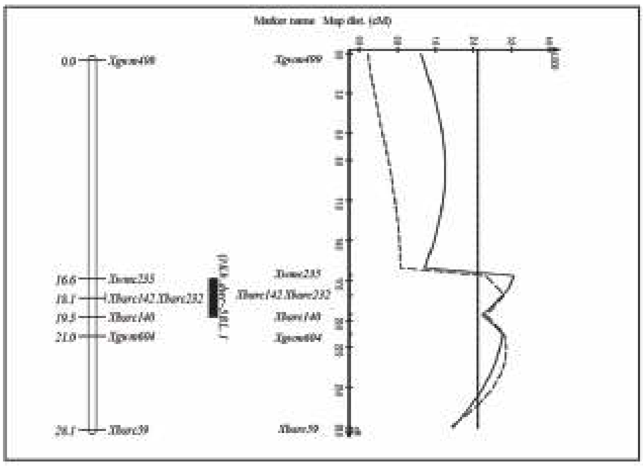


Fig. 1.15 QTL interval map of Qkb.dwr-5BL.1 associated with Karnal bunt resistance in recombinant inbred lines derived from the cross WH542/ALDAN. The maximum LOD score is indicated on the X-axis. The dotted and solid lines represent the respective LOD scores for CIM (2012-13 and 2013-14)

Genetic variability in *Tilletia indica* using rep-PCR fingerprinting

The repetitive sequence based polymerase chain reaction (rep-PCR) was evaluated as a tool to investigate variability among different isolates of *Tilletia indica*. DNA primers (BOX and ERIC) corresponding to conserved repetitive element motifs, originally described in prokaryotes, were used to generate genomic fingerprints of 18 isolates of *T. indica* from different locations of North Western Plain Zone of India. The amplified bands in BOX ranged in length from 600 to 3200 bp whereas for the ERIC, bands ranged from 400 to 3000 bp. A total of 72 bands were amplified of which 70 (97.2%) were polymorphic. The cluster analysis showed that most isolates from the same regions were grouped in the same cluster or a close cluster. However, the isolate, KBJ2 from Jammu was found to be the most distinct from rest of the isolates. The variability found within closely related isolates of *T. indica* demonstrated the effectiveness of rep-PCR markers in identifying genetic diversity of *T. indica* (Fig. 1.16). The results of Principal Component Analysis (PCA) were similar to those detected by cluster analysis. The first two major axis of differentiation (PC1 and PC2) explained 52.98% of the total variation.

Validation of an allele-specific marker (ASM) associated with drought stress tolerance in wheat accessions

Development of functional markers for useful alleles utilizing DREB genes is crucial for crop improvement strategies. We have developed an ASM for distinguishing drought tolerance in bread wheat. This marker was validated in 21 wheat accessions. Bi-allelic variation with this primer was observed in genotypes IC 36761A, IC 57586, IC 30276A, and IC 28665 (Fig 1.17). On the basis of drought susceptibility index analysis, linear regression between AS-PCR and the phenotypic traits like grain yield, thousand grains weight and grain weight were found to be 1.8%, 41.5% and 20.4%, respectively. The highest correlation was observed between SNP and thousand grains weight.

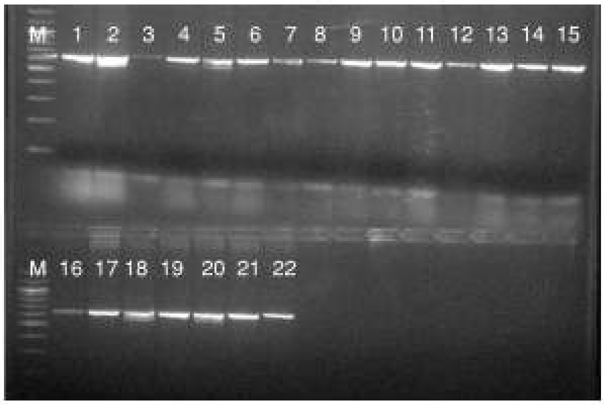
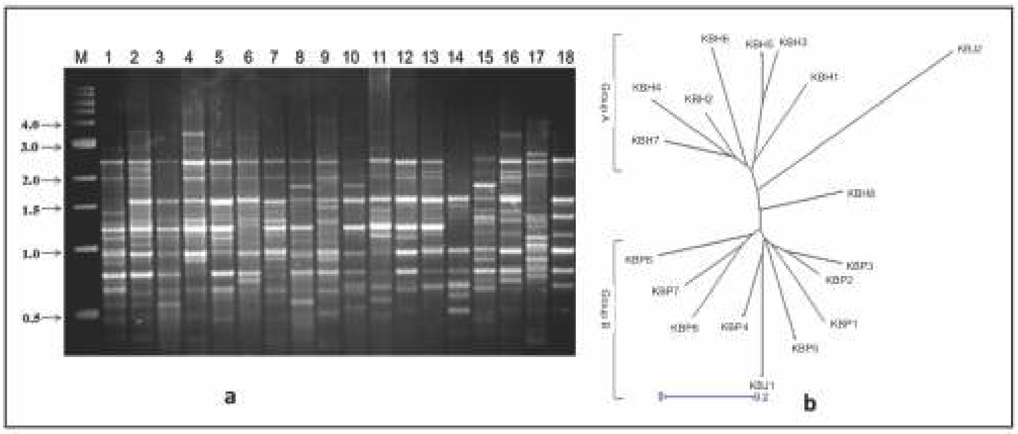


Fig 1.17. Agarose gel representation of SNP derived ASM associated with in 22 Indian wheat landraces assesses for drought tolerance

Legend: Lane 1 IC28661, 2.IC36761A, 3.78753B, 4.IC57985, 5. IC57586, 6. IC41504, 7. IC78869A, 8. IC78856, 9. IC128335, 10. IC31488, 11. IC59572A, 12. IC31488A, 13. IC28938B, 14. IC57889B, 15. IC78872, 16. IC78762B, 17. IC128342, 18. IC30276A, 20. IC28665, 21. IC31405B, and 22 IC78764A. M = Marker



Legend: Lane1- KBH1; 2- KBH2; 3- KBH3; 4- KBH4; 5- KBH5; 6- KBH6; 7- KBH7; 8- KBH8; 9- KBP1; 10- KBP2; 11- KBP3; 12- KBP4; 13- KBP5; 14- KBP6; 15- KBP7; 16- KBP8; 17- KBJ2; 18- KBJ1; M- DNA molecular size marker (1 kbp ladder).

Fig 1.16- a - DNA fingerprint profile of 18 *Tilletia indica* isolates using BOX primer, b- Unrooted neighbour joining tree of 18 Tilletia indica isolates using BOX and ERIC primers

Development of regeneration protocol for Indian wheat genotypes

Wheat transformation through agrobacterium or biolistic method is highly dependent on availability of robust regeneration protocol. Wheat is recalcitrant for tissue culture and lack of reproducible regeneration protocol suitable for different type of explants and genotype is a major hurdle towards an effective wheat functional genomics programme. The transformation work in Indian wheat genotypes is still in primal stage and hence development of reproducible regeneration protocol suitable for Indian wheat genotypes is the need of the hour. At IIWBR an attempt was made to develop a simple, robust and reproducible regeneration protocol for Indian wheat genotypes.

Mature and immature embryos were used as explants in six newly released Indian wheat genotypes (DBW88, DBW90, DBW93, DPW621-50, HD3086 and WH1105). As sterilization is the most significant process in avoiding contamination, the mature and immature seeds were sterilized with 0.1% $HgCl_2$ and 70% ethanol for 3 and 2 minutes respectively. The excised embryos were sterilized with 0.1% $HgCl_2$ and 70% ethanol for 15 seconds. Overall twelve callus induction media (CI 1-12), thirty nine regeneration media (RM1-39) and seven rooting media (RTM1-7) were tested. Out of which, CI6 (MS media containing picloram 2.0 mg/l) for callus induction, RM25 (MS media containing 2,4-D 0.1 mg/l, Zeatin 5.0 mg/l, CuSO4 15 mg/l) for regeneration and RTM1 (half MS without any hormone) for rooting were found to be optimum for all genotypes tested with a regeneration efficiency of 85-90%. The whole protocol from explants sterilization to plantlets hardening took about 48 days (Fig. 1.18). Hence, thus standardized regeneration protocol could efficiently be used in functional genomics studies involving agrobacterium mediated or biolistic transformation for validation of biotic and abiotic stress responsive genes in Indian wheat genotypes.

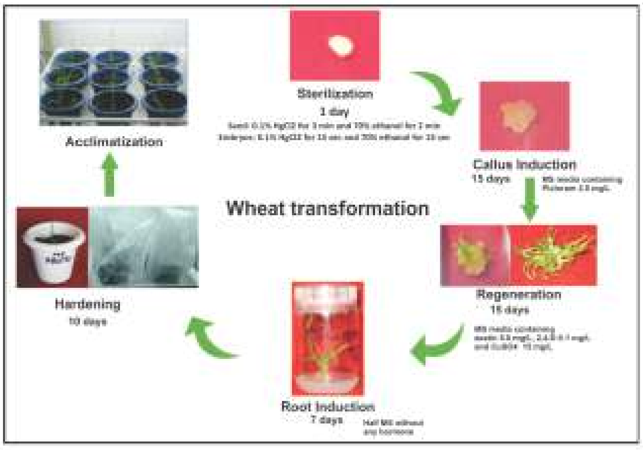


Fig. 1.18 Steps involved in standardization of regeneration protocol and time required for each step

Development of doubled haploids in wheat using wheat x maize system

Breeders make use of different breeding methods to fix and develop homozygous genotypes from different crosses taking around 6-8 years. But by using doubled haploid technique, homozygous lines can be produced in a single generation.

A total of 11374 spikelets were pollinated with maize pollen and a total of 4192 caryopsis were formed in all the varieties (Table 1.55). In case of varieties, caryopsis formation frequency ranged between 25.9 to 51.4%, embryo formation frequency ranged between 4.6 to 22.4% and plant regeneration frequency ranged between 6.4 to 63.6%. Highest caryopsis formation frequency (CFF) of 51.4% was observed in case of variety CBW 38 followed by WH 1105 (48.2%), HD 2967 (46.37), DPW 621-50 (44.54%, DBW 39 (41.7%) and Kharchia Local (25.9%). A total of 646 embryos were excised from the 4192 caryopsis indicating overall embryo formation frequency (EFF) of 15.4% in the varieties. The variety Kharchia local showed highest embryo formation frequency of 22.4% followed by DBW 39 (18.5%), WH 1105 (15.8%), DPW 621-50 (7.4%),

Table 1.55. Caryopsis formation, embryo formation and plant regeneration in wheat varieties

S. No	Variety	Spk. poll.	CF	CFF (%)	EF	EFF (%)	PR	PRF (%)	DH
1	DBW 39	3500	459	41.7	270	18.5	21	7.7	5
2	Kharchia Local	189	49	25.9	11	22.4	7	63.6	2
3	DPW 621-50	1210	539	44.5	40	7.4	17	42.5	-
4	HD 2967	1725	800	46.4	51	6.3	11	21.6	-
5	WH 1105	3050	1470	48.2	233	15.9	15	6.4	1
6	CBW 38	1700	875	51.4	41	4.6	14	34.1	-
	Total	11,374	4,192		646		85		8

Spk.poll – number of spikelets pollinated, CF- no. of caryopsis formed, CFF- caryopsis formation frequency, EF- no. of embryos formed, EFF- embryo formation frequency, PR- no. of plants regenerated, PRF- plant regeneration frequency

HD 2967 (6.3%) and CBW 38 (4.6%). Eighty five haploid seedlings were regenerated from 646 embryos (13.2%). The highest plant regeneration frequency (PRF) of 63.6% was observed in variety Kharchia Local followed by DPW 621-50 (42.5%), CBW 38 (34.1%), HD 2967 (21.6%), DBW 39 (7.7%) and WH 1105 (6.4%). All the haploid seedlings (Fig 1.19) were given colchicine treatment (colchicine 0.1% + 20ml dimethyl sulfoxide + few drops of Tween 20) but only few seedlings got chromosome doubling as depicted from seed set in the treated plants.

Fig. 1.19 Haploid seedlings regenerated after embryo rescue.

Total of nine crosses (Table 1.56) were also used for standardization of doubled haploid induction protocol. The CFF among crosses ranged between 21.4 to 60.52%, EFF ranged between 1.3 to 21.2% and plant regeneration frequency ranged between 9.8 to 44.4%. 934 caryopsis were formed out of 2453 spikelets pollinated (38.1%). The highest CFF of 60.5% was observed in cross PBW 343/HI 1563 followed by other crosses. The PRF was highest for the cross PBW 343/DBW 14 (44.4%) followed by the cross PBW 343/Raj 3765 (42.8%), PBW 343/WH 730 (25.0%), PBW 343/HI 1563 (25%) and HD 2329/Kharchia 65 (9.8%). Plant regeneration was not observed in the crosses PBW 343/HD 2864, PBW 343/K 7903, PBW 343/NIAW 34 and PBW 343/Raj 4037. The regenerated plants were given colchicine treatment resulted in chromosome doubling in few plants. The factors affecting efficient utilization of wheat x maize protocol like embryo formation, induction of haploid embryo, germination by cold treatment and colchicine treatment have been identified. These factors still need to be further investigated for optimum utilization of wheat x maize protocol.

Table 1.56. Caryopsis formation, embryo formation and plant regeneration in F1s of wheat

S. No	Cross	Spk. Poll.	CF	CFF (%)	EF	EFF (%)	PR	PRF (%)	DH
1	PBW 343/DBW 14	415	223	53.7	9	4.1	4	44.4	-
2	PBW 343/HI 1563	152	92	60.5	4	4.3	1	25.0	1
3	PBW 343/HD 2864	70	15	21.4	1	6.6	-	-	-
4	PBW 343/K 7903	176	45	25.6	3	6.6	-	-	-
5	PBW 343/Raj 3765	150	50	33.3	7	14.0	3	42.8	-
6	PBW 343/NIAW 34	270	130	48.1	2	1.5	-	-	-
7	PBW 343/WH 730	210	66	31.4	8	12.1	2	25.0	-
8	PBW 343/Raj 4037	190	72	37.9	1	1.3	-	-	-
9	HD 2329/Kharchia 65	820	241	29.4	51	21.2	5	9.8	1
	Total	2453	934		86		15		

2. CROP PROTECTION

The major thrust areas of Crop Protection are: crop health monitoring (pre and post harvest), distribution of rust pathotypes, host resistance, rust resistance genes postulation and 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 programme, evaluation of disease/pest screening nurseries was undertaken at various hot spot locations under natural and artificially inoculated conditions. The major nurseries were: IPPSN, PPSN, EPPSN, MDSN, MPSN, and disease/pest specific nurseries.

The Initial Plant Pathological Nursery (IPPSN), with 1534 entries and Plant Pathological Screening Nursery (PPSN) with 511 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, flag smut), EPPSN, MDSN, MPSN and the evaluation against nematodes and insect pests. AVT entries were also evaluated at specific locations for Race Specific Adult Plant Resistance (APR) to three rusts (brown, black and yellow). Slow rusting lines for different rusts were identified by calculating the Area Under Disease Progress Curve (AUDPC) at Karnal (stripe rust) and Mahabaleshwar (leaf & stem rusts) centres.

Rust resistance materials in AVT II and I Year (2013-14) with ACI upto 10.0 are given below:

Stem, leaf and stripe rusts: HI 8737 (D), PBW 681, DBW 129, DBW 95, DDW 30 (D), HD 4728 (D), HD 4730, HI 8750 (D), HI 8751 (D), HPW 373, HPW 411, HS 593, HUW 661, K 1204, PBW 677, PBW 697, PBW 703, PBW 723, TL 2995, TL 2996, TL 2998, TL 2999, TL 3000, UAS 451 (D), VL 1003 and VL 3004.

Stem and leaf rusts: BRW 3723, DBW 107, DBW 110, DDK 1042, HD 3118, HUW 666, NIAW 1994, PBW 689, VL 967, DBW 128, DBW 154, DDK 1044, DDK 1046, GW 451, GW 455, HD 2932 + *Lr19*/*Sr25*, HD 3128, HD 3132, HD 3133, HD 3146, HPW 400, HPW 401, HPW 410, HS 547, HS 577, HS 595, HUW 675, HUW 677, HUW 679, MACS 5031, NIAW 2030, PBW 701, PBW 704, PBW 706, UP 2864, UP 2891, VL 1004, VL 3005, VL 976 and VL 977.

Leaf and stripe rusts: UAS 446 (D), WH 1129, HD 2932+*Lr19*/*Sr25*, HI 8755 (D), HS 590, HS 592, HS 594, PBW 695, PBW 698, PBW 722 and TL 2997.

Stem and stripe rusts: K 1217, MACS 3916 (D), PBW 692 and VL 3002.

Seedling resistance in wheat genotypes

AVT's lines of wheat were evaluated against different pathotypes at DWR Regional Station, Flowerdale, Shimla. A wide spectrum of pathotypes of black rust (*Puccinia graminis tritici*), brown rust (*Puccinia triticina*) and stripe rust (*Puccinia striiformis*) of wheat, having different avirulence/virulence structure were used. Resistance to all the rusts was observed on PBW 703. All the wheat lines possessing *Sr*31 resistant to black rust, whereas those possessing *Lr*24 and some with *Lr*26 were resistant to brown rust. Some of the lines with *Yr*9 were resistant to stripe rust pathotypes.

Resistant to brown and black rusts: HI 1544, HI 1563, UP 2891 and HUW 677.

Resistant to brown and stripe rusts: PBW 681, PBW 697, PBW 698, PBW 722 and PBW 723.

Resistant to stripe rust: PBW 660, HD 3128, HD 4728, HPW 411, HS 592, HS 593, HS 594, HUW 675, HUW 693, HW 1099, K1204, MACS 3927(D), PBW 692, PBW 701, PBW 702, VL 1003, VL 1004 and VL 3002.

Resistant to brown rust: HD 2864 HD 3133, CG 1010, GW 451 and GW 455.

Resistant to black rust: All the lines possessing *Sr31*, HPW 401, HPW 410, HS 547, TL 2942, TL 2969, TL 2998, TL 2999 and TL 3000 were resistant to black rust.

Based on rigorous screening of multiple diseases screening nursery at multilocations, following genotypes have been identified for multiple disease resistance:

Resistant to all three rusts + Karnal bunt + Flag smut: PDW 329 (D)

Resistant to all three rusts + Leaf blight + Flag smut + Powdery mildew: TL 2978 (T)

Resistant to all three rusts: GW 1276 (D), HD 3098, PBW 670, Raj 4270, and VL 971

Resistant to stem and leaf rusts: GW 433, GW 1280 (D), HD 3076, HI 1584, HW 5216, KLP 402, KRL 327, MP1259, MP 3353, Raj 4238, Raj 4240, Raj 4245, UAS 336, UP 2824, UP 2825, UP 2828, UP 2852 and VL 971.

Resistant to leaf and stripe rusts: AKDW 4749, HD 3065, HD 3075, HD 3077, HD 3081Q, HD 4725, HI 1579, HI 8626(d), HPW 368, HS 557, MACS 3828, PBW 658, RW 3705, VL 972 and WH 1105

Resistant to stem and leaf rusts + Leaf blight + Flag smut + Powdery mildew + Karnal bunt: HW 1098

Resistant to leaf and stripe rusts + Leaf blight: HS 526, NIAW 1846

Utilization of resistance sources through NGSN

A total of 41 entries known for confirmed sources of multiple disease and insect pests resistance were contributed in the NGSN, 2013-14. They were planted at 22 breeding centres across different agro climatic zones of country for their utilization in breeding programme against various biotic stresses. All entries were utilized in the range of 4.1-37.5 % by most of the breeding centres. The most utilized entries at many centres were DBW 58, HD 3058, HI 1572, HPW 360, HS 534, HS 545, HUW 640, KRL 304, MACS 3828, MP 3288, MP 3304, NW 5013, PBW 648, PBW 658, RSP 561, UAS 320, VL 941 and WH 1095. The Sagar centre, utilized 24 entries in their breeding programme followed by Kanpur and Vijapur.

Preparedness to combat Ug99

For identifying Ug 99 resistance in Indian wheat material, Indian wheat advance lines as well as popular cultivars and registered genetic stocks were evaluated in Kenya since 2005. Indian wheat advance lines (221) were evaluated at Kenya and Ethiopia for resistance against Ug99, as a part of our strategy to meet the threat in case this pathotype. is able to enter India. Following genotypes evaluated at Ethiopia and Kenya during 2013 were categorized resistant (Coefficient of infection upto 10.00).

Wheat lines resistant to Ug99 in Ethiopia: CoW (W), HD 2864, HI 1563, HW 2044, HW 5216, MACS 6222, MP 4010, NIAW 1415, Raj 4229, Raj 4238, GW 432, HD 3090, HD 3093, HD 3096, HI 1584, HUW 652, HW 5224, NIAW 1689, Raj 4240, Raj 4270, TL 2978 and UP 2825.

Wheat lines resistant to Ug99 in Kenya: DDK 1009, HI 1500, HI 8498, HI 8627, HI 8713, HPW 360, HW 1098, HW 2044, K 8027, MACS 2971, MACS 3828, MACS 3828, MP 3336, MPO 1215, NIDW 292 (d), PDW 291, PDW 314, UAS 428, WHD 948, HI 8728, VL 971, HI 8728 (d), HI 8726 (d), GW 1277 (d), HI 8725 (d), GW 1276 (d), HI 8724 (d), UPD 93 (d), MPO 1255 (d), HI 8725 (d), PDW 329 (d), HI 8724 (d), AKDW 2997-16 (d), MACS 5008, DDK 1042, GW 1280 (d), HI 8730 (d), TL 2978, MACS 3817 (d), HI 8731 (d), HI 8728 (d), K 1016, UAS 439 (d), HS 557, AKDW 4749, MPO 1262 (d), MACS 5012, MACS 5022, HI 8727 (d), PDW 327 (d), DBW 88, RKD 219, PBW 675, VL 975, WHD 950 and GW 1280 (d).

During 2005 screening at Kenya, out of 22 lines, three genetic stocks, FLW 2 (PBW 343 + *Sr* 24), FLW 6 (HP 1633 + *Sr* 24) and FLW 8 (HI 1077 + *Sr* 25) were found resistant alongwith HW 1085. Subsequently 102, 318, 420, 241 and 189 lines consisting of elite advance lines, alongwith released varieties were evaluated in 2006, 2008, 2009, 2010 and 2011, respectively in Kenya and Ethiopia against stem rust (*Puccinia graminis f. sp. tritici)* pathotype Ug99 and its variants. Wheat lines *viz*., A-9-30-1, AKDW 4021, DDK 1037, DDK 1038, DDW 14, DL 153-2, Dolma, GW 1250, HD 2781, HD 3014, HD 4720, HDR 77, HI 8381, HI 8498, HI 8880, HI 8882, HI 8890, HI 8892, HI 8894, HI 8898, HI 8899, HUW 234, HW 5211, K 9107, MACS 1967, MACS 2846, MACS 2988, MACS 2998, MACS 3742, MACS 5009, MPO 1215, NDB 1173, NDB 209, NDW 1020, NDW 940, NI 5439, NIDW 295, PBW 315, PBW 612, PDW 274, PDW 316, PDW 317, RSP 561, Sonu, *Sr* 22, *Sr* 32, *Sr* 35, *Sr* 39, *Sr* 42, TL 2942, TL 2963, TL 2966, VLB 1, VLB 856 and WH 147 showed resistance (coefficient of infection upto 10) against Ug 99 and its variants based on evaluation at Kenya and Ethiopia. Above lines identified may be utilized for improving Ug 99 resistance in popular Indian wheat cultivars.

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, Kullu), Nilgiri hills (Tamil Nadu) and J & K (Ladakh). Advisory for stripe rust management was issued during December-March regularly. Information on wheat crop health was disseminated through the "*Wheat Crop Health Newsletter*", Vol. 19(4 issues). Mehtaensis Vol. 34, No. 1 and 2 was issued in January and July, respectively. This crop year marked with the sporadic appearance of yellow (stripe) rust in some pockets of Northern India. Though the yellow rust was observed in early January 2014, however, due to the resistance in cultivated varieties as well as pro active steps for the management, it could be managed well. Black (stem) rust of wheat was observed in May, 2014 on indigenous wheat material planted at Bhowali, Hawalbagh and Pantnagar (Uttarakhand) and in wheat fields from Nashik and Dhule districts of Maharashtra during 2nd fortnight of March, 2014. Except for the yellow rust in NHZ and NWPZ, the overall crop health status was satisfactory in the country.

Stripe rust: Stripe rust was observed 1st time on January 1, 2014 in village Ratangarh in Yamunanagar district of Haryana on variety WH 711. Upto February, 2014, stripe rust was observed at 40 farmers fields in 25 villages in Yamunanagar, 15-20 farmers fields in Karnal, five villages (Darba, Paniwala Mota, Bhagsar, Audhan and Bara Gurha) in the periphery of 5-10 km in Sirsa (small foci of yellow rust in the range of 20-30S) and one village in Ambala. The disease was observed on wheat varieties, WH 711, HD 2932, HD 2851, HD 2967, DPW 621-50, Shri Ram 271, DBW 16, DBW 17 and Barbat. In Sirsa, in the stripe rust infected fields, the farmers have planted the varieties HD 2851, WH 147 and PBW 343. By March stripe rust spread was also in other districts but timely application of chemicals controlled its further spread. In Punjab, stripe rust was observed on var. HD 2967 and PBW 550 in villages, Dabkheraupralla (Roop Nagar) and Bare Bajwara (Hoshiarpur) on January 6, 2014. During February-March, the disease spread to Mohali, Gurdaspur, Ludhiana, Amritsar, Fatehgarh Sahib, Patiala and Bhatinda but timely application of chemicals controlled its further spread and there was no significant loss. In Jammu region, stripe rust was observed in village Tahlar, Zone Arnia, RS Pura in variety. DPW 621-50 on January 21, 2014. During last week of February, the disease was observed in Udhaywalla, Marh, Chinor, Akhnoor, Jammu, RS Pura, Bishna (Jammu district) and Vijaypur (Samba District) with 5 to 60 per cent intensity. Varieties viz. PBW 343, Sonalika, WH 711, PBW 550, PBW 175, RAJ 3077 and RAJ 3765 were infected with yellow rust (20-80 per cent severity) in affected fields but varieties *viz*., DPW 621-50 and HD 2967 were affected upto 20% severity. In other areas of Samba and Kathua districts, yellow rust was less (severity and intensity). In western UP, stripe rust, leaf rust, powdery mildew were observed in last week of March and 1st week of April in Western UP on most of the varieties grown.

On 17.1.2014, stripe rust was noticed in TPN (Kharchia mutant) and SAARC (Agra Local) nurseries including infector rows planted at Dhaulakuan, Himachal Pradesh. The disease spread to other districts, Mandi, Una, Hamirpur, Bilaspur by 1st week of February. The stripe rust was observed in traces in areas such as Chandpur, Majari, Bassi Dabt, Auhar, Bhaani, Reshikesh, Luharwin and Tikkri in Bialspur district in 2nd fortnight of March. The stripe rust in patches was observed in districts *viz*., Hamirpur, Kullu, Mandi, Sirmour, Shimla, Solan, Una and Kangra. In April, 2014, stripe rust was recorded in severe form on susceptible wheat varieties *viz*., HPW 251, VL 829, VL 616, HS 277 (early sown vars), HPW 184, HPW 211, HS 240, VL 738, VL 804, DBW 17, Raj 3765, PBW 343, PBW 502, PBW 550, WH 711, Super 369, Sonak, Kanaku, Local (varietal mixture) (timely sown vars), HPW 42, HS 295, HS 420, VL 892, Raj 3777, Sonalika (late sown vars) etc. at farmers' fields and severity ranged from 40-80S. The stripe rust severity remained comparatively low in foot hills due to warmer climate/rise in temperature in March-April and the wheat varieties *viz*., HPW 236, HPW 211, HPW 249, VL 829, VL 616 etc. which succumbed to stripe rust in mid hills (Bajaura, Malan, Sunder Nagar) recorded less severity 5-20S in foot hill areas (Akrot, Una, Dhaulakuan). Since, the area under resistant varieties has gone up in the state as well as farmers have become vigilant against stripe rust and spraying their crop with propiconazole at the appearance of yellow rust so, the overall severity of yellow rust remained moderate not causing much loss to the wheat crop. In 2nd week of June, yellow rust was observed in Kullu areas In village Bhalayani, yellow rust severity was more (60-80S). During June 20-22, 2014, no rust was observed in wheat crop in Leh (Ladakh).

Stripe rust (traces) was observed in last week of February in Khatima block of Udham Singh Nagar (Uttarakhand) on varieties PBW 343, PBW 502, HD 2967, PBW 550 and DPW 621-50. On May 19, 2014, heavy infection of all three rusts was observed on most of the collections planted at Bhowali (Uttarakhand). Surprisingly, there was high (60-80S) stem rust infection on about 50 % of the collections.

Leaf rust and stem rust: In Kullu area, leaf rust was also observed but most of the pustules are converted in to teliopustules. Leaf rust with severity 20-60S was recorded at few locations viz. Una, Nalagarh, Kunihar, Malan, Kangra etc. Flag smut with incidence ranging from 3-11% was recorded at some locations in foot and mid hill areas. Leaf rust in TPN nursery was observed on 22nd January in varieties WL 711(TS), C 306 (5S), and Agra Local (TS) planted at Pune. By 3rd February, it spread on more varieties and ARI germplasm viz. WL 711, HD 2329, Agra Local. Lal Bahadur, C 306, WH 147, HD 2160, BARI 82, BARI 102, Kenphad 25 and *T. sphaerococuum* and level on infection increased and severity varied from TS to 40S. Leaf rust was also observed in ARI germplasm nursery on varieties viz; Bari-82, Bari-102, Gulab, Kenphad 25 and *Tritium sphaerococcum* with severity ranging from 5S to 40S. No natural incidence of black rust was observed under field condition as well as Trap plot nursery till February 28, 2014. Incidence of foliar blight was observed in many varieties viz; Agra local, Lal Bhahdur, Bijaga yellow, A 206, NI 146, Lok-1, Gold 21, ARI breeding material etc. with severity ranging from 12 to 79. Some traces of stem borer were observed in late sown crop at Hol farm. On Feb. 6-7, natural incidence of leaf rust was observed on varieties DWR 162 and off type mixtures in MACS 6222 with severity ranging from 30S to 60S. On Jan. 13, leaf blight was observed in varieties, Kharchia mutant, Bijaga Yellow, A 206, NI 973 and NI 146 at ARI, Pune. On 30th Jan., leaf blight was observed at farmers fields on varieties, Gold 21 and Gold in villages Sakharwadi and Phadtarwadi (Satara). Laf rust (TS-40S) was observed in off types plants at farmers fields in Western Maharashtra during 2nd fortnight of February. The first natural incidence of leaf rust was observed in Wheat Disease Monitoring Nursery on Lal Bahadur variety on 2/2/2014, which increased upto 80S on Feb. 26, 2014. The incidence of stem rust was not seen in the nursery till Feb., 28, 2014. Out of 20 genotypes in TPN, only HD 2329, HD 2160, HW 2021, HD 2204, C 306, HW 2008, DL 784-3, MACS 2496 and HW 971 were free from leaf rust. Incidence of stem rust has not been observed on the surveyed farmers fields in Nasik district. Survey was undertaken for wheat crop health status in Nasik district on 11/3/2014 and 13/3/2014 by Dr. B.C.Game, ARS, Niphad. Stem rust in farmers field was not noticed. Leaf rust was recorded for the first time in two fields on variety LOK-1 at Jopul village (Dindori Tahsil, Dist.Nasik). In Dindori Tehsil, leaf rust severity was recorded upto 80S on Lok-1 and other susceptible off-types. Incidence of stem rust was found in two fields, first field of Lok-1 and in second field on off-types from Mohadi and Korhate villages. During first fortnight of March, leaf rust upto 60S was reported in farmers fields of western Maharashtra and Marathwada region. Stem rust severity upto 40S was observed in wheat fields from Nashik and Dhule districts of Maharashtra during 2nd fortnight of March, 2014. Leaf rust and stem rust incidence was recorded in trap plot nursery planted at IARI Regional station, Indore on 12.3.2014. Leaf rust was observed in range of 5MR to 80S and stem rust (TR-50MS) on the test varieties in trap plot nursery. In Central Zone, leaf rust in off types in farmers fields of Jabalpur was observed on the way from Kota to Sawai Madhopur. In North Eastern Plain Zone, brown rust was also observed in Kharchia (TPN) at Araul at Dalipnagar on 24th Feb., 2014.

Powdery mildew, flag smut and loose smut: Powdery mildew with high intensity/severity up to 8 (on 0-9 scale) was recorded on susceptible varieties at some locations, otherwise, its overall intensity/severity remained low to moderate (3-5) during current *rabi* season. Loose smut was also observed at some places but incidence was very low. Flag smut with incidence ranging from 3-11% was recorded at some locations in foot and mid hill areas in Una, Nalagarh, Kunihar, Malan, Kangra etc..

Insect pests: The termite damage in wheat fields remained moderate throughout the crop season in Rajasthan. Population of brown wheat mite was medium and noticed later on at ear head stage of the crop. The attack of pink stem borer in wheat was also observed. The incidence of *Spodoptera litura* and *Helicoverpa armigera* was very low but widespread. In Maharashtra, heavy aphid population in Nasik district were observed. The severity of damage was recorded up to 5 to 35 per cent. In Punjab, sporadic incidence of termites was observed in District Faridkot. Moderate to severe incidence of wheat aphid was observed in some villages of Mukatsar (Chakdiwala), Ferozepur (Sarenaga & Sekha Kalan) and Moga districts. Minor incidence of pink stem borer was observed in some parts of Nawanshahr district. Low level of root aphid incidence was also observed in few fields in KVK, Bahowal and adjoining areas. In Haryana, moderate to severe incidence of wheat aphid was observed in some villages of Karnal (Bastli), Kaithal, Jind and Hisar. Moderate termite damage was recorded in some parts of Karnal (Basthali) and Kaithal (Batta). In Shillongni, sporadic infestation of cutworm was observed.

Nematodes: In Haryana, cereal cyst nematode (CCN) was reported in 41.4% (24/58) samples. Other soil borne plant parasitic nematodes reported were *Hoplolaimus* (12 %), *Tylenchorhynchus* sp. (52%), *Helicotylenchus* sp (7%) and *Pratylenchus* sp. (24 %). In Punjab, *H. avenae*, species of *Meloidogyne, Tylenchorhynchus, Hirschmanniella, Helicotylenchus and Hoploloaimus*. *H. avenae* cysts were recorded from Moga (District Moga), Kotkapoora (District Faridkot), Aulakh, Chibranwali (District Muktsar), Abohar and Fazilka (District Fazilka). In Rajasthan, CCN infestation was recorded from 18 districts of Rajasthan. Sangaria, Tibbi, Rawatsar, Nohar and Bhadra Tehsils of Hanumangarh district known as grain bowl of state (adjourning to Haryana) were heavily infested with "Molya Disease". In Bihar, nematological survey of wheat fields was conducted at 15 places in three districts namely Samastipur Muzaffarpur and Vaishali. The stunt nematode (*Tylenchorhynchus nudus* + *T. mashoodi*) was the predominant population (41.50%) followed by lesion nematode, *Pratylenchus* spp. (26.5%), lance nematode (*Helicotylenchus indicus* + *H. dihystera*, 6.5%) and root-knot nematode (5.7%).

Stripe Rust Management

Stripe rust awareness among farmers was created by organizing Farmers' Fair in collaboration with State Department of Agriculture, Yamunanagar at Bilaspur (Yamunanagar) on September 25, 2013 and more than 2500 farmers attended the fair. On September 28, 2013, one Kisan Mela was organized at Kaithal and stripe rust management cards were distributed among the farmers. Farmers Innovator and Seed day was organized at IIWBR, Karnal on October 15, 2013 in which farmers were apprised of the strategies enhancing wheat production including crop production and protection technologies with emphasis on stripe rust management. Preventive steps were taken by DWR (ICAR), DAC and State Departments. Strategy meeting was organized by DAC on Oct 5, 2013 in Panchkula (Haryana) for stripe rust management. Strategy meeting were also organized in Dehradoon and Jammu in October, 2013. A meeting was organized by DAC, Ministry of Agriculture, Govt. of India at Una (HP) on January 8, 2014 for stripe rust management in NWPZ and NHZ. Advisory for stripe rust management was issued by DWR, Karnal on December 17, 2013, January 2, February 3 and March 3, 2014.

Impact of strategies to combat stripe rust of wheat

Though, stripe rust was occurring in India since long, it was in the year 2001 when a new virulence was detected on PBW 343. With the increase in area under PBW 343, eventually the stripe rust spread to large areas (approx. 3mha) in 6 states (Himachal Pradesh, Jammu region of Jammu and Kashmir, Punjab, Haryana, Uttar Pradesh, Uttarakhand). Due to its high intensity in some years resulting in losses to farmers, led to the formulation of a strategic plan during 2010-11 to limit its occurrence below threshold levels of economic losses. Major emphasis was on bringing in farmer's awareness in replacing susceptible varieties with resistant ones, early detection of the rust, identifying initial foci of infection by regular monitoring of crop after 40 days of planting and immediately spraying the crop with fungicides to limit its spread. Special cards were devised for the awareness to farmers and circulated in large numbers in all the affected areas. Every year strategic planning meetings were held under the chairmanship of Secretary, Department of Agriculture and Cooperation, Government of India, for enhancing wheat production and stripe rust management. Advisories were issued as and when the disease was detected with major emphasis on advising farmers for frequent visits in their fields and making available the recommended fungicide (Propiconazole). Extensive training programmes were organized for the officers' of Department of Agriculture, scientists and farmers of affected areas. In high disease prone areas TRAP nursery/advanced varieties trials were planted for early detection of stripe rust/identifying resistant varieties. To create genetic diversity at farmers' field, several stripe rust resistant varieties viz., HD 2967, WH 1105, HD 3086, DBW 88, HD 3059, WH 1021, WH 1080, HD 3043, DBW 71, DBW 90, HS 507, HPW 349 and HS 542 were released. A gradual decline in stripe rust occurred in disease prone states since 2011 due to awareness to farmers leading to drastic decline in area under susceptible varieties, and replacement with resistant varieties viz., PBW550, DPW 621-50, HD 2967, HD 3059, HS 490, VL 829, VL 892, VL 907, PBW 590 in large areas, feedback from farmers of its early detection and timely spraying with fungicide. In the year 2013-14 though the disease was first detected in 1st week of January coupled with favourable environmental conditions throughout the season the disease did not spread to large areas and furthermore its intensity also remained low avoiding losses to the tune of about 3 million tones.

SAARC Wheat Disease Monitoring Nursery

The nursery was planted at 27 locations in India, Bangladesh, Afghanistan, Nepal and Bhutan.

Fusarium head blight or head scab

Management of head scab with bioagents

In order to test the disease suppressive effects of bioagents in reducing the head scab infection on wheat, wheat variety, PDW 291 was selected. Mass culture of *Trichoderma* isolates and *Fusarium* spp./isolates were raised on potato dextrose broth at 25±2°C for 2 weeks. The mycelial mat with spore were harvested from flasks, blended and filtered through 3-layered muslin cloths. Final spore conc. of *Trichoderma* isolates and *Fusarium* spp./isolates were diluted to 1×10^{9} spore/ml and 1×10^{4} spore/ml. respectively using sterilize distilled water. Experiment was conducted in plastic pots in polyhouse in three replications along with control (No treatment with bioagents). Spikes at early anthesis (3 day before *Fusarium* spp./isolates inoculation) were sprayed by spore suspension of bioagents in different treatments (Table 1). *Fusarium* spp./isolates were inoculated by placing a tiny tuft of cotton soaked with the inoculum (1×10^{4} spore/ml) in a floret of the middle spikelet at mid anthesis (After 3 days of bioagent spray) in Feb. 2014. Proper temperature and humidity were maintained in polyhouse. Infected spikes and spikelets were counted after 21 days of inoculation and disease severity was calculated as the proportion of scabbed spikelets /infected spike. Per cent disease control = (% spikelet or spike infection in check - % spikelet or spike infection in treated) x 100 / % spikelet or spike infection in check. Bioagents either used as seed treatment or spray resulted in head scab control as compared to untreated control (Table 2.1).

Inheritance of resistance to Fusarium Head Blight (FHB) in wheat variety, HD 2967

For incorporation of FHB resistance into a recently released high yielding wheat cultivar 'HD 2967' crosses were made with 'Sumai-3', 'Frontana' and 'Aldan' during 2012-13 crop season. The F_1' from these crosses were raised at off-season nursery at Dalang Maidan

Table 2.1. Efficacy of different bioagents against FHB of wheat variety PDW 291 under poly-house conditions during 2013-14

Treatment	% Spikelet infection			Per cent disease control
	7 DAI	14 DAI	21 DAI	
Pseudomonas fluorescens (seed treat.)	20.35	48.5	60.77	37.99
Trichoderma harzianum (P) (soil treat.)	15.33	43.15	65.07	33.60
Trichoderma harzianum (M) (soil treat.)	19.35	38.04	60.72	38.04
Trichoderma virens (soil treat.)	17.79	38.81	62.78	35.94
Gliocladium spp. (soil treat.)	22.62	51.33	63.6	33.72
Gigaspora spp. (soil treat.)	21.12	61.95	72.79	25.72
B. subtilis (spray)	14.46	40.8	60.73	38.03
B. amylofaciens (spray)	14.34	31.45	66.09	32.56
Tv (spray)	24.33	48.17	66.64	32.00
Th-M (spray)	23.75	42.94	66.93	31.70
Tebuconazole(0.075%)	0	16.7	26.06	73.41
Control	42.09	76.33	98	-

during summer 2013. The F_2 plants from the crosses HD 2967/Sumai-3 (120), HD 2967/Frontana (70) and HD 2967/Aldan (75) were planted under controlled polyhouse conditions during 2013-14 crop season at Karnal. Cotton web technique of creating infection was used to create disease epiphytotics on all the three populations. Disease score was recorded to identify resistant, moderately resistant and susceptible plants. The genetic ratios for resistance to FHB indicated a complex nature of resistance in all the three donors.

Karnal bunt

Pathogenic variation in *Tilletia indica* isolates on host differentials

Pathogenic variability in *T. indica* was studied by inoculating 10 isolates (collected from different places of Haryana) on a set of 13 wheat differentials (DBW 88, HD 2967, WH 1105, Raj 3765, PBW 343, WL 711, DDK 1009, PBW 502, HD 2009, HD 29, WL 6975, W 485, HP 1531) during 2013-14 crop season at DWR Karnal. Coefficient of infection (CI) and KB incidence indicated the variation in *Tilletia indica* isolates at pathogenic level used in present study.

Isolation of *Tilletia indica* isolates and development of monosporidial lines

Thirty nine monosporidial lines were developed from single primary sporidia of *T. indica* infected grain of HD 2967 (Karnal). All lines were inoculated on two susceptible wheat genotypes, WL 711 and WH 542. Out of 39 monosporidial lines inoculated on above varieties, there was no infection with 17 lines. Hence these 17 lines were truly monosporidial lines. Compatibility among monosporidial lines was studied by inoculating different combinations of monosporidial lines on two varieties, WL 711 and WH 542.

Post harvest analysis

Karnal Bunt and black point

A total of 8900 grain samples collected from various mandies in different zones, were analyzed for Karnal bunt (KB). The highest KB incidence (83.98%) was recorded from UP followed by Haryana (47.99%), Punjab (39.13%), Rajasthan (30.13%) and Uttarakhand (24.67%). In MP, out of 294 samples, 6.12 per cent samples were KB infected. Based on the overall KB occurrence, it emerged that the KB incidence this year was less than the previous year. No sample from West Bengal, Gujarat (Vijapur), Maharashtra (Pune) and Karnataka (Dharwad) was found infected with KB. Out of 5717 grain samples analyzed for black point from different zones in the country, 78.95 per cent samples were found black point infected (Table 2.2)

Nematodes

In Rajasthan, out of 761 samples collected from five districts *viz.* Ajmer, Alwar, Dausa, Jaipur and Tonk, 118 were found infected with ear cockle nematode (ECN). Highest infestation (30.30%) was recorded from Kishangarh of Ajmer District followed by Devli (24.00%) of Tonk District. In Punjab, out of 1919 wheat grain samples, none of the sample showed incidence of ECN. In Bihar, out of 150 samples collected from Samastipur, Muzaffarpur and Vaishali, none was found infected with ECN.

Table 2.2. Karnal bunt situation in the country during 2013-14 crop season

State	Total samples	Infected samples	% infected samples	Range of infection
Punjab	1919	751	39.13	0.07 - 2.56
Haryana	1769	849	47.99	0 - 5.25
Rajasthan	720	217	30.13	0 - 2.15
Uttarakhand	2845	702	24.67	0 - 10
Himachal Pradesh	381	114	29.90	0 - 1.8
West Bengal	14	0	0	-
U.P.	256	215	83.98	0 - 9.3
M.P.	294	18	6.12	0 - 2.40
Gujarat	490	0	0	-
Maharashtra	112	0	0	-
Karnataka	100	0	0	-
Total	8900	2866	32.20	0 - 10.00

Evaluation of wheat genotypes for insect pest resistance and management

Among AVT lines, none of entry was resistant to shoot fly, aphids, root aphids and brown wheat mite. Two genotypes [NIAW 1415 (C) and A 9-30-1 (D) (C)] showed moderate resistance (>10%) to shoot fly. Genotypes, NW 3069, MACS 6221, VL 924, PDW 315, PDW 317, DBW 46, HPW 308, HPW 309, HI 8692 and WH 1076 have shown moderate resistance to brown wheat mite. Genotypes, NIAW 1994, NIAW 1885, K 1006 (I) (C), DBW 107, WH 1138, HD 2932+*Lr19/Sr25*, KB 2012-03, PBW 723, UAS 451 (D), PBW 692, HD 3128, VL 1004 and VL 3002 were found moderately resistant to root aphid.

Imidacloprid 600 FS (Gaucho) @ 0.72 g a.i. /kg seed was identified quite effective for the control of termite damage and improving yields. Propargite 57 SC (Omite) @ 1.5 ml/l of water was very effective for brown wheat mite management. The foliar application of Pride (Acetamiprid 20SP) @ 20 g.a.i./ha was found to be quite effective for the management of foliar aphids in wheat. The results of initial studies on stored grain pest indicate that emamectin benzoate (Proclaim @40.0 mg/kg) and spinosad (Tracer 4.4 mg/kg) as seed protectant were quite effective for the management of wheat stored grain pests.

3. RESOURCE MANAGEMENT

Resource conservation agricultural practices for the sustainability of rice wheat system

Tillage in rice-wheat system

The results from a long term experiment on tillage effects in rice-wheat system indicated that the rice crop was not affected by tillage in wheat but the tillage in rice especially zero tillage transplanting had an adverse effect on rice productivity (Fig. 3.1). 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. In case of wheat crop, it was not affected by tillage in rice but tillage in wheat had some differences in wheat yield. Over the years, except 2012-13, marginally higher wheat yield was recorded in rotary tillage but the differences were not statistically significant.

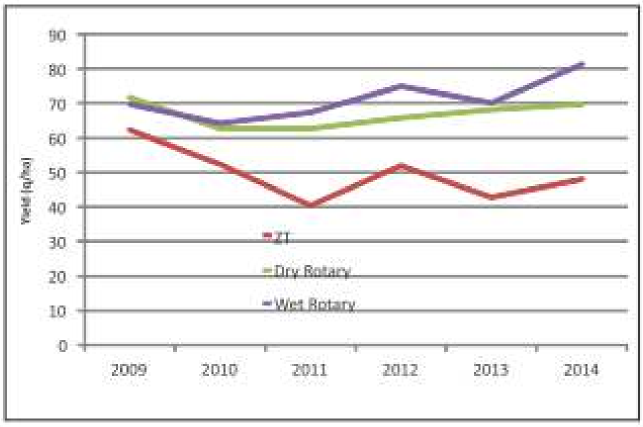


Fig. 3.1. Rice yield under various tillage options

Residue management in wheat productivity

The long term experiment with seven residue management options in main plot and three nitrogen levels in sub-plots showed that the differences due to nitrogen were significant but the effect of residue management options was not significant on wheat productivity. Among nitrogen levels, the highest yield was recorded with 200 kg N/ha which was at par with 150 kg N/ha but significantly higher than the yield at 100 kg N/ha in both the treatments. The yield of direct seeded rice variety Pusa 1509 was significantly lower than the puddled transplanted rice by more than 30% under various residue management options(Fig 3.2).

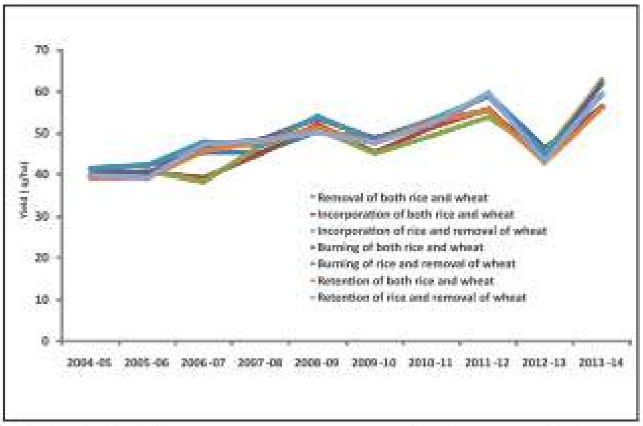


Fig. 3.2.Residue management options in wheat productivity

Residue and irrigation effects on wheat and rice productivity

The experiment with five irrigation schedules in main plots and four surface retained residue loads in subplots showed that the effect of irrigation was significant and lower yield was recorded when only two irrigations were applied but in three or more than irrigation treatments, the yield recorded was similar whch may be due to frequent rains during the wheat crop season. Although the surface residue load and interaction effects were not significant but the surface residue retention favourably affected the wheat productivity when only two irrigations were applied as the yield recorded at 6 t/ha surface residue had yield similar to other irrigation treatments (Fig 3.3). The wheat yield obtained was generally higher where more than 4 t/ha crop residue was retained on the soil surface.

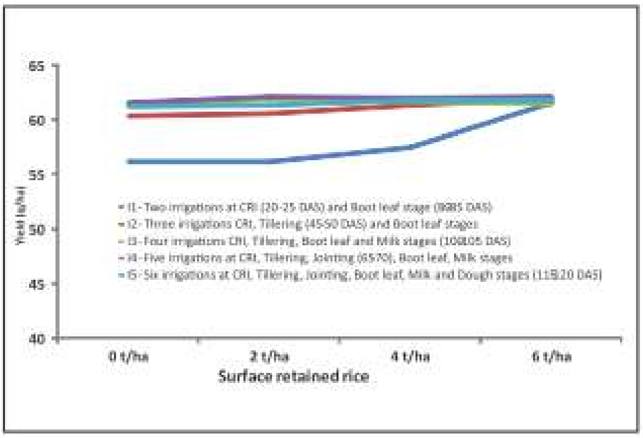


Fig. 3.3. Effect of Irrigation and residue on wheat yield

Tillage effect on wheat yield in farmers' participatory trials

A farmer's participatory experiment with five wheat varieties namely HD 2967, DBW 88, WH 1105, DPW 621-50 and PBW 550 and two tillage options namely zero tillage and conventional was conducted at four locations around Karnal (Fig 3.4). It was obseerved that on mean basis across different varieties, zero tillage gave marginally higher yield than conventional but the difference was not significant. Among varieties PBW 550 gave lower mean yield compared to other varieties, which gave similar productivity. The lower mean yield in PBW 550 was mainly due to its possible sensitivity to water stagnation at two locations where water tended to stagnate due to frequent rains, it gave substantially lower yield compared to others whereas at other two locations all the varieties recorded almost similar productivity.

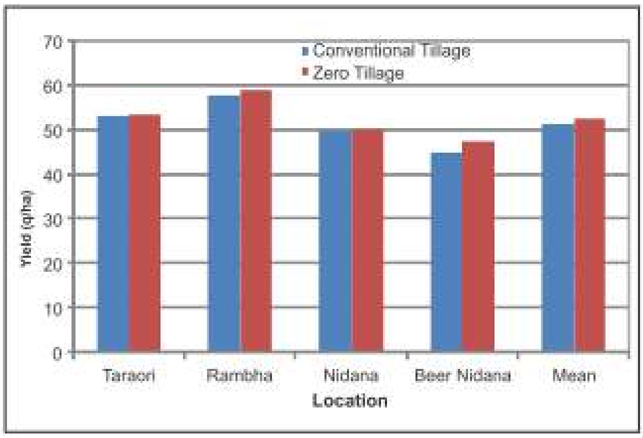


Fig 3.4. Wheat productivity under conventional and zero tillage

Comparative performance of Direct Seeded and Transplanted rice

A field experiment was conducted with two varieties, namely NK 3325- a hybrid varieties and Pusa 1509 a short statured, short duration scented rice variety, to evaluate the comparative performance under direct seeded (DSR) and transplanted (TPR) conditions (Fig 3.5). The nitrogen levels varied from 0 to 300 kg/ha for NK 3325 and 0 to 240 kg/ha for Pusa 1509. In case of NK 3325, the yield increased with nitrogen upto 250 kg N/ha under TPR and upto 300kg N/ha under DSR but the yield levels were very low for DSR compared to TPR. The application of 300 kg N/ha for DSR gave yield similar to 50 kg N/ha applied for TPR conditions. Almost similar trend was observed for variety Pusa 1509 wherein nitrogen reponse was observed upto 120 kg N/ha in TPR and upto 200 kg N/ha in DSR. It was observed that both the varieties of rice were very poor performers under DSR compared to TPR and the yield reduction varied from 28 to 49% for NK 3325 and 26 to 39% for Pusa 1509 under different nitrogen levels.

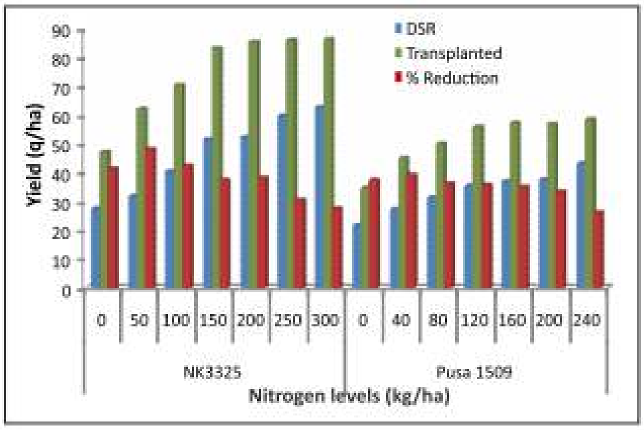


Fig 3.5. Comparative performance of DSR and TPR

Performance of relay wheat in cotton-wheat cropping system

Wheat yield after cotton is generally low due to late sown conditions. An experiment was conducted in collaboration with CICR RS Sirsa at their research farm with four varieties (HD 2967, PBW 550, WH 1105 and DPW 621-50) under different planting options given in the figure 3.6. The highest yield was recorded in treatment where wheat was sown after short duration cotton during the third week of November. Relay planting of wheat in longer duration cotton gave 3-7% higher grain yield, when power tiller was used either to drill or to mix the seed after broadcasting whereas yield reduction up to 7% was observed when dry or soaked seed was broadcasted in the standing cotton. This might be due to poor crop establishement in broadcasting compared to drilling or mixing seed with soil after broadcasting using power tiller.

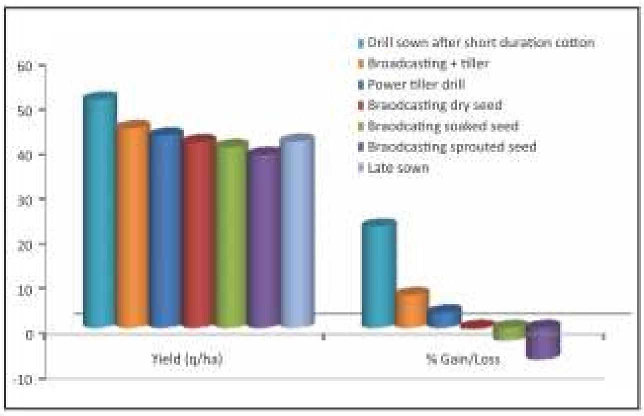


Fig 3.6. Relay wheat in cotton-wheat cropping system

Organic fertilisation in rice-wheat cropping system

This experiment consisting of four released High Yielding Varieties (HYV) of wheat (HD 2967, DPW 621-

50, PBW 550 and WH 1105) and five combinations of organic nutrient supply (control, farm yard manure (FYM) 10 t/ha, farm yard manure (FYM) 20 t/ha, farm yard manure (FYM) 30 t/ha and recommended doses of chemical fertilizers at the rate of 150:60:40 kg/ha N, P_2O_5 and K_2O, respectively) thus making total 20 treatment combinations was conducted in Randomized Block Design with three replications.

The results of this experiment presented in Table 3.1 and 3. 2 revealed that application of farm yard manure (FYM) 10 t/ha to 30 t/ha increased the biomass and grain yield of all the high yielding varieties of wheat significantly as compared to control (no organic or chemical fertilizer) treatment. However, the highest biomass and grain yield of all the high yielding varieties of wheat were recorded in the recommended NPK fertilizers treatment which was significantly higher than all the organic treatments including 30t/ha FYM treatment. Among the high yielding varieties, PBW 550 recorded the highest grain yield (34.36 q/ha) followed by HD 2967 (34.19 q/ha), DPW 621-50 (33.87 q/ha) and WH 11.05 (32.73 q/ha). All the varieties performed similarly at all the organics levels (Table 3.2).

Table 3.1. Effect of organics on biomass of High Yielding Varieties wheat

Treatment/ Variety	Nutrient source					
	Control	FYM 10 t/ha	FYM 20 t/ha	FYM 30 t/ha	Rec. NPK	Mean
HD 2967	62.85	68.75	79.17	88.89	117.36	83.40
DPW 621-50	68.06	73.61	73.61	86.11	106.25	81.53
PBW 550	70.14	61.46	75.69	89.58	104.17	80.21
WH 1105	63.19	52.78	74.65	88.19	101.04	75.97
CD (0.05) (t/ha)			5.56			

Table 3.2. Effect of organics on productivity of High Yielding Varieties wheat

Treatment/ Variety	Nutrient source					
	Control	FYM 10 t/ha	FYM 20 t/ha	FYM 30 t/ha	Rec. NPK	Mean
HD 2967	20.61	29.15	34.49	38.75	47.94	34.19
DPW 621-50	22.55	29.14	33.42	39.15	45.09	33.87
PBW 550	22.84	29.19	34.92	39.30	45.56	34.36
WH 1105	20.70	28.72	33.82	38.04	42.35	32.73
CD (0.05) (t/ha)			2.94			

Integrated Nutrient Management in rice- wheat system

This experiment consisting of 7 combinations [Recommended NPK (T1), T1+FYM15t/ha, , Rec. N only, Rec. P only, Rec. K only, T1+ GM and absolute control] of major and organic nutrients viz. FYM and green manuring was conducted in Randomized Block Design with three replications. Wheat variety DPW 621-50 was grown. The results presented in Table 3.3 revealed that biomass and grain yield were significantly lower where only P or K were applied as compared to all other treatments indicating the significance of nitrogen.

Table 3.3. Integrated nutrient management in wheat (2013-14)

Treatment	Biomass (q/ha)	Grain yield (q/ha)
1. Recommended N only	131.49	50.67
2. Recommended P only	42.95	15.97
3. Recommended K only	44.61	15.80
4. Recommended NPK	134.89	51.73
5. Rec.NPK + FYM 15 t/ha	137.71	53.40
6. Rec. NPK + Green manuring (Dhaincha)	130.52	51.53
7. Absolute control (no fertilizers or manures)	50.79	17.41
CD (0.05)	2.37	1.32

The highest and significantly more productivity (53.40 q/ha) was recorded in treatment where all the major nutrients along with Farm Yard Manure (FYM) 15 t/ha (T5) were applied followed by the treatment (T4) in which all the major nutrients (51.73 q/ha), all the major nutrients as well as green manuring (51.53 q/ha) (T6) and only recommended N (50.67 q/ha) were applied (T1). These treatments being in descending order to each other were significantly higher than where only P or K or no fertilizers or manures (absolute control) were applied.

Improving nitrogen use efficiency with different scheduling in wheat

This experiment of nitrogen scheduling comprising 13 combinations, as mentioned in Table 3.4, was conducted in Randomized Block Design with three replications. Wheat variety DBW17 was grown. The results presented in Table 3.4 revealed that significantly higher yield was obtained when nitrogen was applied in three equal splits (1/3 Basal, 1/3 Tillering, 1/3 Jointing) compared to treatment where nitrogen was applied in four equal splits (1/4 Basal, 1/4 Tillering, 1/4 Jointing, 1/4 Boot 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 (9 to 10 days after irrigation when field was in suitable condition for passing through/ walking) at all the three nitrogen levels.

Table 3.4. Effect of Nitrogen Scheduling on Wheat (2013-14)

Treatment	Biomass (q/ha)	Yield (q/ha)
1. 90 kg N/ha in 3 equal splits (1/3b,1/3T,1/3J) after irrigation	96.83	41.81
2. 90 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) after irrigation	85.71	37.90
3. 90 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) before irrigation	101.59	42.73
4. 90 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) before irrigation	92.46	40.88
5. 120 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) after irrigation	103.57	46.00
6. 120 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) after irrigation	92.46	42.25
7. 120 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) before irrigation	109.52	47.17
8. 120 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) before irrigation	98.02	43.43
9. 150 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) after irrigation	113.10	50.15
10. 150 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) after irrigation	100.79	46.97
11. 150 kg N/ha in 3 equal splits (1/3b, 1/3T, 1/3J) before irrigation	123.41	54.92
12.150 kg N/ha in 4 equal splits (1/4b, 1/4T, 1/4J, 1/4boot leaf) before irrigation	111.90	50.82
13. Control (no nitrogen)	44.05	18.50
CD (0.05)	4.83	2.54

Water Management

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

Experiment conducted to study the water use efficiency of wheat crop at different soil matric potentials under residue retaining at surface and non residue conditions. This experiment consisting of 3 main plot treatments (no residue, residue retaining @ 2.5 ton/ha and residue retaining @ 5 ton/ha) and 3 sub plot treatments (60 kPa, 80 kPa and irrigations at critical growth stages of wheat crop) was conducted in split plot design with three replications. Wheat cultivar HD 2967 was grown. The results revealed that irrigation scheduling at above mentioned soil matric potential produced yield with statistically non-significant difference. However, numerically values shows the difference and maximum yield was recorded with irrigations at critical growth stages (54.98 q/ha) followed by irrigations at 60 kPa (54.73 q/ha) and irrigations at 80 kPa (53.62 q/ha). While, amongst the main plot treatments highest yield were recorded from treatment of no residue retaining (control) which was 55.36 q/ha followed by residue retention @ 5 ton per hectare (54.13 q/ha) and residue retaining @ 2.5 ton per hectare (53.84 q/ha). These results of residue treatment did not show any trend which could be due to fair amount of rainfall (231.8 mm) that too well distributed during the crop season.

Effect of matriconditioning in crop establishment under initial soil moisture deficit conditions

This experiment consisting of 3 main plot treatments (seeding at optimum moisture level, seeding at sub optimal moisture and seeding in air dry soil followed by irrigation) and 3 sub plot treatments (no seed priming, matriconditioning of seed and pre-germinated seeds) was conducted in split plot design with three replications. Wheat variety HD 2967 was grown. Results showed that matriconditioning of seed (52.26 q/ha) produced significantly higher grain yield as compared to dry seed (50.82 q/ha) and pre-germinated seeds (50.15 q/ha). Whereas, among seeding methods, seeding at optimum soil moisture produced significantly higher grain yield (52.26 q/ha) compared to seeding in air dry soil followed by irrigation (50.62 q/ha) and seeding at sub optimum soil moisture level (50.36 q/ha). Matriconditioning of seeds is one of the economic technologies that might result in increasing seed germination and emergence under stress conditions consequently proper crop establishment. The results of experiment showed that matriconditioning of seeds improve germination indices, seedling growth and crop establishment.

Evaluation of wheat yield and water use efficiency under micro-irrigation with various planting methods and zero tillage conditions

This experiment was conducted with wheat cultivar HD 2967 sown by two methods *i.e.* flat sown and raised bed planting under zero tillage conditions. Among irrigation treatments, four irrigation treatments *i.e.* drip irrigation, sprinkler irrigation, drip + rainport and check basin method of irrigation treatments were imposed. Results revealed that maximum and significantly higher grain yield produced under drip + rainport irrigation (55.45 q/ha), followed by drip irrigation (54.75 q/ha), sprinkler irrigation (52.95 q/ha) compared to check basins method of irrigation (50.42 q/ha). Among planting methods both the methods are produced statistically similar yield. However, flat sown method produced numerically slightly higher yield (53.58 q/ha) in comparison of raised bed sown crop

(53.21 q/ha). Maximum and significantly higher water use efficiency was recorded for sprinkler irrigation (1.61 kg m^{-3}) followed by drip + rainport (1.57 kg m^{-3}), drip (1.55 kg m^{-3}) over check-basins method of irrigation (1.21 kg m^{-3}). Among planting methods raised bed sown crop resulted in higher water use efficiency (1.55kg m^{-3}) than flat sown crop (1.43 kg m^{-3}).

Yield maximisation in wheat through agronomic manipulation

Effect of P application on rice-wheat productivity

An experiment was conducted with and without P application either in rice and/or wheat under rice-vegetable pea-wheat, rice-wheat green gram and rice-wheat- cowpea crop sequence. Major objective for this experiment was to skip P application due to shortage of P containing fertilizers, particularly DAP, during wheat sowing or rice transplanting season. It was observed that skipping of P application in rice or wheat or in both the crops produced similar rice and little lower wheat productivity. The results revealed that continuous applications of P containing fertilizers in all crops can be avoided particularly when 300 % cropping intensity is maintained with inclusion of legume crops like green gram and cowpea (Fig. 3.7 and 3.8).

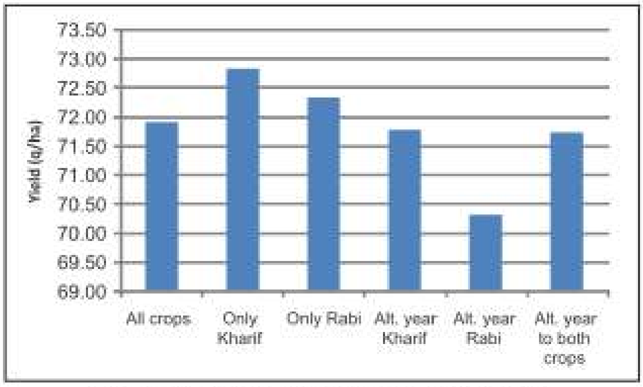


Fig 3.7. Skipping of P application on rice yield

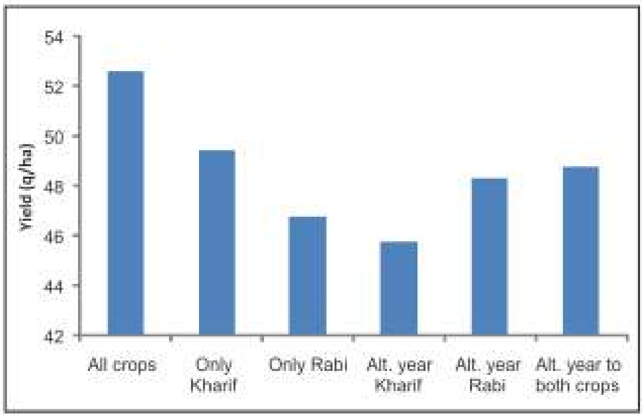


Fig 3.8. Effect of skipping P application on wheat yield

Rice straw incorporation

A trial was conducted with rice straw removal, incorporation and green manuring in rice-wheat cropping system. Results revealed that rice productivity was similar whether straw incorporated or removed. When green gram was incorporated then it saved 25 % nitrogen to rice crop and enhanced the rice yield as well. In wheat season when rice straw was incorporated and 25 % higher nitrogen was applied then it produced at par wheat yield as compared to recommended practices. This showed that rice straw incorporation increases the immobilsation of available soil nitrogen present in the field thereby required more N for wheat crop (Fig. 3.10).

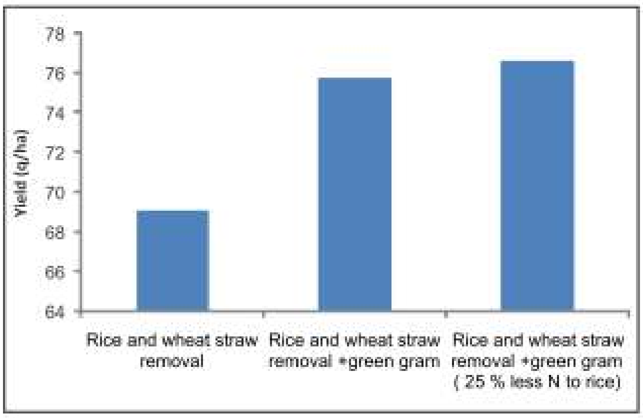


Fig 3.9. Effect of green gram on rice yield

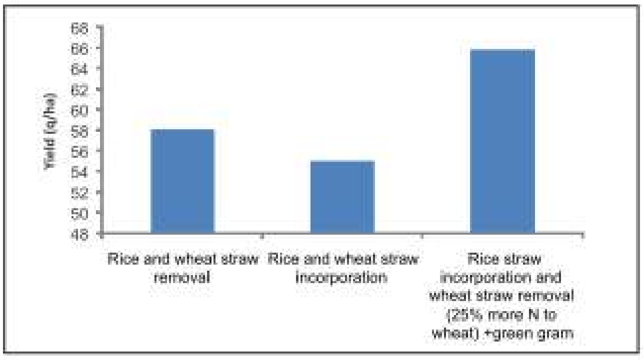


Fig 3.10. Effect of rice straw management on wheat yield

Intercropping of vegtables and spices with wheat

An experiment with vegetables and spices was sown in furrows and wheat on bed to utilise early vegetative period of the crop when growth was slow. Vegetables like cauliflower, cabbage, raddish, turnip and fenugreek and spices like coriander were tried in furrows and wheat on the top of bed during this crop season under bed planting. Pure crop was also grown under bed planting system. Raddish and turnip showed good performance in intercropping in furrows whereas cauliflower, cabbage, fenugreek and corinader performance was poor in furrows(Fig. 3.11).

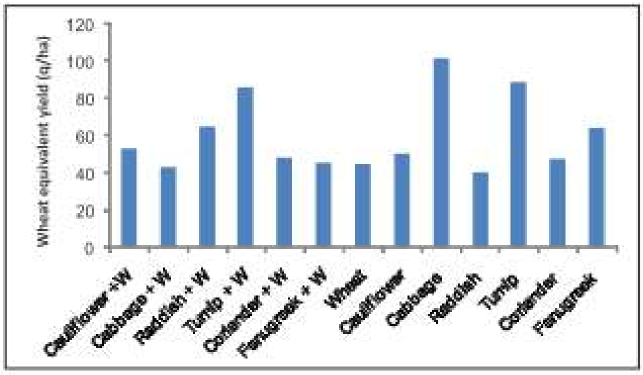


Fig. 3.11. Equivalent wheat yield for different intercrops and pure crops

Direct seeded rice

An experiment was conducted with three main plot treatments viz direct seeded rice, zero tillage transplanted rice and puddled transplanted rice and four subplots in wheat. Results on rice crop revealed the direct seeded rice produced lesser grain yield than puddled transplanted rice. Wheat yield was unaffected by different methods of rice seeding and maximum grain yield was obtained at 150 kg N/ha application.

Weed management in wheat

Weed infestation is one of the major problems in crop production. For realizing potential crop yield, proper weed management is very important. For controlling weeds in wheat, herbicides are preferred due to cost and time effectiveness. The emergence of new weed flora and evolution of new cases of herbicide resistance demand evaluation of new herbicides from different chemical groups. Field experiments were conducted for evaluation of herbicides and herbicide mixtures against weeds in wheat and the results of which are as follows.

Evaluation of flufenacet against grass weeds in wheat

Flufenacet at 200-300 g/ha applied as early post emergence was evaluated for control of grass weeds in wheat (Table 3.5). The application of flufenacet as early post-emergence (EPOST) was made 1-2 days before first irrigation, whereas post-emergence (POST) clodinafop application was done at 35-39 DAS (days after sowing). Weeds infested the experimental plots were *P. minor*, *Avena ludoviciana*, *Medicago denticulata*, *Melilotus alba* and *Coronopus didymus*.

Under untreated weedy control, *P. minor*, being the most dominant weed had the highest dry weight accumulation (294.3 g/m^2) comprising of about 73.2 % of the total dry weight (402.9 g/m^2). Wild oat was second dominant weed based on weed dry weight accumulation.

Flufenacet drastically reduced the dry weight of grass weeds (*P. minor* and wild oat) but was not effective against broad leaved weeds. Flufenacet at 250 and 300 g/ha was similar to standard check herbicide clodinafop in reducing the dry weight of *P. minor* and wild oat. Flufenacet at 250-300 g/ha provided significantly better control of grassy weeds (*P. minor* and wild oat) compared to lower dose of 200 g/ha.

The uncontrolled weed competition throughout the season resulted in the lowest grain yield of 23.3 q/ha.

Table 3.5. Performance of early post -emergence application of Flufenacet against weeds in wheat 2013-14

Herbicide	Dose (a.i.)/ha (g)	Weed dry wt. (g/m^2)					***Grass WCE %	Grain Yield (q/ha)
		Phalaris minor	Wild oat	Broadleaf weeds	Total grasses	Total weeds		
Flufenacet	200	5.97 (35.0)	3.84 (19.1)	4.26 (17.6)	7.32 (54.1)	8.46 (71.7)	86.4	49.6
Flufenacet	250	3.66 (12.6)	2.19 (6.7)	4.16 (18.8)	4.34 (19.3)	5.98 (38.1)	95.1	53.8
Flufenacet	300	1.81 (2.6)	2.02 (5.2)	4.67 (20.9)	2.57 (7.8)	5.39 (28.7)	98.0	54.2
Clodinafop	60	1.07 (0.2)	1.00 (0.0)	4.03 (16.3)	1.07 (0.2)	4.05 (16.4)	100.0	53.9
Hand weeding-2 (20 and 40 DAS)	-	4.95 (25.4)	1.77 (3.3)	1.64 (2.0)	5.19 (28.7)	5.45 (30.7)	92.8	54.2
Weedy control	-	17.14 (294.3)	10.14 (102.3)	2.62 (6.2)	19.92 (396.6)	20.07 (402.9)	0.0	23.3
LSD 5%		1.33	2.31	1.45	1.97	2.00		2.44

*DAS= days after sowing; **Original values in parenthesis and square root transformation $\sqrt{(x+1)}$ is used for statistical analysis; ***WCE= Weed control efficiency

Flufenacet at 250-300 g/ha applied as early post-emergence provided better yield compared to its lower dose of 200 g/ha and untreated control. However, flufenacet at 250-300 g/ha was statistical similar to clodinafop. The better yield under these treatments was due to good control of dominant weeds (*P. minor* and wild oat).

Flufenacet bioefficacy against multiple herbicide resistant *P. minor*

Four herbicides were evaluated against two biotypes of *P. minor* (One susceptible and other having multiple herbicide resistance). Flufenacet was applied as early post emergence i.e. 1-2 leaf stage of *P. minor*, where as other herbicides were applied as post-emergence at 3-4 leaf stage. Flufenacet was found effective (Fig. 3.12; Photo 3.1) against susceptible and multiple herbicide resistant populations of *P. minor* (Resistant to isoproturon, clodinafop and sulfosulfuron). Flufenacet at 150-300 g a.i./ha provided complete control of both populations of *P. minor*. Isoproturon, sulfosulfuron and clodinafop at recommended doses provided more than 99% control of susceptible population of *P. minor* but respective control by these herbicides of multiple herbicide resistant *P. minor* was 31.2, 28.1 and 15.6% only (Fig.3.12). Multiple herbicide resistance is an emerging serious problem in north western plains zone (Haryana and Punjab). Presently, clodinafop and sulfosulfuron are the two most widely used grass herbicides in these areas. Due to non-availability of effective post mergence herbicides, farmers are facing yield penalty. Since, this herbicide is effective against multiple herbicide resistant populations, therefore can be an option in the resistant management programme.

Photo. 3.1. Flufenacet effect on multiple herbicide resistant population of *P. minor*

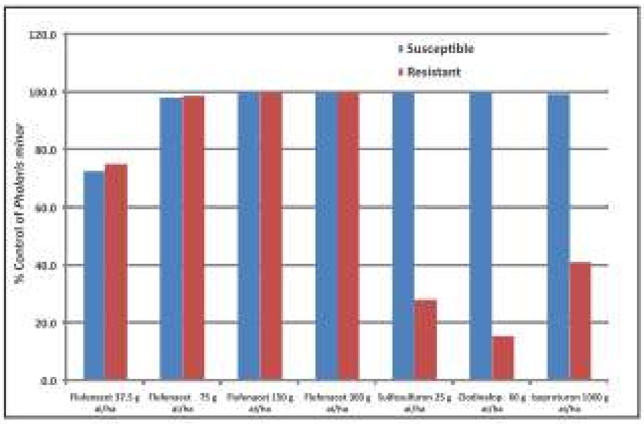


Fig. 3.12. Differential response of P. minor populations to different herbicides in pot study

Evaluation of Pyroxsulam against weeds in wheat

Pyroxsulam at 12, 15 and 18 g/ha without and with surfactant was evaluated in comparison to sulfosulfuron and metsulfuron for control of weeds in wheat (Table 3.6).

Table 3.6. Performance of Pyroxsulam against weeds in wheat

Herbicide	Herbicide Dose/ha (g a.i.) & Surfactant dose ml/ha	Weed dry weight (g/m² (120 Days after sowing)						WCE[#](%)	Yield (q/ha)
		P. minor	*Wild oat*	*Rumex*	*Medicago*	Other	Total		
Pyroxsulam	12	11.39(131.9)*	1.41(1.3)	1.07(0.2)	1.10(0.2)	1.23(0.6)	11.5(134.3)	71.3	50.77
Pyroxsulam	15	10.55(111.8)	1.24(0.7)	1.00(0.0)	1.07(0.2)	1.00(0.0)	10.59(112.6)	75.9	52.58
Pyroxsulam	18	7.97(63.1)	1.00(0.0)	1.00(0.0)	1.06(0.1)	1.01(0.0)	7.98(63.3)	86.5	55.00
Pyroxsulam+Polyglycol	12+1000	7.85(64.0)	1.31(0.9)	1.04(0.1)	1.07(0.2)	1.25(0.7)	8.01(65.8)	85.9	55.60
Pyroxsulam+Polyglycol	15+1000	6.87(46.4)	1.00(0.0)	1.02(0.0)	1.03(0.1)	1.15(0.4)	6.90(46.9)	90.0	56.96
Pyroxsulam+Polyglycol	18+1000	5.22(27.9)	1.00(0.0)	1.00(0.0)	1.06(0.1)	1.00(0.0)	5.23(28.1)	94.0	59.41
Sulfosulfuron+Surfactant	25+1250	3.19(10.0)	2.03(5.3)	8.82(76.8)	1.08(0.2)	1.25(0.6)	9.69(92.9)	80.1	52.78
Metsulfuron+Surfactant	4+500	17.09(291.9)	8.25(70.8)	1.07(0.2)	1.00(0.0)	1.10(0.2)	19.00(363.1)	22.3	30.89
Untreated weedy check	-	17.61(311.3)	8.53(84.6)	8.08(65.5)	2.60(5.9)	1.07(0.2)	21.48(467.4)	-	26.05
CD at 5%	2.83	3.22	0.82	0.30	NS	3.33			

*Original values in parenthesis and are square root transformed ($\sqrt{x+1}$) for statistical analysis; [#]WCE= Weed Control Efficiency

P. minor, *Avena ludoviciana*, *Medicago denticulata* and *Rumex dentatus* were the main infesting weeds. Minimum weed dry weight was observed in pyroxsulam 18 g/ha with surfactant polyglycol (1000 ml/ha) and the highest weed dry weight was observed in weedy check (467.4 g m^{-2}).

There was significant reduction in the dry weight of *P. minor* and wild oat under various herbicides application treatment compared to weedy check except metsulfuron 4 g/ha as it was ineffective against grassy weeds. For control of *Rumex* except sulfosulfuron, all doses of pyroxsulam provided excellent control.

The dry matter of grassy weeds reduced as the dose of pyroxsulam increased and minimum dry weight of grassy weeds was observed with sulfosulfuron 25g/ha application. There was no significant difference, when pyroxsulam was applied at the rate of 12-18 g/ha for dry weight of wild oat. These treatments were superior over sulfosulfuron 25 g, metsulfuron 4 g/ha and weedy check. Among the herbicide treatments, the maximum grassy weed dry weight was observed under metsulfuron as it was effective against only broadleaf weeds. Whereas, the broad-leaved weeds dry weight was maximum under weedy check treatment followed by sulfosulfuron 25 g/ha. The higher broad-leaved weeds dry weight in sulfosulfuron was due to the presence of *Rumex* as sulfosulfuron does not provide the effective control of this weed. Pyroxsulam provided the effective broad-spectrum weed control and was superior to sulfosulfuron 25 g/ha due to control of *Rumex dentatus*.

Maximum (94.0 %) weed control efficiency (WCE) based on weed dry weight was observed with application of pyroxsulam at 18 g/ha in combination with surfactant polyglycol 1000 ml/ha. The WCE with application of sulfosulfuron and metsulfuron was lower compared to pyroxsulam at 18 g/ha with surfactant.

Pyroxsulam without surfactant was poor in controlling the *P. minor* compared to its application with surfactant (Polyglycol 1000 ml/ha). The dry weight of *P. minor* under pyroxsulam with surfactant at 18 g/ha was statistically not different from sulfosulfuron. Pyroxsulam was superior due to control of *Rumex dentatus* as sulfosulfuron was ineffective against this weed.

The weed competition throughout the season resulted in the lowest grain yield (26.05 q/ha) compared to all other weed control treatments. The presence of the weeds throughout the crop season reduced the grain yield by 53.9%. All the herbicide treatment produced significantly more grain yield than weedy check. Among herbicide treatments, metsulfuron 4 g/ha had lowest yield (30.89 q/ha) as it was ineffective against grassy weeds. The wheat grain yield under Pyroxsulam with surfactant (55.60-59.41q/ha) was better compared to without surfactant (50.77-55.00 q/ha) and sulfosulfuron (52.78 q/ha) application due to better control of complex weed flora.

Pyroxsulam at 18 g/ha with surfactant (Polyglycol) 1000 ml/ha is effective against grassy (*P. minor* and wild oat) and broadleaf weeds and as a result of broad spectrum weed kill this herbicide is superior over sulfosulfuron and metsulfuron.

Metsulfuron resistance in *Rumex dentatus* and its control

Application of metsulfuron at 2 and 4 g/ha effectively controlled the susceptible population of *Rumex dentatus* but failed to control the resistant population (Fig 3.13). The fresh weight of resistant population was 176.7 and 184.3 g/pot at metsulfuron 2 and 4 g/ha, respectively. The resistant population showed the cross resisatnce to Atlantis (400 g/ha). However, the resisatnt population was effectively controlled by carfentrazone (10 and 20 g/ha) alone and its ready mixture with metsulfuron {12.5(10+2.5) and 25.0 (20+5) g/ha}. The response of both the populations was similar against the 2,4-D. This study clearly indicate that the ready mix combination *i.e* metsulfuron + carfentrazone 25 g/ha can be an effective tool for management of sulfonylurea resistant *Rumex dentatus* also.

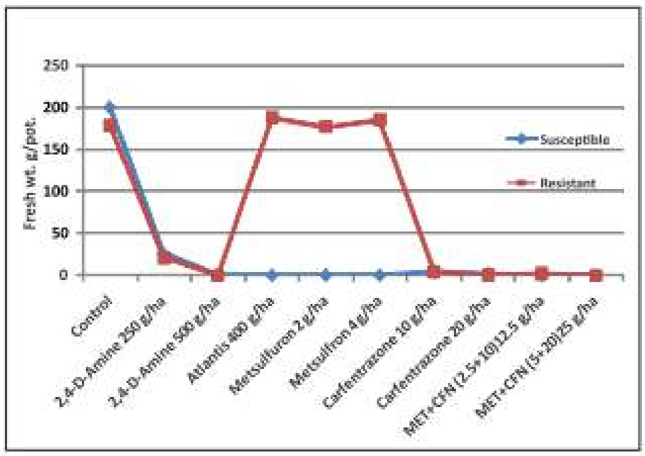


Fig. 3.13. Control of metsulfuron resistant *Rumex dentatus*
MET= metsulfuron and CFN=carfentrazone

4. QUALITY AND BASIC SCIENCES

Quality analysis

Analysis of AICW & BIP Trials

Nine thousand six hundred two (9602) wheat grain samples belonging to different AVTs, NIVTs, IVTs, QCSN and special trials were analyzed during 2013-14 that included evaluation of all the AVT-II entries including checks for identification of promising genotypes for chapati, bread, biscuit and pasta (Table 4.1).

Table 4.1. Promising genotypes identified for wheat products

Products	Genotypes
Chapati (>8.0/10.0)	WH 1129, MP 3382, C 306, K 8027, HD 2888, HD 2864, HD 2932, MP 3336, HI 1500, MACS 6478, HD 2932 and NIAW 1415.
Bread (> 575ml loaf volume)	UAS 347, NIAW 1994, NW 2036, MACS 6222, HD 2.932, Raj 4083, HD 3090, NI 5439 and NIAW 1415.
Biscuit (>10 spread factor)	HS 490
Pasta (>7.0/9.0)	HI 8736, HI 8737, UAS 446.

In addition, promising genotypes were identified both for *T. aestivum* and *T. durum* for individual quality parameters like grain appearance, test weight, protein, grain hardness index sedimentation value, moisture, phenol test, extraction rate, wet gluten, dry gluten, gluten index, high molecular weight gluteinin subunits (HMWGS), y-gliadin, yellow pigment, iron & zinc (Table 4.2).

Different quality parameters have shown wide variability (Table 4.3). If we can make segregated procurement possible in the country, better quality wheat products can be made available.

Table 4.3. Variability in quality and nutritional parameters

Parameter	*T. aestivum*		*T. durum*	
	Mean	Variability	Mean	Variability
Test Weight (kg/hl)	79.4	69.5-83.6	82.0	74.0-83.8
Protein content (%)	11.3	7.9-14.9	11.5	9.0-14.1
Grain Hardness index	64	14-99	70	49-99
Sedimentation (ml)	46	26-67	35	22-53
Extraction Rate (%)	68.6	57.2-73.6	-	-
Yellow Pigment (ppm)	3.38	1.93-6.23	5.43	2.39-8.06
Iron content (ppm)	39.1	28.1-68.3	39.3	29.4-53.5
Zinc content (ppm)	36.8	19.3-59.8	39.7	23.2-59.1

Two hundred twenty nine (229), 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 61.6% and 38.4% of the total entries, whereas percent entries having 1, 2* and N subunits were 27.7%, 59.7% and 12.6% respectively (Fig.4.1). Likewise, percent entries having subunits 7, 7+8, 7+9, 17+18, 20 and 13+16 were 34.6, 20.1, 12.0, 27.0, 2.5 and 3.8 respectively.

Table 4.2. Promising genotypes identified for processing and nutritional quality parameters

Parameter	*T. aestivum*	*T. durum*
Protein Content	MP 3382, CG 1010, MACS 6222, MACS 6478, HD 2932, Raj 4083, HI 5439, NIAW 1415, NIAW 2030, HW 5216, MACS 6507 (>12.5%)	HI 8755, UAS 428, UAS 446, HI 8751, MACS 3927 (>12.5%).
Sedimentation value	HS 594, PBW 681, HUW 666, DPW 621-50, PBW 692, HUW 675, HI 5439 (60 ml)	PDW 233, DDW 30, DDW 27, HI 3927 (40 ml).
Grain Hardness Index	DBW 98, PBW 704, C 306, K 1217, NI 5439, NIAW 1415, NIAW 2030, COW (W) 1, (80)	MACS 3927, DDW 27, UAS 446, HI 8751, HI 8754, MACS 3927 (>80)
	HS 490, VL 3002, WH 1164 (<45)	
Yellow Pigment	VL 907, VL 804, HS 542, HS 490, DBW 39, DBW 107, NW 2036, BRW 3723, COW (W) 1 (>4.0 ppm)	PDW 233, HD 4728, HD 4730, DDW 30, HI 8627, NIDW 295, DDW 27 (6.0 ppm).
Iron Content	PBW 689, HI 1500, MP 3288, CG 1010, COW (W) 1, HW 2044, HW 5216, UAS 358, MACS 6507 (>50.0 ppm).	A-9-30-1, HI 8751, HI 8754, MACS 3927 (>45.0 ppm).
Zinc Content	HPW 401, HS 590, TL 2995, CG 1010, HI 1500, COW (W) 1, HW 2044, HW 5216, MACS 6507 (>45.0 ppm).	A-9-30-1, MACS 3927, HI 8755, AKDW 2997-16, HI 8754, MACS 3927 (45 ppm)

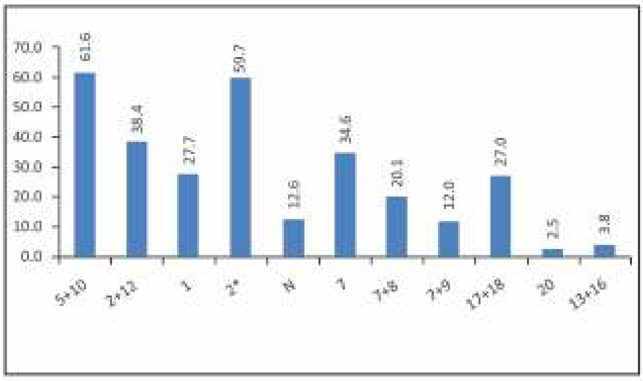


Fig. 4.1. Distribution of HMGWS

Promising entries were selected from NIVTs for promotion to AVT under irrigated timely sown (ITS) condition based on quality traits. From NIVT 1A, the selected entry was Raj. 4376 for NWPZ. From NIVT 2, the selected entries were PBW 715 and HI 1603 for CZ and HD 3164 and HI 1603 for PZ.

New initiative for Wheat export (Analysis of FCI Wheat grain samples)

Considering the production level of 95.93 million tons during the year 2013-14, India can emerge as a major player for wheat export. More than seven thousand five hundred wheat grain samples drawn from stocks of Food Corporation of India (FCI) covering three states viz. Punjab, Haryana & Madhya Pradesh were analysed during last two years for various wheat grading parameters like test weight, damaged kernel, foreign matter, shrunken & broken kernel, total defects & other classes and wheat functional parameters like protein, moisture, wet gluten, dry gluten & falling no. Based on these quality data, Food Corporation of India could export about 6.5 million tons of wheat through its exporting agencies during last two years.

Quality analysis of National Nurseries

During the year (2013-14), 103, 92 and 70 lines including checks belonging to NGSN, EIGN-I and EIGN-II were grown at DWR Research Farm, Karnal. All the lines of these three nurseries were analysed for processing quality parameters viz. test weight, protein content, grain hardness index, moisture content & sedimentation value and also for nutritional quality parameters like iron & zinc. These processing and nutritional parameters showed wide variability (Table 4.4).

Table 4.4. Variability in processing and nutritional quality parameters

Parameter	NGSN	EIGN-I	EIGN-II
Test Weight (Kg/hl)	78.2 (69.0-83.0)	79.0 (74.3-82.4)	80.0 (74.0-83.2)
Protein Content (%)	13.2 (11.6-14.6)	13.2 (11.1-14.9)	13.0 (10.7-14.7)
Sedimentation Value(ml)	44 (21-63)	51 (36-61)	36 (23-41)
Grain Hardness Index	76 (28-102)	66 (26-86)	88 (67-101)
Iron (ppm)	41.2 (30.2-53.5)	43.2 (35.8-53.1)	40.4 (33.4-47.8)
Zinc (ppm)	34.5 (26.1-46.9)	33.8 (28.0-42.5)	34.8 (26.0-44.0)

Attempts were made to identify promising genotypes for various processing and nutritional quality parameters from all the 3 nurseries viz. NGSN (Table 4.5), EIGN-I (Table 4.6.) and EIGN-II (Table 4.7.).

Selected superior lines were analysed for molecular characterization of for grain hardness (pin a & pin b), HMW & LMW glutenins and gamma gliadins, vernalization and storage protein genes (Fig. 4.2).

Table 4.5. Promising genotypes for processing and nutritional quality parameters (NGSN)

Parameters	Value	Genotypes
Test Weight (kg/hl)	>82.0	MACS 3828, AKAW 4210-6, HI 8713 (D) HI 1569, HI 8498 (D) (C), Raj 4390, HS 533, MACS 3744
Protein Content (%)	>14.0	RSP 561, PHS 1101, PHS 1102, PHS 1103, PHS 1108, PHS 1109, NWL 09-11, J 07-40, HPW 355, NWL 09-07, VW 321, GW 09-201, Local Check (C), LOK 54
Sedimentation Value (ml)	>55	DBW 58, NWL 09-11, LBPY 2010-11, LOK 65, LOK BOLD, WSM 41, LBPY 2010-24, NWL 09-8, Raj 4387, WH 1080, MP 3288
Grain Hardness Index	>90	HI 8703 (D), TL 2969 (T), MACS 3742 (D), MP 3304, DDK 1041 (dic), HI 8715 (D), HI 8498 (D) (C), NWL 09-07, NIAW 577, DBPY 08-4, HI 8713 (D)
	<45.0	HPW 355
Iron (ppm)	>45.0	Sonalika (C), RAJ 4238, Local Check, DDK 1041 , (dic), DBW 17 (C), KB 2013-06, PHS 1101, PHS 1103, PHS 1107, PHS 1108, DL 1063, GW 09-201, LOK 54, WSM 41, Raj 4390, PBW 640, DBW 71
Zinc(ppm)	>40.0	UP 2798, DDK 1041 (dic), PHS 1107, HI 8498 (D) (C), DL 1063, LOK BOLD

Table 4.6. Promising genotypes for processing and nutritional quality parameters (EIGN-I)

Parameters	Value	Genotypes
Test Weight (kg/hl)	>81.0	33rd ESWYT 122, 130, DBW 17 (C), 14th FHBSN 6403, 22nd ISEPTON 6218, 6233, 6234, 20th SAWYT 315, 339, 30th SAWSN 3013, DBW 17 (C)
Protein Content (%)	>14.0	33rd ESWYT 150, 45th IBWSN 1045, 1134, 1195, 1287, 23rd HRWSN 2007
Sedimentation value (ml)	>55	33rd ESWYT 103, 109, 119, 122, 136, 141, 145, 150,20th HRWYT 235, 45th IBWSN 1018, 1021, 1225, 1282, 1301, 7th STEMRRSN 6067, 23rd HRWSN 2108, 2118, 20th SAWYT 306, 308, 338, 340, 30th SAWSN 3011, 3012, 3047, 3065, 3085, DBW 621-50, 7th EBWYT 527
Grain Hardness Index	>85	20th HRWYT 235, 22nd ISEPTON 6218
	<45	45th IBWSN 1122 , 23rd HRWSN 2002, 22nd ISEPTON 6219, 20th SAWYT 315, 337, 30th SAWSN 3005, 3029
Iron (ppm)	>45.0	33rd ESWYT 145, 150, 20th HRWYT 214, 236, 45th IBWSN 1045, 1134, 1294, 1301, 1314, GW 322 (C), 7th STEMRRSN 6007, 6111, 14th FHBSN 6403, 23rd HRWSN 2118, DBW 17 (C), 20th SAWYT 337, 338, 339, 343, 30th SAWSN 3008, 3029, 3048, 3055, GW 322 (C)
Zinc (ppm)	>40.0	45th IBWSN 1134, 7th STEMRRSN 6144

Table 4.7. Promising genotypes for processing and nutritional quality parameters (EIGN-II)

Parameters	Value	Genotypes
Test Weight (kg/hl)	>82.0	IDYN-17, 20, 25, 36, 21, 33, IDSN-36, 43, 49, 81
Protein Content (%)	>14.0	IDYN-57, 117, IDSN-43, HI 8498 (C)
Sedimentation value (ml)	>40	IDYN-21, IDSN-43, 59, 121
Grain Hardness Index	>95	IDYN-13, 4, 20, 32, 36, 38, 41, 49, 50, IDSN-49, 97, PDW 291 (C)
Iron (ppm)	>45.0	IDYN-30, 33, 36, 43, HI 8498 (C), PDW 291 (C), IDSN-117, PDW 291 (C), HI 8498 (C)
Zinc (ppm)	>40.0	IDYN-30, IDSN-22, 78, 117, 143, PDW 291 (C), HI 8498 (C)

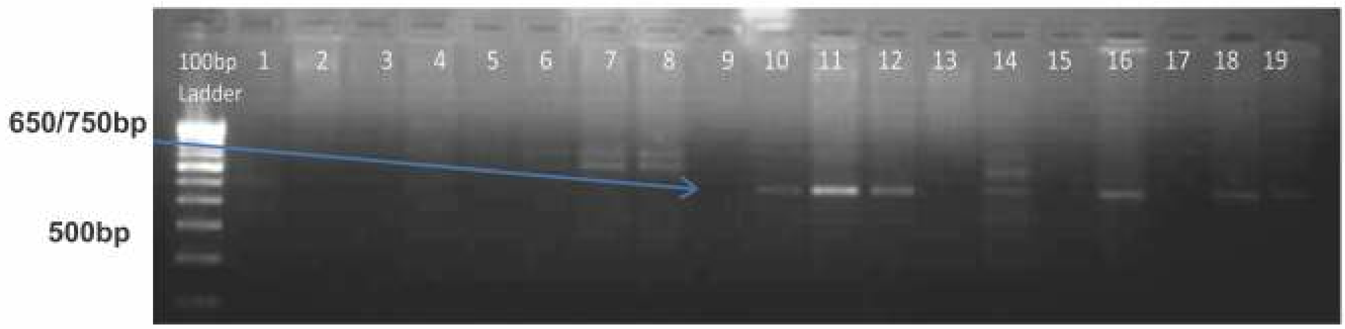
Genetic improvement in grain quality

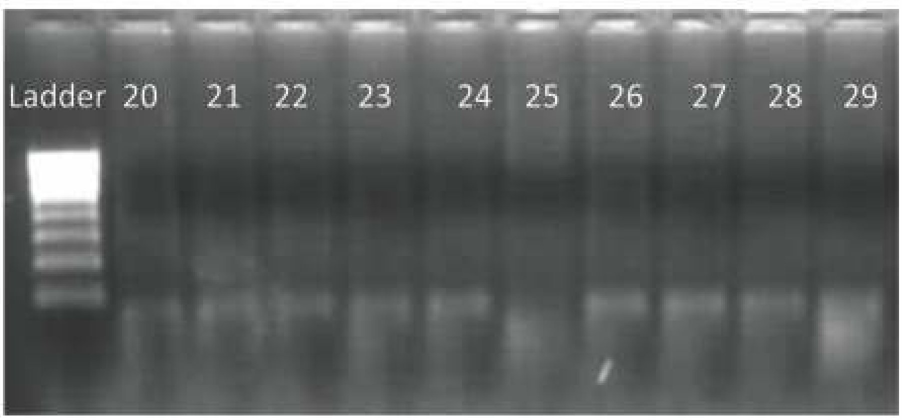
Creation of new variability

New donors of high yield, protein content, sedimentation value, grain hardness, soft grain texture, *chapatti* quality, bread loaf volume and flour recovery were utilized to augment genetic variability in wheat quality. In this endeavor, 367 new combinations were attempted and 360 F_1 were evaluated.

Evaluation of developed material

A total of 288 F_2s were raised and examined for yield traits and disease intensity. Selection was exercised at different plant growth phases and 556 recombinant





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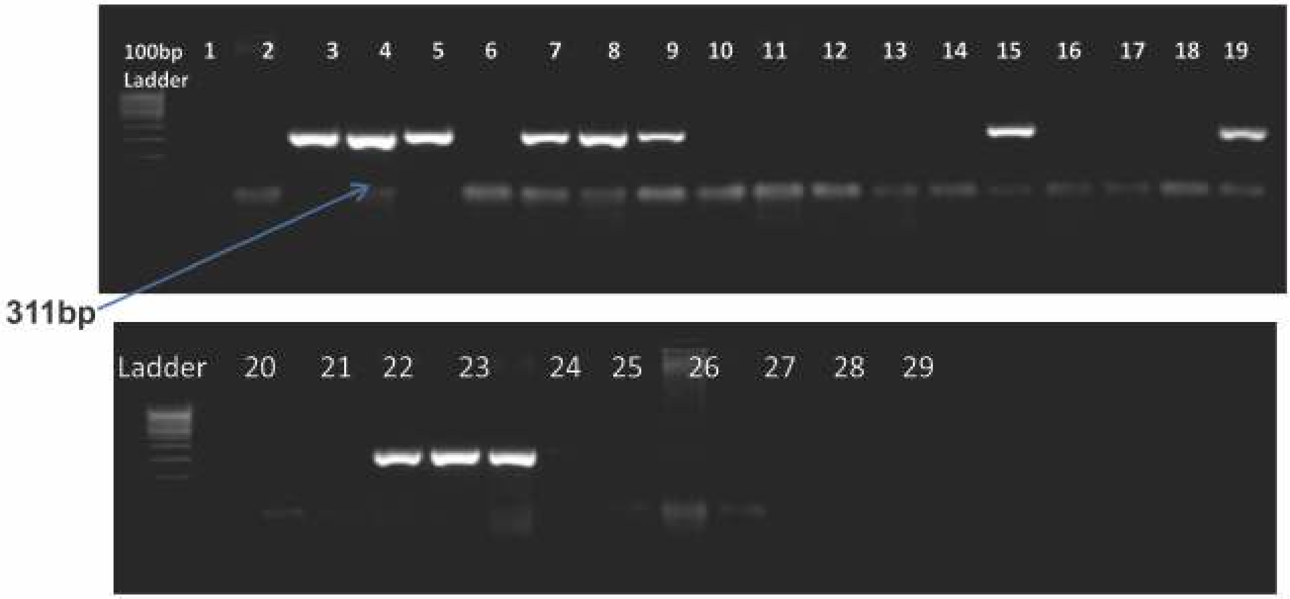


B

Fig. 4.2. PCR amplification in NGSN, EIGN-I and EIGN-II entries (A) with allele-specific PCR marker Vrn-A1 (B) with allele-specific PCR marker Storage protein activator spa-B. (Entries code NGSN 1. DBW58, 2. LOK62, 3. PHS1108, 4. HPW 355, 5. LBPY 2010-11, 6. LOK65, 7. LOK BOLD, 8. LBPY 2010-24, 9. Raj 4388; EIGN-I 10.20th HRWYT 219, 11. 45th IBWSN 1122, 12. 13th HRWSN 2002, 13. 22nd ISEPTON 6219, 14. 20th SAWYT 31515. 20th SAWYT 337, 16. 30th SAWSN 3005, 17. 30th SAWSN 3029, 18. 30th SAWSN 3071, 19. DBW39©; EIGN-II 20. IDYN-14, 21.IDYN-20, 22. IDYN-21, 23. IDYN-32, 24. IDYN-50, 25. IDSN-43, 26. I DSN-59, 27. IDSN-121, 28. PDW291©, 29. HI 8498©)

plants were selected for generation advancement. 7343 progenies/ families were field evaluated in F_3 and F_4. It involved 4261 progenies of 341 crosses in F_3 and 3082 progenies of 261 crosses in F_4. Taking plant characteristics, yield components and disease reactions into account, 5762 spikes and 120 single plants were selected in F_3 and F_4.

Grain quality in advance lines

In advance generations (F_5-F_7); 107 bulks, 515 families and 997 progenies were evaluated. In F_6-F_7, material was raised in bigger plots. 38 bulks were selected for quality and yield evaluation during 2014-15. Evaluation for component traits revealed that certain advance lines (Table 4.8) had good sedimentation value (60 to 64ml), grain protein content (13.5 to 14.6% at 14% moisture level), grain hardness (index 90-100) and soft grains (hardness index 5-30).

End-product quality in advance lines

Advance derivatives were examined for chapati, bread quality and flour recovery. Several lines (Table 4.9) recorded good bread loaf volume (600 to 630cc), bread quality score (8.0 to 8.3), *chapatti* quality score (8.0 to 8.6) and extraction rate (72 to 74%).

Evaluation in yield trials

Elite advance derivatives were yield evaluated in Preliminary Yield Evaluation Trial and analysed for

Table 4.8. Grain quality characteristics in improved lines

Stage	Sedimentation value ≥60ml		Grain protein content ≥13.5%		Grain hardness index ≥90		Grain hardness index <30	
	Number	Range	Number	Range	Number	Range	Number	Range
PYT	4	60-64	6	13.5-14.5	2	91-93	4	26-30
F_7	1	60	5	13.5-14.4	3	90-93	1	28
F_6	1	62	3	13.9-14.6	-	-	-	
Germplasm	4	60-64	24	13.5-15.2	6	90-100	11	5-21

Table 4.9. End-product quality and flour recovery in improved lines

Material	Bread Loaf volume ≥600cc		Bread quality score ≥8.0		Chapati quality score ≥8.0		Flour extraction rate ≥72%	
	Number	Range	Number	Range	Number	Range	Number	Range
PYT	5	610-625	3	8.1-8.3	10	8.0-8.4	8	71.8-73.6
F_7	7	600-625	4	8.0-8.2	5	8.0-8.6	4	71.8-73.6
F_6	5	615-630	3	8.0-8.2	3	8.0-8.1	2	72.2-73.6
Germplasm	2	600-620	2	8.0-8.1	4	8.0-8.4	10	72.1-73.8

Table 4.10. Performance of elite lines selected for station trials

Entry	Yield (t/ha)	GPC (%)	TGW (g)	Loaf volume (cc)	Chapati score	Extraction rate (%)
QBP 1401	5.95	13.6	40.7	475	8.00	66.3
QBP 1402	6.64	13.3	43.8	590	7.37	71.4
QBP 1403	5.56	11.7	44.6	430	7.54	70.5
QBP 1404	5.50	13.2	47.0	610	6.75	73.6
QBP 1405	5.32	12.4	46.7	565	6.75	65.2
QBP 1406	5.93	11.6	46.9	480	7.12	69.0
QBP 1407	5.81	10.7	49.8	525	7.04	70.5
QBP 1408	4.96	12.0	50.2	485	6.87	72.2

GPC: Grain protein content; TGW: Thousand grains weight

Table 4.11. Efffect of micronutrients spray on yield and grain quality

Treatment	Plot yield (g)	Protein (%)	Hardness index	Loaf volume (cc)	Chapati score	Extraction rate (%)
Check	2957	11.9	73	527	7.23	67.8
Borax	3091	12.5	80	539	7.24	67.7
Cu So_4	3122	12.2	77	535	7.39	68.8
Fe So_4	3135	12.1	82	531	7.44	68.2
Mn So_4	3145	12.1	75	546	7.60	68.1
Zn So_4	3426	11.8	82	531	7.38	67.5

grain quality attributes. Two entries had an edge over checks in grain yield and another five performed at par with checks. In view of rust resistance and grain yield, 8 entries of PYT were selected for yield evaluation in the station trials (Table 4.10).

Exploring micronutrients for quality improvement

A pilot study was conducted to study whether micronutrients can aid grain and end-product quality. Two sparys of five micronutrients namely borax, copper sulphate, ferrous sulphate, zincs sulphate and manganese sulphate were applied in multiplication plots of entries under test in the coordinated trials. Grain were examined for yield, protein flour recovery, grain hardness, sedimentation value and product quality (Table 4.11). Improvement in yield was visible in almost all the micronutrients but zinc was most effective. Except sedimentaion value, micronutrient specific quality improvemnt was apparent in all genotypes. Boron was most effective for protein whereas iron and zinc enhanced grain hardness. Managnese was found useful in end-product quality specially bread loaf volume and *chapati* score.

Material in national trials

Four lines found superior in station trials were chosen for yield evaluation in the coordinated trials. DBW 157 and DBW 162 were selected for NIVT 1A whereas DBW 168 and DBW 170 found suitable for NIVT 2. Besides yield and disease resistance, these entries have good blend of grain quality components.

Quality Component Screening Nursery

New genetic stocks: Three genotypes namely QLD 46, GW 09-246 (d) and QLD 49 completed three years testing in QCSN and their average performance was compared with the checks and recently identified genetic resources. QLD 46 had all characteristics of rainfed variety C 306 as it is tall, late flowering, had good grain appearance (GAS: 6.5), sedimentation value (44ml), grain protein (13.2%) and bold grains (TGW: 46.4g). It shall be examined for *chapatti* quality for any further decision. Durum entry GW 09-246 excelled in test weight (81.7 kg/hl) but remained at par with check PDW 233 and recently identified genetic resources like K 1005 and GW 07-112 for all other parameters. QLD 49, a bread wheat genotype derived from cross 37th IBWSN 72 / 5th IAT at DWR had very soft grain texture with grain hardness index only 13. Rest of the grain quality parameters i.e. protein (12.3%), test weight (78.2 kg/hl), sedimentation value (44ml), GAS (5.5) and yield (351 g/m^2) were comparable with HI 977 and other soft grain genotype QLD 28. Therefore, QLD 49 was identified as genetic resource for grain softness.

HMW and LMW allelic diversity and relationship with mixograph parameters

Two hundred forty diverse set of wheat cultivars released in India during the last several decades were evaluated for HMW and LMW glutenin alleles, for assessing their diversity and effect on sedimentation volume and mixograph parameters. The effect of *Glu-1* and *Glu-3* loci on sedimentation volume and

Table 4.12. F-values as determined by ANOVA showing the effect of Glu-1 and Glu-3 loci on sedimentation volume and mixograph parameters.

Locus	DF	Protein (14%)	Sedimentation Value	Mixing Peak time	Peak Slope	Peak height	Peak Width	Width at 8.0
Glu-A1	2	1.4	1.4	5.7 **	2.0	0.7	2.5	2.0
Glu-B1	4	1.8	3.3 **	1.7	1.1	3.3*	0.3	2.8 *
Glu-D1	1	2.3	17.5 ***	1.7	0.6	1.0	0.6	3.4 *
Glu-A3	3	0.8	0.9	2.0	0.5	0.3	0.6	0.7
Glu-B3	4	1.1	1.1	2.1	5.5 **	0.9	0.5	3.4 **
Glu-D3	4	0.3	0.8	2.6 *	0.4	0.2	0.5	1.3

DF: degree of freedom, * significant at p< 0.05, ** significant at p< 0.01, *** significant at p < 0.001.

mixograph parameters is shown in the table 4.12. Both SDS-PAGE and PCR based markers were employed in identifying alleles encoded at *Glu-1* and *Glu-3* loci. Extensive allelic variation was observed at both the *Glu-1* and *Glu-3* loci. There was prevalence of *Glu-A1b*, *Glu-B1i*, *Glu-D1a*, *Glu-A3c*, *Glu-B3b*, *Glu-B3g* and *Glu-D3b*. The alleles *Glu-A1b*, *Glu-B1i*, *Glu-D1d*, *Glu-A3b*, *Glu-B3g/h* and *Glu-D3b* exhibited high SDS-sedimentation volume. *Glu-B1i* and *Glu-D1d* showed highly significant positive effect ($p<0.001$) on sedimentation volume and also had additive effects. However, surprisingly overall there was decline in the frequency of *Glu-B1i* allele during last two decades in Indian wheat breeding and not a single 1B/1R translocation cultivar possessed this allele. *Glu-A1b* showed significant positive effect on mixograph peak time, peak slope and peak width. *Glu-B3g* exhibited significantly higher mixograph peak time and width at 8 and *Glu-B3h* showed higher dough stability. *Glu-B3j* (1B/1R translocation) exhibited highest peak slope indicating the negative effect on dough strength. This information can be useful in designing breeding program for the improvement of Indian bread wheat quality.

Improving protein content and dough strength

Recently *Gpc-B1* locus transferred from *dicoccoides* into bread wheat was used making crosses with high yielding backgrounds. There was large variation in grain protein content of F_2 population of a cross between HD2967 and *Gpc-B1* derived lines. Surprisingly, it ranged from 11.0 to 20% at 14% moisture basis. The F_2 generation will be further advanced into F_3 during 2014-15 crop season and genetic analysis will be done. The promising segregants will also be used in making further crosses to improve grain protein content. The population will also be utilized for mapping studies. There was large variation in sedimentation value also indicating possibility of increasing both grain protein content and gluten strength simultaneously. In addition, significant positive correlation of HMW glutenin subunit 17+18 on glutenin strength will be utilized in improving 1B/1R translocation lines. We employed molecular markers for subunit 17+18 in backcross breeding to transfer these subunit genes into high yielding varieties such as PBW 343, PBW 502, DBW 17, PBW 550, DPW 50 and HD 2967. The materials are at different back cross stages such as BC_3F_6, BC_2F4 and BC_3F_5. The selected backcross lines (BC3F4) were also used in crossing with latest released varieties such as DPW 621-50 and HD 2967 using molecular markers during 2014-15 crop season.

Improving biscuit quality of wheat using Nap Hal and soft germplasm lines

Molecular markers and microlevel tests were used to transfer *Glu-D1* double null of NAP HAL into high yielding backgrounds of wheat such as PBW 373, UP 2425, Raj. 3765, DPW-621-50, HD 2967. Materials are at different stages of development. Advanced backcross lines of a cross between NAP HAL and PBW373 and UP 2425 were used in making crosses with DPW-621-50 and HD 2967. The segregating generations of these crosses showed Glu-D1 null lines with very low sedimentation value having great promise for improving biscuit making quality. BC_3F_6 seeds harvested from selected BC_3F_5 plants of a cross between PBW 373 and NAP Hal showed low sedimentation value and some of them exhibited transgressive segrergants towards low sedimentation under soft background. Soft germplasm lines namely HPW 114 and EC 378793 were used as donors. Materials are at BC_3F_7 and BC_4F_7 stages. There was significant increase in the spread factor of BC_2F_7 back cross lines of a cross between HD 2687 and HPW 114. The lines with high spread factor and higher yield potential will be registered as genetic stock for future use in breeding for improving biscuit making quality.

Nutritional quality (Biofortification)

The objectives of the present study were to (i) investigate the variation in Fe and Zn content in wheat grains among bread wheat lines and synthetic hexaploids, (ii) analyze the genotype*environment interactions (GE) and (iii) identify promising lines with higher Fe and Zn concentrations in the grain. Two fold differences were observed in Fe and Zn content in wheat varieties developed in India and synthetic hexaploids. It is interesting to note that greater variability was observed for Zn content in this set of synthetic hexaploids (from 25ppm to 58ppm). Synthetic hexaploids showed significantly higher Zn content in grain as compared to bread and durum wheats ($p<0.001$)). Large diversity in Zn levels in synthetic hexaploids may be because of the fact that synthetics were developed by crossing different species of tetraploids with different accessions of *Ae. squarrosa* (diploids). Higher content of Zn in hexaploids may be contributed by *A. tauschii* genome. However reduction in Fe and Zn content was observed during last several decades. Higher Fe and Zn content was observed among wheat varieties developed during early part of the last century. However both Fe and Zn content remained unchanged during subsequent periods of variety development because of release of 1B/1R translocation lines during 90's and onwards in India. It seems that 1B/1R translocation lines are more efficient in absorbing Fe and Zn.

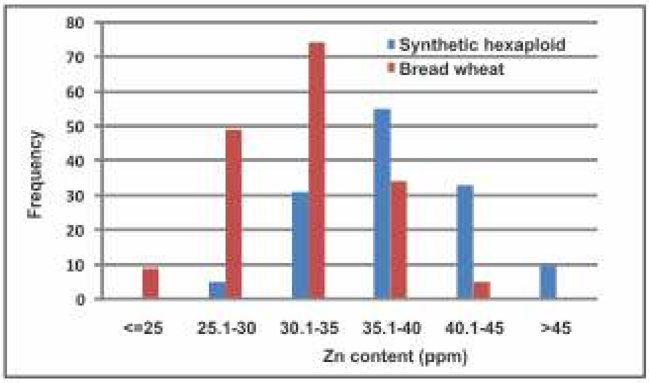


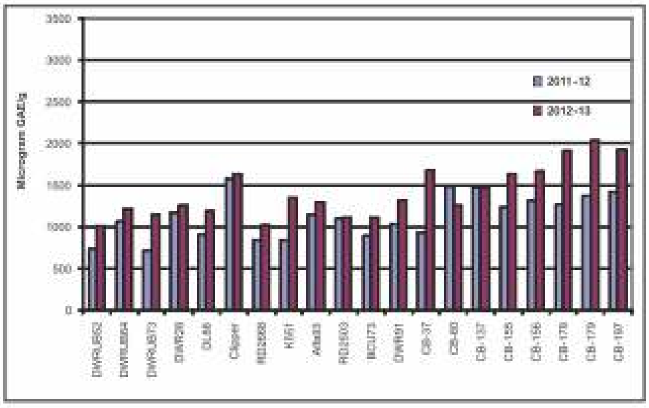
Fig. 4.3. Frequency distribution of Zn content in synthetic hexaploid and bread wheat

Phytic acid and inorganic phosphorus levels in dough after time intervals

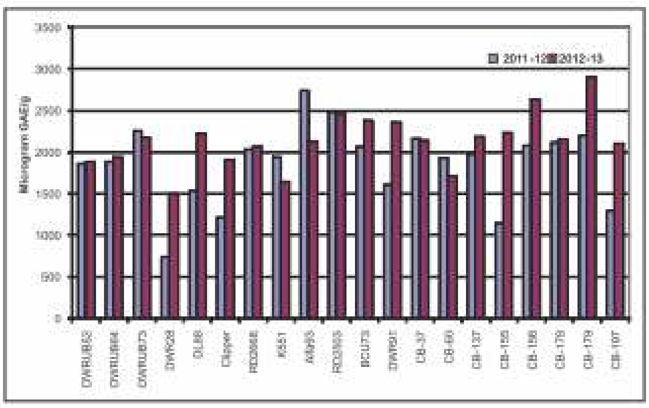
Most of the phosphorus in the grain is bound with phytic acid and unavailable to humans and monogastric animals. Therefore an experiment was designed to identify the amount of phosphorus released at different time intervals of dough storage. There was 5 fold increases in inorganic phosphorus content of dough after 8 hours of storage at room temperature. Phytic acid content also decreased during dough storage. The experiment is in progress to identify the relationship between phytase and phytic acid content during dough storage. In addition, segregating generations of cross between synthetic hexaploids 70 and PBW 373, 343 and 550 were advanced based on microlevel tests for assessing phytase levels. Materials are at BC$_2$F$_4$ and BC$_3$F$_3$ levels. There were many segregating lines with higher phytase levels and some with transgressive segregants towards very high phytase levels. This demonstrated the utility of synthetic hexaploids in increasing phytase levels in wheat.

Effect of growing year on the phenolic content of barley

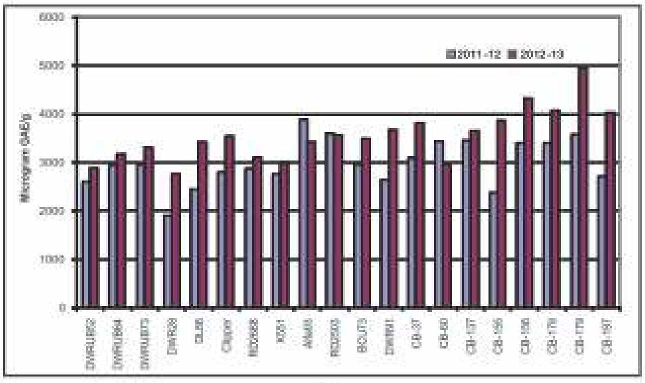
The free, bound and total phenolic content in 20 selected barley genotypes were studied for two years (2011-12 & 2012-13). Year to year variations were observed in the phenolic content in all the genotypes with higher content in 2012-13 as compared to 2011-12. In the year 2011-12, the ranges for the free, bound and total phenolics were 0.70-1.60, 0.75-2.75 and 1.90-3.90 mg GAE/g respectively. In the year 2012-13, higher total phenolics were obtained for most of the genotypes with free, bound and total phenolics in the range of 1.00-2.05, 1.50-2.90 and 2.80-4.95 mg GAE/g respectively. In the present study, the main difference in the environmental conditions was the high rainfall and relative humidity during the grain development phase in the year 2012-13 with minor temperature differences. These conditions might be responsible for the differences in the antioxidant activity and phenolics in two years. Further studies are required to explain the exact role of environmental conditions on these two properties.



(A)



(B)



(C)

Fig. 4.4 Effect of growth year on the (A) free, (B) bound and (C) total phenolic content of Barley

Effect of Barley blending on the antioxidant activity and phenolic content of wheat flour and chapatti

Barley is a very good source bioactive compounds which can provide additional health benefits if included in the diet. But, very less amount of barley is directly used as food. Barley has higher levels of antioxidants including phenolics. This information was utilized to enhance the antioxidant activity and phenolic content of wheat flour and the chapattis. Chapattis were prepared using two varieties of barley (BHS 352 & DWRB 73) in different ratios (upto 30%) with wheat (C 306). The antioxidant activity of BHS 352 was 60% and that of DWRB 73 was 43% as estimated by DPPH assay. The antioxidant activity of wheat flour increased from 14.5 to 32.0% with 30% barley flour of BHS 352 and increased from 14.5 to 28.0 % with DWRB 73 (Fig. 4.5). In case of chapattis, the antioxidant activity of C 306 chapattis increased from 9.5 to 14.0 with BHS 352 and from 9.5 to 11.0 with DWRB 73. The phenolic content of BHS 352 was 854.44µgGAE/g and that of DWRB 73 was 582.22 µgGAE/g. The phenolic content of the wheat flour increased from 366 to 489 GAE/g with BHS 352 blending and from 366 to 427µgGAE/g with DWRB 73 blending. In chapattis, the phenolic content did not change significantly (Fig. 4.6). With BHS352, the phenolic content increased from 238 to 290 µgGAE/g and from 238 to 260 µgGAE/g with DWRB 73. Thus, BHS 352, a hulless barley variety is good source of antioxidants and phenolics and can be used for blending with wheat flour for chapatti preparation to increase the nutritional value of wheat chapattis.

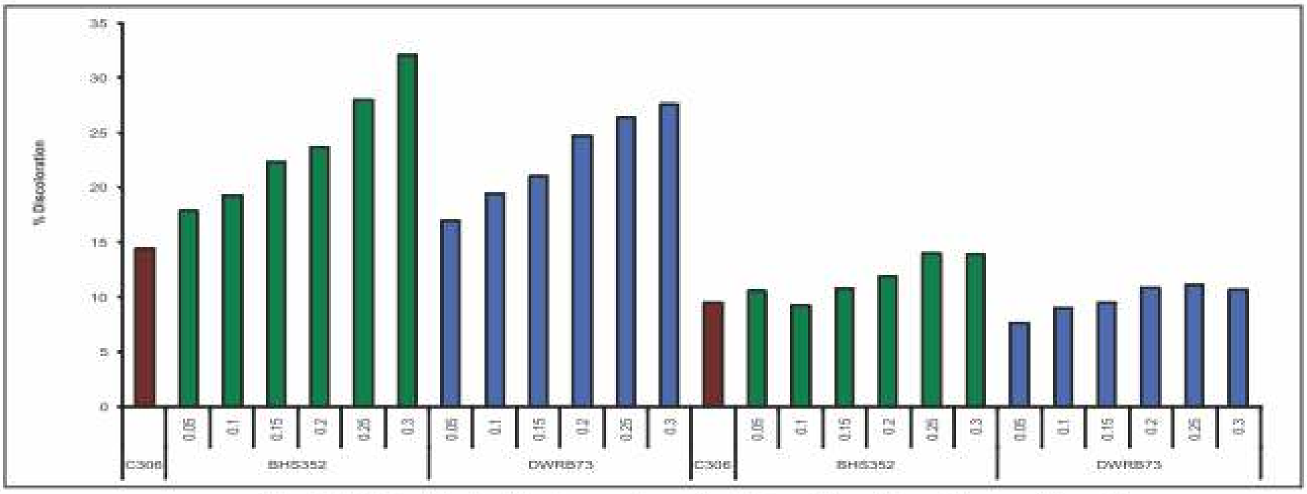


Fig. 4.5. Effect of barley blending on the antioxidant activity of wheat flour and chapattis

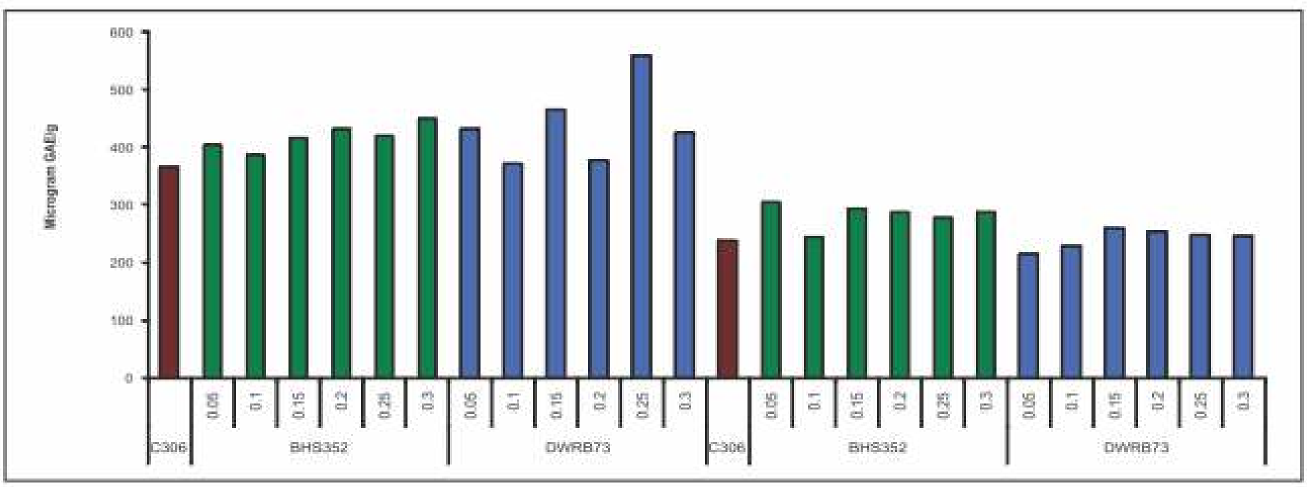


Fig. 4.6. Effect of barley blending on the phenolic content of wheat flour and chapattis

5. SOCIAL SCIENCES

Wheat is the second most important staple food crop after rice and its contribution to India's economy is significant. Globally, India ranks second in wheat production. In 2014-15, the country produced 90.78 mt of wheat from an area of 30.37 mha with an average productivity of 2989 kg/ha as per the third advance estimates of Ministry of Agriculture, India. A decline in production has been noticed in comparison to the previous year record production (95.85 mt). In the case of barley, the estimated production has been at 1.63 mt from an area of 0.67 mha with an average productivity of 2242 kg/ha. Decreased production is due to unseasonal rains and hailstorms in most of the major wheat growing states of the country during the crop season 2014-15. Despite this, the farmers will face a tough task to store wheat particularly for seed purpose. Dissemination of timely information like meteorological data has helped the farmers to some extent to save their crop particularly during harvesting. Even then, a lot of efforts have to be taken to counter the uncertain situation faced by the farmers.

Wheat Front Line Demonstrations (WFLDs) 2013-14

During the wheat crop season 2013-14, 600 Wheat Front Line Demonstrations (WFLDs) of one hectare each were allotted to 63 cooperating centres of which 565 were conducted through 60 cooperating centers. Technologies on improved wheat (*T.aestivum, T.durum and T. dicoccum*) varieties with complete package of practices, rotavator, zero tillage/happy seeder, bio-fertilizer, sprinkler/drip irrigation and chemical control of yellow rust were demonstrated. These WFLDs covered 572.96 hectares area of 1147 farmers in 19 states. The maximum number of WFLDs were conducted in UP (90) followed by Rajasthan (50), Bihar (50), Punjab (40), Maharashtra (40), HP (31.4), Haryana (30), MP (30), Jharkhand (24.8), J&K (20), West Bengal (20), Gujarat (20), Chhattisgarh (20), Uttarakhand (20), Tamil Nadu (20), Delhi (19.6), Assam (15), Karnataka (14) and Nagaland (10).

From Table 5.1, it is clear that the maximum yield gain was observed in MP (41.65%) followed by J&K (33.18%), Jharkhand (30.64%), Chhattisgarh (23.07%), Assam (22.76%), HP (21.71%), West Bengal (19.42%), Bihar (15.07%), Maharashtra (15.05%), Rajasthan (14.93%), Delhi (13.52%), Karnataka (13.18%), UP (08.87%) and Gujarat (06.11%).

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

State	Mean yield (q/ha)		% Gain
	Improved	Check	
UP	49.73	45.68	08.87***
HP	28.76	23.63	21.71***
J&K	31.55	23.69	33.18***
Bihar	37.33	32.44	15.07***
Jharkhand	30.06	23.01	30.64***
Punjab	52.36	51.07	02.53^{NS}
Haryana	54.63	53.70	01.73^{NS}
Uttarakhand	40.35	32.76	23.17^{NS}
Delhi	50.54	44.52	13.52***
Gujarat	43.77	41.25	06.11*
MP	43.53	30.73	41.65***
Chhattisgarh	26.51	21.54	23.07***
Maharashtra	33.78	29.36	15.05*
Karnataka	34.18	30.20	13.18***
West Bengal	34.31	28.73	19.42***
Assam	25.84	21.05	22.76***
Rajasthan	50.59	44.02	14.93***
Tamilnadu	24.96	-	-

*** Significant at 1 per cent level, * Significant at 10 per cent level, NS– Non-significant

The yield gain due to improved varieties over regional was highest in CZ (48.34%) followed by NHZ (46.44%), NEPZ (30.72%), PZ (25.76%) and NWPZ (18.09%) (Table 5.2). 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	27.94	19.08	46.44***
NEPZ	34.72	26.56	30.72***
NWPZ	51.38	43.51	18.09***
CZ	42.07	28.36	48.34***
PZ	33.64	26.75	25.76***
SHZ	24.96	-	-

*** Significant at 1 per cent level

FLDs on Bio-fertilizer (Azotobactor & PSB) along with 100 % inorganic fertilizer as compared to check (100% recommended dose of inorganic fertilizer) showed that the yield gain was non-significant at most of the centers. In PZ, there was a significant yield gain of 06.16 per cent at Dharwad center.

In the case of improved durum varieties, HI 8713 (d) gave a significant average yield of 58.00 q/ha at Udaipur centre in CZ followed by the same variety at Kota center (54.50 q/ha). WHD 948 (d) gave a significant average yield of 41.63 q/ha at Niphad followed by the same variety at Parbhani center in PZ (32.10 q/ha). Variety MACS 2971 (dicoccum) gave a significant average yield of 40.00 q/ha at Parbhani centre in PZ.

In NHZ, at Bajaura center, improved rainfed variety HPW 349 yielded 35.64 q/ha which was significantly higher than the check varieties, followed by VL 907 (31.21 q/ha) at Rajouri, VL 907 (29.99 q/ha) at Berthin Bilaspur, HS 507 (29.30 q/ha) at Rajouri, VL 907 (28.11 q/ha) at Almora, VL 907 (26.77 q/ha) at Berthin Bilaspur and VL 907 (19.61 q/ha) at Khudwani Anantnag centre. In CZ, HD 2987 gave 45.50 q/ha yield which was non-significant and MP 3288 gave a significant yield of 32.10 q/ha at Sarkanda Bilaspur center. In PZ, NIAW 1415 gave a significant average yield of 39.90 q/ha at Niphad followed by HI 1544 (33.23 q/ha) at Parbhani center.

Among RCTs, zero tillage gave a significant yield gain of 5.71% at Nawada center in NEPZ. However, in other centres it was non-significant despite higher yield from WFLDs than checks. In case of happy seeder, the yield gain was negative and significant (Table 5.3). There was patchy germination in some parts of the FLD plot.

Table 5.3. Performance of Zero Tillage over conventional tillage

Zone & Centre	Improved varieties	Zero Tillage Mean yield (q/ha)	Conventional Tillage Mean yield (q/ha)	% Gain
NEPZ				
Shillongani	CBW 38	22.00	18.50	18.92^{NS}
Nawada	CBW 38	42.36	40.07	05.71**
NWPZ				
Ludhiana	HD 2967	59.60	59.13	00.79^{NS}
Gurdaspur	HD 2967	37.75	35.00	07.86^{NS}
Saharanpur	HD 2967	54.50	53.50	01.87^{NS}
Pantnagar	HD 2967	46.12	44.50	03.64^{NS}
Ropar (Happy seeder)	HD 2967	50.73	52.97	04.23**

** - Significant at 5 percent level, NS– Non-significant

Constraints analysis in different wheat producing zones of India during 2013-14

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, respectively. Based on total score the average score for each constraint was calculated to ascertain seriousness of each constraint and finally ranking was done.

Northern Hills Zone (NHZ)

In northern hills zone, small land holdings, yellow rust, high cost of inputs, non-availability of seeds of newly released varieties, imbalance use of fertilizers, late sowing, lack of knowledge among farmers about recent technologies, lack of facility of canal irrigation water, untimely rain/ erratic rainfall/ weather vagaries, poor soil fertility, *Phalaris minor, Avena ludoviciana* (Jangali Jai), lack of irrigation facilities, poor quality seeds, *Chenopodium album* (Bathua) were some of the major constraints perceived by the farmers.

North Eastern Plains Zone (NEPZ)

Realizing the potential of north eastern plains zone, all categories of constraints need to be addressed immediately for achieving the targets of second green revolution. Among major constraints of this zone, yellow rust was ranked first followed by loose smut, powdery mildew, Karnal bunt, aphid, termite, lack of knowledge among farmers about recent technologies and stem borer. In NEPZ too, infestation of wheat field with weeds such as *Phalaris minor*, *Cyprus rotundus* (Motha), *Chenopodium album* (Bathua), *Avena ludoviciana* (Jangali Jai), *Malva parviflora* (Chughra), *Convolvulus arvensis* (Hirankhuri), *Rumex dentatus* (Jangali Palak) were noticed. Farmers need to be educated and trained on weed management strategies in future to tackle the weed problem.

North Western Plains Zone (NWPZ)

In NWPZ, *Phalaris minor* (Mandusi), non-availability of electricity, high cost of inputs, non-availability of seed of newly released variety, low price of wheat, small land holdings, *Chenopodium album* (Bathua), non-availability of labour, lack of facility of canal irrigation water, erratic power supply, high temperature at maturity, yellow rust, poor quality seeds, low organic matter, termite and imbalanced use of fertilizer were perceived as major constraints.

Central Zone (CZ)

In central zone, high temperature at maturity, high cost of inputs, water stress, *Phalaris minor, Avena ludoviciana* (Jangali Jai), non-availability of labour, low organic matter, Zn deficiency, lack of irrigation facilities and *Cyprus rotundus* (Motha) were ranked as major constraints.

Peninsular Zone (PZ)

In peninsular zone, low price of wheat, poor quality of fertilizers, high temperature at maturity, poor quality seed, non-availability of seed of newly released variety and erratic power supply were the major constraints faced by wheat growers.

Southern Hills Zone (SHZ)

In SHZ, the major constraints were high temperature at maturity, declining water table, untimely rain, damage of grains by birds, and incidence of loose smut.

Overall constraints

The overall constraint analysis revealed that yellow rust is the most serious constraint in the country during 2013-14 rabi season followed by *Phalaris minor*, high cost of inputs, loose smut, non-availability of seed of newly released variety, low price of wheat, small land holdings, bathua, non-availability of labour, lack of knowledge among farmers about recent technologies, erratic power supply, high temperature at maturity, poor quality seeds, low organic matter, termite and imbalanced use of fertilizer (Table 5.4).

Table 5.4.Overall constraints

Constraints	Score	Rank
Yellow rust	443	I
Phalaris minor	427	II
High cost of inputs	421	III
Loose smut	385	IV
Nonavailability of seed of newly released variety	384	V
Low price of wheat	382	VI
Small land holdings	380	VII
Chenopodium album (Bathua)	377	VIII
Non availability of labour	372	IX
Lack of knowledge among farmers about recent technologies	367	X
Erratic power supply	365	XI
Hightemperature at maturity	361	XII
Poor quality seeds	346	XIII
Low organic matter	337	XIV
Termite	336	XV
Imbalanced use of fertilizer	332	XVI

Costs and returns from wheat FLDs vis-à-vis check plots (2013-14)

Primary data for the agricultural year 2013-2014 were collected by the cooperating centres from the farmers who were allotted with FLDs. Every effort was made by the FLD coordinators to collect realistic data from the sample farmers and unrealistic data from the centres were deleted. On an average, FLDs registered better returns in comparison to check varieties. In the case of Tamil Nadu (SHZ), the costs and returns from wheat check varieties were not estimated as wheat was not grown in the selected farm where the FLDs were conducted. A significant difference in returns per rupee of investment was noticed between FLD and check plots across states, zones and technologies. Among states, Tamil Nadu registered the highest returns per rupee of investment (₹ 5.85), followed by Madhya Pradesh and Punjab. Analysis on costs and returns indicated that profit per hectare from FLDs was highest in Haryana (₹ 74230), followed by Uttar Pradesh (₹ 73301) and Punjab (₹ 70591). However, profit from check varieties was more in Haryana relative to FLD which is due to higher cost of sprinkler demonstration conducted by the KVK, Bhiwani (Haryana). Interestingly, operational costs in Punjab and Uttarakhand were lower in FLDs than check plots. The possible reason was in Punjab, demonstration of improved varieties reduced the cost on weedicides and insecticides. Similarly in the case of Uttarakhand, demonstration of zero tillage had a significant impact on cost reduction of FLDs conducted by the Pantnagar centre. Estimates of cost of production indicated that the cost incurred in producing a unit quantity of output was less in traditional wheat growing states and zones with the exception of Tamil Nadu due to the likelihood of getting more yield. Among wheat growing zones, returns per rupee of investment was highest in SHZ due to less operational costs in raising the crop. Wheat is not a main crop of SHZ and it is grown generally with a fewer irrigations. Fortunately the crop season has encountered a good monsoon which resulted in a good yield. CZ also realized a good return per rupee of investment which is mainly due to the incentives offered during procurement in addition to the support price given by states like Madhya Pradesh.

Among wheat production and protection technologies, happy seeder and chemical control of rust gave a good profit. However, the results were not consistent across sites owing to testing of particular technology in different locations of diverse soil properties. Among technologies, sprinkler irrigation conducted by the KVK, Bhiwani (Haryana) resulted in higher operational costs due to its establishment charges. Overall, on an average, an Indian farmer by adopting a new wheat variety or production/protection technology will get ₹ 2.88 per rupee of investment in his/her farm. Further, ₹ 716 have to be spent to produce a quintal of wheat through adoption of a new wheat variety or production/protection technology in comparison to ₹ 819 which is estimated from check varieties.

Overall, the analyses on costs and returns indicated that profit per hectare from FLDs was more than the check varieties establishing the fact that FLDs carry the successful technologies from lab to land. However, the present estimates are only the indicators for comparison for the current year without giving room for concrete conclusions. It may not have a complete relevance to the previous year estimates as the demonstrations were conducted in different sites/locations and mostly not repetitive in nature. Further, the difference in profits estimated from wheat cultivation is subject to farm-farmer-region specific conditions as it varies from one another.

Barley front line demonstrations

During the rabi crop season 2013-14, barley front line demonstrations (BFLDs) were not allocated by the Department of Agriculture & Cooperation, Ministry of Agriculture, New Delhi.

Conducting Wheat and Barley FLDs at ICAR-IIWBR, Karnal centre

During rabi 2014-15, twenty (20 hectares) wheat FLDs were conducted at 30 farmers' fields in the villages namely Jadoli Khurd and Jadoli Kalan in Karnal district of Haryana using varieties DBW 88, HD 3086 and WH 1105; and Rasulpur village in Muzaffarnagar district of UP using variety DBW 71. The demonstrations were conducted with complete package of practices. Farmers were provided the critical inputs as per provision under the programme.

During rabi 2014-15, five (5 hectares) barley FLDs were conducted at five farmers' fields in Malkana village located in Bathinda district of Punjab state using variety DWRB 92. The demonstrations were conducted with complete package of practices. Farmers were provided with the critical inputs as per the provision under the programme.

Conducting special wheat FLDs in high altitude area of HP during Summer-2014

During Summer-2014, 2.6 hectares of Special wheat FLDs were conducted at 20 farmers' fields in the villages namely Khangsar, Nukar, Jagla, Bargul, Raling, Shipting, Angroop and Teeling in Lahaul & Spiti district of Himachal Pradesh using HS 375 variety.

Monitoring

The ICAR-IIWBR team accompanied by the experts from Ministry of Agriculture and the concerned centres monitored the following wheat front line demonstration centres during the current crop season.

- Dr. Satyavir Singh monitored wheat FLDs conducted by Dhaulakuan, Shimla, Bajaura, Kathua and Ropar centres during 9-14 March, 2015.
- Dr. Sendhil R monitored wheat FLDs conducted by Amity University, Noida and CATAT, New Delhi Centres on 18.03.2015 and 19.03.2015.
- Dr. Randhir Singh monitored the wheat FLDs in Bhiwani and Hisar districts during 30 March 2015
- Dr. Anuj Kumar monitored ARS, Durgapura and KVK Banasthali centres during 31.03.2015 to 01.04.2015.

Factors affecting wheat yield in western UP

Agra district was selected in Western UP during 2013-14 comprising six tehsils i.e. Agra Sadar, Kiraoli, Atmadpur, Kheragarh, Fatehabad and Bah. From each tehsil, one village was selected randomly, thus total six villages were selected. From each selected village and from each of the four categories of farmers (marginal, small, medium and large), a total of 20 respondent farmers were selected making a total sample size of 120.

A majority of the farmers were middle aged, educated up to matriculation standard, never attended an agriculture related training. The 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. Selected respondents have 21 to 30 years' experience in agriculture, living in joint family with 5 to 6 family members. They hold membership at least in one organisation, consult the progressive farmers and their neighbours/friends/relatives, scientists/experts of KVKs/state agricultural universities/ICAR, agriculture officers/ADOs 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, 45.00% of the farmers had cultivated wheat crop in 50-75 per cent of the total operational land holding area. Generally the farmers purchase the wheat seed from government and private agencies. The average wheat yield obtained was 18.76 q/acre and 18.03 q/acre under rice-wheat and sugarcane-wheat cropping system, respectively. The wheat yield had shown a decreasing trend if the sowing is delayed. The highest average wheat yield (19.70 q/acre) was obtained by large farm size holders followed by small (18.56 q/acre), medium (17.87 q/acre) and marginal (17.75 q/acre) holders. A majority of the sample farmers adopted line sowing method. It was observed that a majority of the sample respondent farmers had medium level of attitude towards wheat production technology, medium level of knowledge and medium level of adoption of scientific wheat cultivation practices. The overall analysis of constraints in wheat production indicated that, high cost of inputs is the most serious constraint in Agra district of Western UP followed by non-availability of seed of newly released variety, non-availability of labour, lack of knowledge among farmers about recent technologies, non-availability of electricity, erratic power supply, lack of knowledge about appropriate dose and method of herbicide application among the farmers, untimely rain/erratic rainfall/weather vagaries, lack of facility of canal irrigation water, *Chenopodium album* (Bathua), *Phalaris minor* (Mandusi), poor information delivery by state extension machinery, poor participation in exposure visits arranged by various departments, water stress, low price of wheat, higher custom hiring rate of land leveling, field preparation, sowing & harvesting, lack of training facility, small land holdings, poor quality seeds, lack of irrigation facilities, high temperature at maturity, poor participation in kisan melas/field day/kisan goshthi/training, *Avena ludoviciana* (Jangali Jai), low organic matter, termite, temperature fluctuation during crop growth, late sowing, lack of extension literature, *Rumex dentatus* (Jangali Palak), declining water table and imbalanced use of fertilizer.

Weed management strategies at farmers' field in India

Bihar is the sixth largest wheat producer in India, however, the productivity is low and poor management of weeds is one of the reasons for less yield. A majority (59.02 %) of the farmers were old aged followed by middle (38.35 %) and a few young (2.63%). Around 81 per cent of the farmers were literate. About 35 per cent of the farmers were educated upto matric followed by middle (19.92%), graduate (14.29), primary (9.02%), intermediate (10+2) (3.01%) and post graduate (0.38%). The average experience in agriculture was 28 years. Both joint family (72.56%) and nuclear family (27.44 %) systems were prevalent in the rural society. Almost half of the farmers had more than 8 family members and 19.54 percent of the farmers had 5-6 family members. Average size of the household was 11.

Most of the farmers (48.97 %) were members of the cooperative credit societies to avail loan facilities for agriculture inputs particularly fertilizers. The average land holding size of the surveyed farmers was 4.13 acres. The farmers, irrespective of education level rely on multiple sources for getting agriculture related information. Literate farmers relied more on other farmers and state department of agriculture. The highly educated farmers were using more number of sources to get information. About three fourths of the farmers were using other farmers for getting agriculture information. Mass media like TV (8.65%), newspaper (10.15%) and radio (4.89%) were also used by some of the farmers. State Department of Agriculture was used by 30.45 percent of the farmers which indicates that the state officers are geared up to increase wheat production in the state. Private dealers (37.59%) have also been used by the farmers particularly for getting input related information like chemicals and seed.

The highest area sown under wheat was 61.39 percent in rice-wheat rotation followed by maize-wheat (53.95%), sugarcane-wheat (50.97%) and vegetable-wheat (40.32%). A majority of the farmers had purchased seed either from government (8.27%) or private input dealers (89.85%). Some of the farmers had used their own seed (1.88%). All the farmers had used less dose of nitrogen across the crop rotations, highest being in vegetable-wheat (43.11 kg/acre) followed by maize-wheat (39.24 kg/acre), rice- wheat (34.97 kg/acre) and sugarcane-wheat (34.54 kg/acre). Phosphorus was almost as per the recommendation, on higher side in vegetable-wheat and maize-wheat rotations. Potash was used below the recommended level. Some of the farmers had used zinc and sulphur too. All the farmers had applied nitrogen and phosphorus across crop rotations. Potash was applied by 26.32 percent, zinc by 25.19 percent and sulphur by a negligible percentage.

The farmers still grow outdated low yielding varieties like UP 262 under timely sown (61.65%) as well as late sown (56.39%) conditions. PBW 343 (24.44%) and PBW 154 (12.56%) were the other two more prominent varieties being grown by the farmers under both the conditions.

Most of the farmers (58.65%) were not aware of the extent of loss caused by weeds in wheat crop. About 38.35 percent of the farmers had applied herbicides, whereas, a majority (61.65 %) had not applied any herbicide. *Phalaris minor*, *Chenopodium album* and *Cyprus rotundus* were the major weeds in order of importance across the rice-wheat, maize-wheat and sugarcane-wheat and vegetable wheat crop rotations. A mere 38.35 percent of the farmers had applied herbicides across the crop rotations. Broad leaf weeds being a major problem in these areas, a majority of the farmers who had applied herbicides, used 2,4 D (12.78 %) and Isoproturon (13.91%) in rice-wheat rotations. A similar trend was observed in vegetable-wheat, maize-wheat and sugarcane-wheat crop rotations. *Phalaris minor* was the major weed being not controlled.

Poor quality of herbicide, lack of knowledge about herbicide, herbicide not timely sprayed, resistance and lack of knowledge about proper timing of spray and dose were the reasons of poor control of weeds. Most of the farmers (71.43%) did not suggest any measure to control weeds.

Irrespective of level of education, some of the farmers were aware of different agronomic management practices to control weeds. Those farmers who were aware of the different agronomic management practices to control weeds had also adopted the practices including increased seed rate, early sown, zero tillage, residue retention and crop rotation.

Impact of resource conservation technologies of wheat in Haryana

The study was conducted during 2013-14 in Panipat district of Haryana with 120 farmers who have adopted either of the three resource conservation technologies viz; zero tillage, rotary tillage and laser land leveler. Data were collected from Baupur, Karad and Nain villages of Israna block and Urlana Khurd and Nara villages of Matloda block. A majority of the farmers (58.33%) belonged to middle age group (30-50 years) and were well educated. Agriculture was their main occupation and most of the sample farmers (63.33%) were also rearing animals for milk production and a few were involved in business to supplement their income. When farmers were categorized based on owned land holding it was observed that 35.83% of the farmers were under large category and 13.33% were falling under very large category. When categorization was done on total land holding basis the 37.5% and 24.17% were falling under large and very large category, respectively. Tube well and canal were the major source of irrigation in the study area and quality of water was good except in Nain village. The soil was medium to high fertile and was medium to heavy in texture. The farmers contact ADOs and agriculture officers, neighbours/friends, progressive farmers, input dealers and experts from research institutions for agriculture related information. Regarding utilization of mass media for information on agriculture, TV was ranked first followed by kisan mela/exhibitions and news paper. A large number of farmers were under low category of material possession as it was observed that most of the small and marginal farmers and even those farmers who were taking land on lease basis were dependent on custom hire services for most of the agricultural operations. Out of 120 sampled farmers, 70% adopted zero tillage, 63.33% rotary tillage, 53.33% laser land leveler, 38.33% zero tillage+rotary tillage,36.67% zero tillage+ laser land leveler, 30.83% rotary tillage+laser land leveler and 18.33% zero tillage+rotary tillage+laser land leveler. Average rate of custom hiring/acre for zero tillage, rotary tillage and laser land leveler was Rs 689, Rs.992 and Rs.625, respectively. In case of zero tillage it ranged from Rs. 500-1100/acre, in rotary tillage Rs. 600-1200/acre and in laser land leveler Rs. 500-750/hour. Although farmers were using reaper for making straw even burning of straw was done by 21% farmers of the farmers. The farmers were very keen to talk about advantages of zero tillage technology and they emphasised that state department of agriculture is making effort to popularize this technology in the state and machine is easily available during peak hours of wheat sowing. The positive impact of adoption zero tillage was on cost saving, time saving, management of *Phalaris minor*, fuel saving, yield and germination. It was also recorded that continuous use of zero tillage increased organic carbon in soil, improved water retention capacity, improved fertility status of soil, decreased lodging, avoided terminal heat and also gave more or at par yield. The increase in broad leaf weeds was observed in zero tillage fields especially Malwa grass and chugra. It was observed that adoption of rotary tillage had positive impact on time and cost saving, germination and yield. Rotary tillage was found good in increasing organic carbon content in soil, improving water retention capacity, increasing fertility status of soil and avoiding terminal heat and farmers found it very simple to adopt. Some of the farmers observed more lodging under rotary tillage than conventional method. Adoption of laser land leveler was observed with 53.33% of the sample farmers because of its positive impact on saving of time in field preparation and irrigation and overall water requirement to the crop. The adoption of laser land leveler could save 30-40% of irrigation water. Most of the farmers reported that it increases area under cultivation, avoid wastage of water due to even distribution of water, reduces lodging of wheat crop and finally more yield was recorded by all the farmers. 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.

Estimation of Total Factor Productivity (TFP) and returns to investment on Wheat and Barley research

During this period secondary data on output and inputs have been sourced for 1991-92 to 2000-01 from the Directorate of Economics and Statistics, Government of India (collected through cost of cultivation scheme) and TFP was estimated using Malmquist index. The analysis indicated that a majority of the wheat producing states registered an increase in the yield. Inputs intensification has been noticed in major wheat producing states. Minimum expenses were incurred on plant protection chemicals for the Bihar wheat growers. Overall, the fertilizer usage increased and manure application has been declining. Human labour is also declining leading to increased mechanisation. Further, the use of animal power has been declining.

The following are the salient findings of the TFP analysis in wheat for 1991-92 to 2000-01: Among years there exists a mixed trend in TFP change. With 1991-92 as the base, the TFP change was highest in 1992-93 owing to higher technological progress followed by efficiency change. During the decade, the mean TFP declined by 0.5 per cent. The reason was slowdown in technological progress as well as efficiency change. However, across states, barring Gujarat, Madhya Pradesh and Rajasthan, the rest of the states showed a decline in TFP change. The increased growth was more pronounced in Rajasthan, followed by Madhya Pradesh and Gujarat. The decline was more evident in Bihar followed by Punjab, Haryana and Uttar Pradesh.

6. REGIONAL STATION FLOWERDALE, SHIMLA

Incidence of Wheat and Barley rusts

This crop year was marked with the sporadic appearance of yellow (stripe) rust in some pockets of Northern India. Though the yellow rust was observed in early January 2014, it was managed well due to resistance in cultivated varieties as well as pro-active steps taken for its management. Black (stem) rust of wheat was observed on indigenous wheat material planted at Bhowali, Hawalbagh, Pantnagar (Uttarakhand) and barley material in Karnataka. It was not observed on the present day cultivars. Indirectly it implies that inoculum exists in nature but present day wheat material is able to resist black rust of wheat. Brown (leaf) rust was widely distributed in different wheat growing areas of India. In nutshell there was no major incidence of wheat rusts in India during 2013-14. Role of grasses in wheat rust epidemiology is also being studied. Rust was also reported on the species of *Panicum*, *Melinis*, *Digitaria*, *Eragostis* and *Themeda* from Wellington (Nilgiri hills) in the month of June and July, 2014. However, so far these samples could not infect wheat.

Pathotype distribution of Wheat rusts

About 1625 samples were collected from fifteen states of India and adjoining countries like Bhutan, Nepal, and Bangladesh. Among them only 1361 samples were analysed for three rusts of wheat and yellow rust of barley for pathotype distribution.

i. Yellow rust of Wheat & Barley (*Puccinia striiformis*)

During this crop season, 358 samples of yellow rust of wheat and barley were analyzed from six North Indian states and Nepal. Population of yellow rust of wheat was avirulent to *Yr*5, *Yr*10, *Yr*11, *Yr*12, *Yr*13, *Yr*14, *Yr*15, *Yr*24, *Yr*26, *Yr*Sp and *Yr*Sk. Owing to the cool and humid weather, the population of pathotype 46S119, which is virulent to *Yr*9 and *Yr*A has increased in proportion and was observed in more than 73.3 % of the samples analyzed so far (Table 6.1).

Since 2011, there is a drastic shift of pathotypes in favor of pathotype 46S119. Partly, it is due to the cold climate over the years as well as decrease in the area under PBW 343. Many of the wheat lines/varieties which were resistant to yellow rust in farmers' field prior to 2011 became susceptible due to this shift in virulence. The proportion of PBW 343 virulent pathotype 78S84 which is virulent to *Yr*9 and *Yr*27 and avirulent to *Yr*A has reduced to 17.4%. Three other pathotypes and the new pathotypes were found in about 9% of the samples. Prevalence of barley yellow rust was negligible during the year. In barley yellow rust pathotype M and 57 were observed in four sample from Himachal Pradesh, Jammu and Kashmir whereas single sample from Punjab was of pathotype M.

New pathotypes

In eleven samples a new pathotype has been identified which was not very virulent but it was very

Table 6.1. Pathotype distribution of Puccinia striiformis (Yellow rust) during 2013-2014

S. No.	State /country	No. of Samples	Pathotypes observed							
			Wheat						Barley	
			46S119	78S84	47S103T	46S103P	46S102N	NP	1S0(M)	0S0(57)
1	Himachal Pradesh	200	154*	21	5	2	1	13	3	1
2	Jammu & Kashmir	29	19	7	1		-	-	1	1
3	Punjab	58	33	21	-	2	-	1	1	-
4	Haryana	35	28	6	-	-	-	1	-	-
5	Uttarakhand	23	17	3	-	-	-	1	-	2
6	Uttar Pradesh	11	3	3	-	-	-	5	-	-
7	Bihar	1	1	-	-	-	-	-	-	-
8	Nepal	1	1	-	-	-	-	-	-	-
	Total	358	256	61	6	4	1	21	5	4

* Probable new pathotype in one sample. NP=New pathotype

competitive. During repeated tests, new pathotype has shown virulence to *Yr*1, *Yr* 6 and *Yr* 7 but is avirulent to *Yr*9. In one sample, a new pathotype which has virulence of both 46S119 and 78S84 but is also virulent to Riebesel 47/51. Further studies are under way.

ii. Black rust of wheat (*Puccinia graminis tritici*)

Black rust was not observed on the present day cultivars. Indirectly it implies that inoculum of black rust exists in nature but present day wheat material is able to resist it. Black rust of wheat was observed in 9 states of India, Nepal and Bangladesh. Virulence on *Sr*31 (Ug99 type of pathotypes) were not identified anywhere in India, Bangladesh, Bhutan and Nepal. Population of black rust of wheat was avirulent to *Sr*26, *Sr*27, *Sr*31, *Sr*32, *Sr*35, *Sr*39, *Sr*40, *Sr*43, *Sr*Tt3 and *Sr*Tmp. Pathotype 40A was frequent in Tamil Nadu and Gujarat. Among the 223 samples analyzed, pathotype 11 was widely observed in Karnataka, Maharashtra and some areas in Northern India but not in the Nilgiri hills.

Diversity of pathotype population was maximum in Madhya Pradesh. Seven pathotypes were identified in 15 samples with the predominance of pathotype 40A in this state. In Uttar Pradesh, pathotype 11 was identified in two samples whereas in Uttarakhand, Rajasthan and Himachal Pradesh pathotype 21-1 which was identified in 1985 was observed in maximum numbers of samples. In North Indian states, other pathotypes of 21 groups were identified in few samples, whereas pathotype 11 was observed in Uttarakhand (Table 6.2).

New pathotypes

Preliminary studies have shown the occurrence of two new pathotypes in one sample each from Tamil Nadu. These were designated as 40-4 and 40-5. Both the pathotypes seem to be an off-shoot of pathotype 40A. While 40-4 is virulent to *Sr*21, 40-5 has additional virulence to *Sr*7a. These new pathotypes appear to be virulence selection in 40A on diploid and tetraploid wheat.

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

Thirty two pathotypes were identified in 793 samples of brown rust of wheat analyzed from 15 states of India, Nepal, Bhutan and Bangladesh. Population of brown rust of wheat in the region was avirulent to *Lr*24, *Lr*25, *Lr*29, *Lr*32, *Lr*39, *Lr*42, *Lr*45 and *Lr*47. Pathotype 77-5, virulent to *Lr*23 and *Lr*26 was predominant in 14 states and 3 neighboring countries. Pathotype 104-2 was virulent to *Lr*23 and *Lr*26 succeeded 77-5 and was observed in 12 states and two adjoining countries Nepal and Bangladesh. In Nilgiri hills, the proportion of pathotype 77-9 has increased in comparison to the previous years and was identified in 56% of the samples analyzed from that area. Frequency of predominant pathotype 77-5 for the last more than 18 years has reduced considerably. Likewise, in Karnataka, pathotypes 77-9, 12 and 77-11 were most frequent. In addition pathotype 77-5, 12-2 and 104-2 were also identified in many samples. Fifteen other pathotypes were identified in the remaining samples. In Maharashtra pathotype 12 was most frequent followed by pathotype 77-5 whereas other pathotype were

Table 6.2. Pathotype distribution of *Puccinia graminis tritici* (black rust) during 2013-2014

S. No.	State/ country	Samples analyzed	Pathotypes observed*									
			79G31 (11)	123G15 (15-1)	9G5 (21)	24G5 (21-1)	75G5 (21A-2)	62G29-1 (40-1)	58G13-3 (40-2)	127G29 (40-3)	62G29 (40A)	NP**
1	Tamil Nadu	56	-	-	-	-	-	3	-	8	43	2
2	Karnataka	70	69	-	-	-	-	-	1	-	-	
3	Maharashtra	14	8							1	5	
4	Gujarat	8	1	-	-	-	-	1	-	1	5	
5	Madhya Pradesh	15	2	1	-	-	2	1	2	3	4	
6	Uttar Pradesh	2	2	-	-	-	-	-	-	-	-	
7	Uttarakhand	36	8	-	3	21	4	-	-	-	-	
8	Rajasthan	6	-	-	-	5		-	-	-	1	
9	Himachal Pradesh	5	-	-	-	2	2	-	1	-	-	
10	Nepal	6	2	-	1	1	1	-	-	-	1	
11	Bangladesh	5	-	-	-	2	3	-	-	-		
	Total	223	92	1	4	31	12	5	4	13	59	2

** Probable new pathotype

Table 6.3. Pathotype distribution of Puccinia triticina (brown rust) during 2013-2014

S. No.	State/ country	No. of Samples	Pathotypes observed*																												
			12(5R5)	12-1 (5R37)	12-2 (1R5)	12-3 (49R37)	12-4 (69R13)	12-5 (29R45)	12-6 (5R45)	12-9 (93R37)	12A (5R13)	77-1 (109R63)	77-2 (109R31-1)	77-3 (125R55)	77-4 (125R23-1)	77-5 (121R63-1)	77-6 (121R55-1)	77-9 (121R60-1)	77-10 (377R60-1)	77-11 (125R28)	77-12 (121R52-1)	77A (109R31)	77A-1 (109R23)	104-2 (21R55)	104-3 (21R63)	104-4 (93R57)	104A (21R31)	104B (29R23)	162 (93R07)	162-1(93R47)	162-2(93R39)	162A(93R15)
1	Tamil Nadu	71										1				12	8	40			9									1		
2	Karnataka	185	36	2	14	3	2	1	1		1	1	1	1	1	21	3	38		29	3	2	2	15	2		1		3		2	
3	Maharashtra	52	28				1				1			1		7	1	3	1	4				3			1				1	
4	Gujarat	19											2			5								10					1		1	
5	Madhya Pradesh	73	1									1				2	3	3		1				45	10		1	2	2		2	
6	Bihar	10							1				2			4								2	1							
7	West Bengal	15														9	5															1
8	Chhattisgarh	2											1			1																
9	Rajasthan	29														7	2	2						11	2					4	1	
10	Uttar Pradesh	75	1	2				1		1		3		1		25	1	8						22	4				1	3	1	
11	Haryana	16				2	1							1		3		1		1				3	1	2						1
12	Uttarakhand	36		3						2		2				6	1							11	5	1			1		2	
13	Punjab	7				1						1		2		1		1						1								
14	Himachal Pradesh	47		1						1		1		2		14	5			1				14	5	2						1
15	Jammu Kashmir	3								2														1								
16	Nepal	64	1			2	2							1		39		2						13	2		1		1			
17	Bhutan	17		1												15	1															
18	Bangladesh	72		4	2	2	2					1		2		35	1							6	10	1	1			3		2
	Total	793	67	13	16	10	8	2	2	6	2	11	6	11	1	206	31	98	1	36	12	2	2	157	42	6	6	2	9	11	10	5

*In one sample each pathotype 108-1(57R27) and 12-7(93R45) were observed from U.P. and Uttarakhand, respectively identified in few samples only. Contrarily pathotype 104-2 was predominant in Gujarat, Rajasthan and Madhya Pradesh. Based on the analysis of 25 samples from North eastern states of Bihar and West Bengal pt 77-5 was the most predominant. In Uttar Pradesh, pts. 77-5 and 104-2 were identified in 33 and 29% of the samples, respectively. Twelve other pathotypes were detected in few samples only. In Uttarakhand, pathotype 104-2 was most frequent whereas in Himachal Pradesh pt 77-5 and 104-2 were more predominant with equal frequency. In Punjab, pt. 77-3 was found in maximum number of samples. In Jammu & Kashmir, pathotype, 12-9 occurred in two samples whereas 104-2 in one sample analyzed. In Nepal, Bhutan and Bangladesh pathotype 77-5 and 104-2 were identified in maximum numbers of samples whereas fifteen other pathotype were identified in few samples only (Table 6.3).

New pathotypes

In few samples from the Nilgiri hills, a new pathotype designated as 77-12 was identified. The new pathotype is close to the pathotype 77-9 but is avirulent to *Lr*20. In a sample from Maharashtra, a new pathotype, designated as 77-13 was identified. This pathotype appears to be the result of a loss of virulence on *Lr*26 in the pathotype 77-10, which has virulence to *Lr*28. Further studies on rust resistance, avirulence/virulence structure are being undertaken.

Predominant pathotypes of *Puccinia* on wheat in India

During 2013-14, in *Puccinia striiformis* (yellow/stripe rust of wheat), the 46S119 was the pre-dominant pathotype followed by 78S84 (Table 6.4). In *Puccinia triticina* (brown/leaf rust of wheat) pathotype 77-5 (121R63-1) was the most predominant followed by pathotype 104-2 (21R55). In *Puccinia graminis tritici* (black/stem rust of wheat) pathotype 11 (79G31) was most predominant in Northern India followed by pathotype 40A (62G29).

Table 6.4. Predominant pathotypes of Puccinia on wheat in India

Wheat Rusts	Predominant pathotypes
Yellow	46S119 followed by 78S84 (virulent on PBW343) in Northern India
Brown	121R63-1(77-5) followed by 21R55 (104-2), 121R60-1 (77-9)
Black	79G31(11), 62G29(40A)

Evaluation for rust resistance

This year, 3552 lines of wheat and barley, which includes AVT, NBDSN, EBDSN and breeder's material were evaluated for rust resistance (Fig. 6.1).

Fig. 6.1. Evaluation for rust resistance

Evaluation of AVT material

i. Rust resistance

To identify rust resistant lines of wheat and to characterize rust resistance genes, 93 lines of AVT-II and 107 lines of AVT-I of wheat were evaluated against different pathotypes. A wide spectrum of pathotypes of black rust (*Puccinia graminis tritici*), Brown rust (*Puccinia triticina*) and Yellow rust (*Puccinia striiformis*) of wheat, having different avirulence/virulence structure were used in the studies. Resistance to all the rusts was observed on PBW703 of AVTI. Nine other lines were resistant to two of the rusts whereas 31 lines were resistant to one or other rust. All wheat lines were possessing *Sr*31 resistance to black rust, whereas those possessing *Lr*24 and some with *Lr*26 were resistant to brown rust. Some of the lines with *Yr*9 were resistant to yellow rust pathotypes also.

AVT II Year

a. **Resistant to brown and black rusts :** HI 1544, HI 1563
b. **Resistant to brown and yellow rusts :** PBW 681
c. **Resistant to yellow rust only :** PBW 660(I)(C)
d. **Resistant to brown rust only :** HD 2864

AVT I Year

a. **Resistant to all the rusts :** PBW 703.
b. **Resistant to brown and black rusts :** UP 2891, HUW 677
c. **Resistant to yellow and brown rusts** : PBW 697, PBW 698, PBW 722, PBW 723
d. **Resistant to yellow rust only :** HD 3128, HD 4728, HPW 411, HS 592, HS 593, HS 594, HUW 675, HUW 693, HW 1099, K 1204, MACS 3927(D), PBW 692,

PBW 701, PBW 702, VL 1003, VL 1004, VL 3002

e. **Resistant to black rust only:** All the lines possessing *Sr*31, HPW 401, HPW 410, HS 547, TL 2942, TL 2969, TL 2998, TL 2999 and TL3000 were resistant to black rust.

f. **Resistant to brown rust only :** HD 3133, CG 1010, GW 451, GW 455

ii. Rust resistance genes in AVT lines

Rust resistance genes (*Lr, Sr, Yr*) were characterized by using gene matching technique. Rust resistance genes could be characterized only in the lines where differential host-pathogen interaction was present. However, genetic linkage, morphological markers, characteristic infection types and pedigree also formed the basis for postulating rust resistance genes in absence of host pathogen differential reactions. Overall diversity for rust resistance genes in AVT lines has been presented in Table 6.5.

Table 6.5. Diversity for rust resistance

Rust	No. of lines	Number of genes inferred:	Details of resistance genes*
Yellow	147	5	*Yr*2, *Yr*9, *Yr*A, *Yr*18, *Yr*27
Black	182	14	*Sr*2, *Sr*5, *Sr*7b, *Sr*8a, *Sr*9b, *Sr*9e, *Sr*11, *Sr*12, *Sr*13, *Sr*24, *Sr*25, *Sr*26, *Sr*30, *Sr*31
Brown	164	12	*Lr*1, *Lr*2a, *Lr*3, *Lr*10, *Lr*13, *Lr*14a, *Lr*18, *Lr*19, *Lr*20, *Lr*23, *Lr*24, *Lr*26

Yr genes

AVT II: In AVT II material, 5*Yr* genes/patterns were characterized in 71 lines. *Yr*2 was found to confer resistance in maximum number of lines (46). However, this gene is susceptible to many of the virulent pathotypes. *Yr*9 which is linked to *Lr*26 and *Sr*31 was postulated in 21 lines. Other resistance genes like *Yr*A, *Yr*18, *Yr*27, were postulated in few lines only.

AVT I: Four *Yr* genes were postulated in 76 lines of AVT I material. Among these *Yr*2 was inferred in 47 lines. *Yr*9 which is linked to *Lr*26 and *Sr*31 was identified in 17 lines. *Yr*A was characterized in 15 lines whereas *Yr*27 was identified in 2 lines only.

Sr genes

AVT II: Eleven *Sr* genes (*Sr*2, 5, 7b, 8a, 9b, 9e, 11, 12, 13, 24, 31) were characterized in 83 lines. *Sr*11 was postulated in 33 lines followed by *Sr*2 and *Sr*31 in 27 and 21 lines, respectively. Postulation of *Sr*2 is based on characteristic micro-flecking. Postulation of *Sr*31 is based on its linkage to *Lr*26 and *Yr*9. *Sr*9b was identified in 12 lines, *Sr*7b in 9, *Sr*5 in 7, *Sr*8a and *Sr*9e in 6 lines each. *Sr* 24 was inferred in 5 lines whereas *Sr*12 and *Sr*13 in one line each. Most of the durum wheat varieties had resistance based on *Sr*7b, *Sr9e*, *Sr*11, *Sr* 12 and *Sr*13.

AVT I: Twelve *Sr* genes (*Sr*2, 5, 7b, 8a, 9b, 9e, 11, 13, 25, 26, 30, 31) were characterized in 99 lines. *Sr*11 was postulated in 50 lines followed by *Sr*2 and *Sr*9b in 42, 19 lines, respectively. Postulation of *Sr*31 is based on its linkage to *Lr*26 and *Yr*9 was identified in 17 lines whereas *Sr*7b in 17 lines. *Sr*13, *Sr*8a were postulated in 13 and 3 lines, respectively. Other resistance genes *Sr*9e, *Sr*25, *Sr*26 and *Sr*30 were postulated in one line each. Most of the durum wheat varieties had resistance based on *Sr*7b and *Sr*11.

Lr genes

AVT II: Nine *Lr* genes (*Lr*1, 3, 10, 13, 18, 23, 24, 26, 34) were characterized in 77 lines. Most of the lines possessed more than two resistance genes. *Lr*23 was the most common resistance gene and was characterized in 37% of the lines followed by *Lr*13 (28 lines). The proportion of lines with *Lr*26 has reduced and was identified in 21 lines only. Likewise *Lr*10 was inferred in 17 lines, *Lr*3 in 3 lines, whereas *Lr*24 and *Lr*34 were postulated in 5 lines each. *Lr*18 was inferred in one line only.

AVT I: Ten *Lr* genes (*Lr*1, 2a, 10, 13, 14a, 18, 19, 20, 23, 26) were characterized in 87 lines. Many of the lines possessed combination of resistance genes. *Lr*13 was the most common resistance gene and was characterized in about 39% of the lines followed by *Lr*23 (28 lines), *Lr*10 was postulated in 20 lines, whereas *Lr*26 was characterized in 17 lines. The proportion of lines with *Lr*26 has reduced. *Lr*1, *Lr*18 were postulated in 12 and 4 lines, respectively. *Lr*2a, *Lr*14a, *Lr*19 and *Lr*20 were inferred in one line each.

Gene pyramiding and genetic analysis for rust resistance

Characterization of genetically diverse sources of rust resistance has been integral part of the breeding programme for rust resistance in wheat. Validation of available markers is being done for developing rust resistant genetic stocks. In a search for new sources of resistance, wheat germplasm and advanced varietal trial lines are regularly evaluated for seedling and adult plant resistance to three rusts at the IIWBR Regional Station, Shimla. The study was conducted during 2012-13 and 2013-14 under greenhouse conditions. Based on seedling resistance test against important pathotypes of the three rusts and gene postulation nineteen genotypes namely AKDW 4749, HI 8713, HI8726, HI 8727, MACS 3828, MACS5008, DDK 1009, DDK 1042, WHD-946, UAS 320, UAS 347, VL3002, HD2189, HD3076, NW5054, NIAW 1951, PBW683, PDW314, RNB1001 were identified as novel sources of resistance to leaf rust and were used for crossing with Local Red

(Durum line susceptible to all the races of leaf rust) and LWH (Bread wheat susceptible line) to generate mapping population for genetic analysis. Using SSR markers two F_3 mapping population namely LWH /Lok-1 and Agra Local/NI5439 are being analyzed for possessing potential source of new resistance gene against leaf and black rusts, respectively. Thirty one different crosses were made during wheat season 2013-2014. Among the crosses made nine combinations were among *Triticum aestivum* genotypes, seven crosses between *T. durum* genotypes and universally susceptible LWH (Local Wheat Hango) for genetic analysis of brown rust resistance. Beside these 25 crosses were attempted to incorporate rust resistance/develop resistance stock of wheat during 2013-14. The rust resistance genes which are being transferred/incorporated in different backgrounds are *Yr*24, *Yr*UN, *Sr*26, *Sr*32, *Sr*39 and *Sr*43. Fourteen segregating populations viz. HI1500/ *Sr*43 (F6), NI5439/Eagle *Sr*26 (F_6), Lok-1/ *Sr*39 (F_4), Lok-1/*Sr*32 (F_3), Lok-45/Kite (F_3), Lok-45/*Sr*32 (F_4), HI1500/*Sr*32 (F_5), Raj 3765/ Eagle *Sr26* (BC_2F_3), *Yr*2/Kalyansona (F_3), Lok-1/ Kite *Sr26* (F_3), HI1077/Kite (F3), Raj 3765/Kite (F3) and NI5439/Kite (F_3) were evaluated for rust resistance against the pathotypes of rusts and plant characters. Selected plants were used for generation advancement to pyramid genes of rust resistance.

Development of rust resistant genetic stocks

Six wheat rust resistant genetic stocks (FLW10, FLW16, FLW18, FLW21, FLW22 and FWW2) developed by DWR, Shimla were screened for seedling resistant test against virulent pathotypes of black, brown and yellow rusts (Fig. 6.2). The seedling response of these stocks is depicted in Table 6.6. Multi location field evaluation of genetic stocks was conducted at Wellington (Tamil Nadu), Karnal (Haryana) and Shimla (Himachal Pradesh). All these stocks were found to be resistant to virulent pathotypes of wheat rusts and showed superiority in morpho-agronomic characters (Table 6.7). All these genetic stocks are in the pipeline for registration at National Bureau of Plant Genetic Resources (NBPGR, New Delhi) and will serve as the

Table 6.6. Seedling resistance test and field evaluation of genetic stocks with virulent pathotypes of brown, black and yellow rusts

Genetic stock	Brown rust							Black rust					Yellow rust				
	SRT					APR		SRT			APR		SRT			APR	
	77-2	77-5	77-7	77-8	104-2	W-04	K-05	40A	40-1	117-1	W-04	K-05	78S84	46S103	46S119	W-04	K-05
FLW10	0;	3'	3'	0;	3'	40S	30S	2	2	2	15MR	0	0;	0;	0;	R	R
FLW16	0;	3'	3'	3'	3'	40S	30S	2	2	2	15MR	0	0;	0;	0;	R	R
FLW18	0;	0;	0;	0;	0;	R	R	2	2	2	15MR	0	3+	0;	;2	10MR	R
FLW21	;	;1	;1	;1	;1	R	R	2	2	2	10MR	0	0;	0;	0;	R	R
FLW22	0;	0;	0;	0;	0;	R	R	2	2	2	10MR	0	0;	0;	0;	R	R
FWW2	0;	0;	0;	0;	0;	R	R	2	2	2	5MR	0	;	0;	3'	R	

R	Resistance	; ;1 ;2 2	Resistance	77-2	109R31-1	40A	62G29
MR	Moderate Resistance	3'	Susceptible	77-5	121R63-1	40-1	62G29-1
S	Susceptible	W-04	Wellington 2004	77-7	121R127	117-1	166G2
0	Free from rust/No rust response	K-05	Karnal 2004-05	77-8	253R31	SRT	Seedling resistance test
0;	Immune			104-2	21R55	APR	Adult plant resistance

Table 6.7. Specific and morpho-agronomic characters of genetic stocks

Genetic stock	Pedigree	Specific character	Genes for rust resistance	Days to maturity	Plant height (cm)	1000 grain weight (g)	Yield/ m (g)	Grain colour
FLW10	(WH542/Moro (Yr10))	Resistant to black and yellow rusts	Lr26(M), Sr31, Yr9+Yr10*	118	75	39.7	98	Amber
FLW16	(UP2338/Triticum spelta album (Yr5))	Resistant to black and yellow rusts	Lr26 (M), Sr31, Yr9+Yr5*	120	78	38.1	93	Amber
FLW18	(PBW343/Lr39 (KS92WGRC15))	Resistant to black and brown rusts	Lr26 (M)+Lr39*, Sr31, Yr9+YrPBW343	125	89	38	98	Amber
FLW21	(UP2338/Centurk// UP2338/Yr15)	Resistant to brown, black and yellow rusts	Lr28+Lr26(M), Sr24+Sr31, Yr9+Yr15*	122	91	37.3	118	Non-amber
FLW22	(WH542/Lr28//WH542 /China84-40022)	Resistant to brown black and yellow rusts	Lr24+Lr26(M), Sr24+Sr31, Yr9+Yr china84*	118	90	38.4	116	Amber
FWW2	(PBW343/PH137)	Resistant to black and brown rusts	Lr19+Lr26 (M), Sr31, Yr9**	118	85	40.6	138	Amber

* Resistance derived from winter wheat
**Additional resistance factor
M Validated with molecular marker

Fig. 6.2. Development of rust resistant genetic stocks

basic material for pyramiding of wheat rusts resistance genes. The major characteristics of these genetic stocks are summarised below.

FLW10 was derived from the cross between WH542 and Moro (*Yr*10). Wheat rust resistance genes like *Lr*26, *Sr*31, *Yr*9 and *Yr*10 have been confirmed in it. It was found to be resistant to all the pathotypes of black and yellow rusts. Yield per meter row was slightly less than WH542.

FLW16 developed from cross between UP2338 and *Triticum spelta album* (*Yr*5), was found to be resistant to virulent pathotypes of black (40A, 40-1 and 117-1) and yellow (78S84, 46S103 and 46S119) rusts. FLW 16 carries *Lr*26, *Sr31*, *Yr*9 and *Yr*5 genes for wheat rust resistance.

FLW18 is developed from cross between PBW343 and *Lr*39 (KS92WGRC15). It is completely resistant to black and brown rusts and partially resistant to yellow rust of wheat. In addition to *Lr*39 gene from KS92WGRC15 it also carries *Sr*31, *Yr*9 and *Yr27*. Its yield is slightly less than PBW343.

FLW21 is derived from double cross between UP2338/Centurk and UP2338/*Yr*15. Till date this stock along with FLW22 is the only wheat line or stock available in India having resistance to all the three rusts of wheat. In addition to *Yr*15, it also carries *Lr*24, *Lr*26, *Sr*24, *Sr*31, *Yr*9 and *Yr*15. This stock has red seed with test weight of 37.3 g.

FLW22 is developed through double cross between WH542/*Lr*28 and WH542/China84-40022. This stock is also resistant to all the three rusts of wheat. It carries *Lr*28+*Lr*26, *Sr*31, *Yr*9 and Yr China84 genes for wheat rusts resistance. Its average plant height is 90 cm and matures in about 118 days. The average yield per meter row is at par with WH542.

FWW2 is derived from cross between PBW343 and PH137. It is resistant to brown and black rusts. It carries *Lr*19, *Lr*26, *Sr31* and *Yr*9 genes for wheat rusts resistance. Average plant height of this stock is about 85 cm with test weight of 40.6 g. FWW2 matures in 118 days and per meter row yield is slightly less than PBW343.

Studies on DNA polymorphism in wheat rust pathotypes

Studies on molecular variability among yellow and brown rust pathotypes was carried forward during the period under report. Among the 26 yellow rust specific SSR (ST-SSR) primer pairs tested against selected yellow rust pathotypes, polymorphic ones were

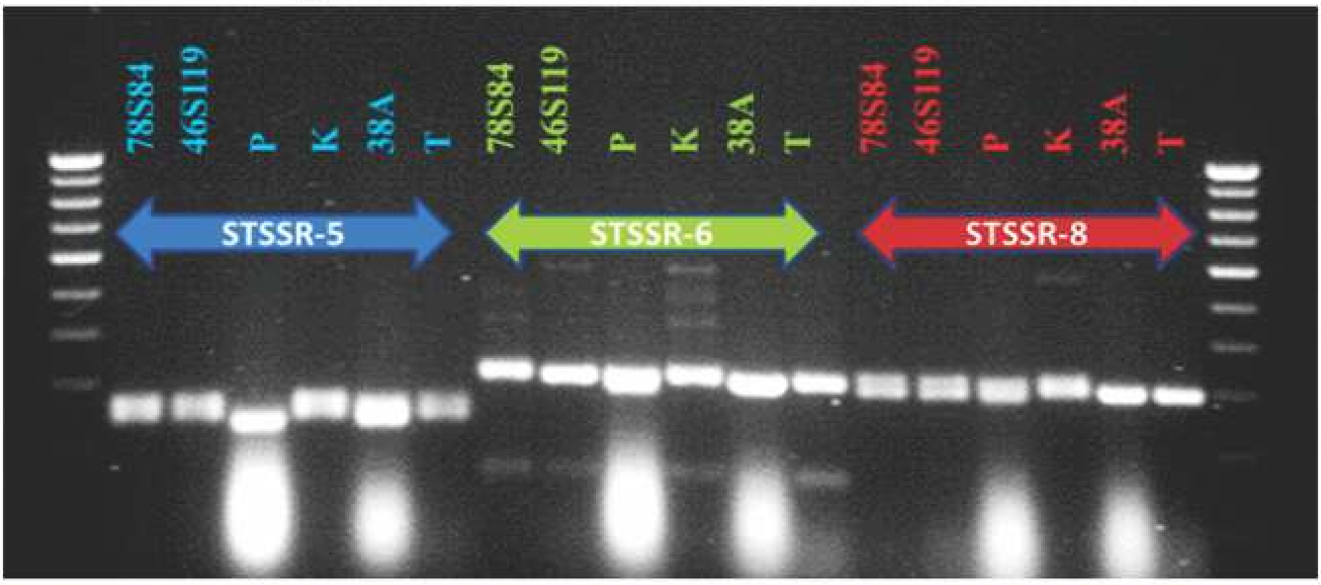
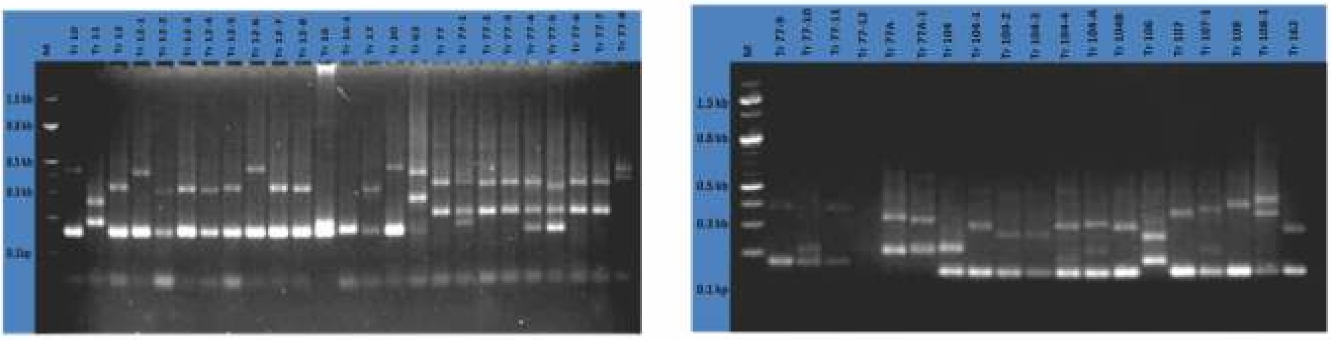


Fig. 6.3. Variability among yellow rust races. Polymerase chain reaction (PCR) amplification was performed using the yellow rust specific SSR Primer (STSSR-5, 6 and 8). PCR products were separated in 3% super MT4 agarose horizontal gel electrophoresis.

studied against predominant yellow rust pathotypes. The PCR product was resolved in 3% super MT4 agarose (Life Technologies). Some of the primers clearly differentiated among yellow rust pathotypes (Fig. 6.3).

Twenty five primers were used to study variability among brown rust pathotypes. Initially, out of 25 SSR (TR-SSR) primer pairs, 06 were found to be polymorphic to selected brown rust pathotypes. These six primer pairs were further tested against all the brown rust pathotypes. The PCR product was resolved in 3% super MT4 agarose (Life Technologies) instead of normal agarose, which in earlier attempts was not able to resolve the DNA bands properly. Some of the primers clearly differentiate among brown rust pathotypes. Interestingly, the banding pattern with some primers in a group of pathotypes with similar pathogenicity/virulence was more or less similar with some exceptions (Fig. 6.4). Out of twenty six SSR (ST-SSR) primer pairs tested against selected yellow rust pathotypes, very few were polymorphic. These polymorphic primers are under further testing against all the yellow rust pathotypes. In addition, total DNA was isolated from more than 100 different grasses, showing rust (yellow, brown, black) like infection. Attempts were made to amplify the DNA from these grasses using *Puccinia striiformis* and *Puccinia triticina* specific SSR primers. But there was no amplification in any of the samples, ruling out the probable association of *Puccinia striiformis* and *Puccinia triticina* with rusts on these grasses.

An analysis of polymorphism among brown rust pathotypes based on SSR analysis and their infection types on brown rust differential sets and the clustering in the same was done in the form of dendrogram (Fig. 6.5). To carry out analysis in NTSys, infection types of the pathotypes on differential sets, '0' and '1' was assigned for resistant and susceptible reaction, respectively.



'A' 'B'

Fig. 6.4. Variability among leaf rust races. Polymerase chain reaction (PCR) amplification was performed using the Brown rust Specific SSR Primer (TRSSR-16). PCR products were separated by 3 % Super MT4 Agarose horizontal gel electrophoresis.

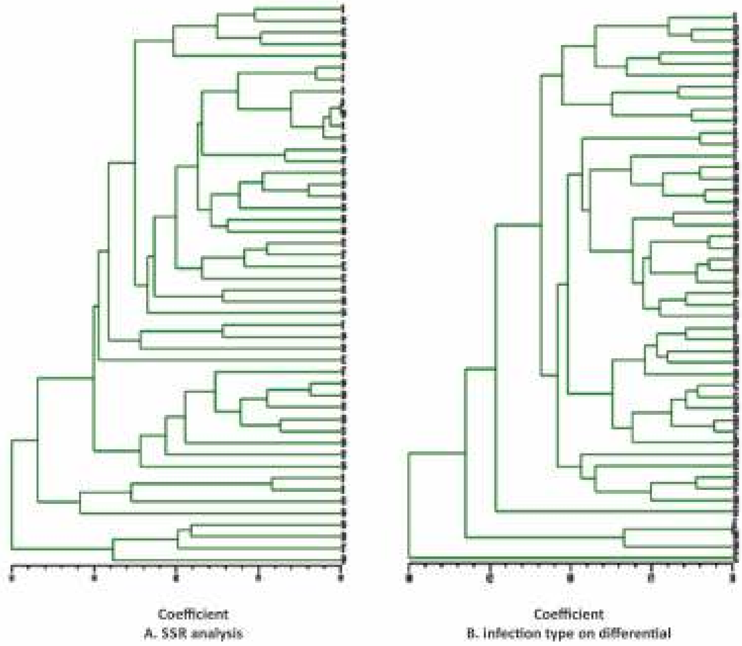


Fig. 6.5. Dendrogram showing clustering of brown rust pathotypes on the basis of SSR marker analysis and infection type on differentials (Sample Id's pathotypes are explained at Table 6.8).

Table 6.8. Description of sample id's used in the dendrogram

Sample Id.											
S1	10	S9	12-6	S17	77	S25	77-8	S33	104-1	S41	107-1
S2	11	S10	12-7	S18	77-1	S26	77-9	S34	104-2	S42	108
S3	12	S11	12-8	S19	77-2	S27	77-10	S35	104-3	S43	108-1
S4	12-1	S12	16	S20	77-3	S28	77-11	S36	104-4	S44	162
S5	12-2	S13	16-1	S21	77-4	S29	77-12	S37	104A	S45	162-1
S6	12-3	S14	17	S22	77-5	S30	77A	S38	104B	S46	162-2
S7	12-4	S15	20	S23	77-6	S31	77A-1	S39	106	S47	162-3
S8	12-5	S16	63	S24	77-7	S32	104	S40	107	S48	162A

National repository of rust pathotypes

More than 127 pathotypes of three rust pathogens of wheat, barley, rusts of oat, linseed were maintained in pure form as live cultures (Fig. 6.6.) and also cryo-preserved for long term storage. Nucleus and bulk inocula of urediospores were supplied to 56 Scientists in different parts of India.

Fig. 6.6. Multiplication of nucleus inoculum

Wheat disease monitoring nurseries

To monitor the occurrence of different diseases of wheat in SAARC countries during 2013-14, wheat disease monitoring nursery was planted at 28 locations across the six SAARC countries viz. Afghanistan, Bangladesh, Bhutan, India, Nepal and Pakistan. Data from Pakistan, Bhutan and Afghanistan are awaited. Wheat disease monitoring nursery was also planted at 70 locations in strategic areas in India. The areas bordering to neighboring countries, hotspot locations and main wheat belt have been taken care of. Like previous year, wheat rusts appeared almost one month late during 2013-14. There was not much change in wheat disease situation in comparison to the preceding years.

7. REGIONAL STATION DALANG-MAIDAN, LAHAUL-SPITI

The IIWBR, Regional Station located at Dalang Maidan, Lahaul & Spiti, Himachal Pradesh act as a national service centre for providing various kind of support to wheat and barley researchers of the country. This station has been established as a wheat summer nursery facility for generation advancement, corrective crossing, seed multiplication and evaluation of breeding material during offseason to reduce time lag for the development of a variety.

Generation advancement of wheat and barley

During the period of May-October, 2014, about 49,553 lines of wheat, barley and mustard from 20 co-operators of different institutes were advanced at IIWBR Regional Station, Dalang Maidan, which was all time high (Fig.7.1). The material from all the six zones was advanced at the station. The maximum material was obtained from North Western Plains Zone (86%) followed by Northern Hills Zone (7%) and Central Zone (3%). Apart from this some wild species were also grown at the centre. The major centers which utilized the national facility were IIWBR, Karnal; IARI, New Delhi; CCSHAU, Hisar; VPKAS, Almora and NABI, Mohali (Fig. 7.2).

Corrective hybridization

During this season of year 2014 about 1000 corrective crosses were attempted by the researchers across the institutes. More than 50% crosses were attempted by IARI, New Delhi. A new initiative for doubled haploid production was initiated by the scientist of IIWBR in which 400 spikes of wheat were crossed with maize.

Screening wheat and barley material against rusts

The station inherently a good location for screening yellow rust and powdery mildew. Around 20,000 lines were screened by various centers for yellow rust. The maximum lines were from IARI, New Delhi followed by IIWBR, Karnal and PAU, Ludhiana. This season also showed that it can also act as screening centre for powdery mildew.

Natural repository for wheat and barley germplasm

The Regional Station acts as natural repository for wheat and barley germplasm and at present 9000 wheat accessions and 2000 barley accessions are being conserved and maintained here under natural conditions. More than 90% germination was recorded in germplasm accessions after eight years of storage at Dalang Maidan.

Centre for high altitude wheat and barley varietal trials

During the year under report, 06 entries were evaluated in four replications under AVT-TS-VHA 2014 trial.

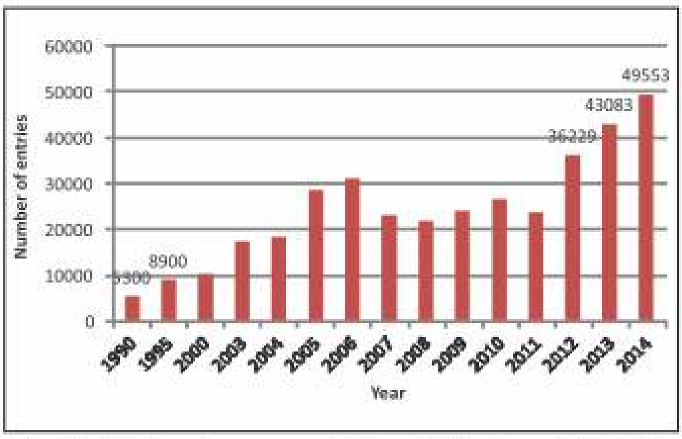


Fig. 7.1. No. of entries grown at Dalang Maidan from 1990-2014

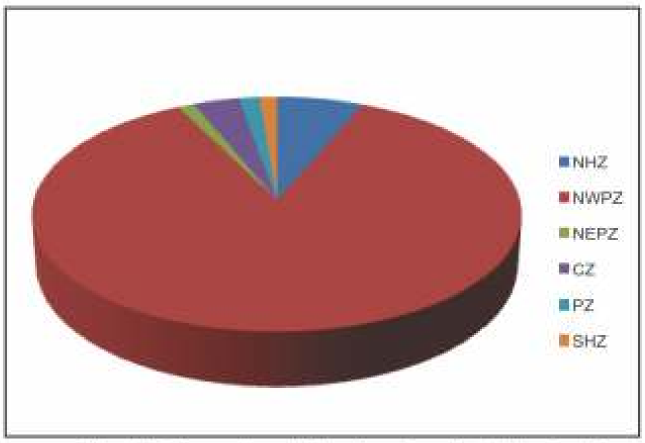


Fig. 7.2. Zone wise distribution of material planted at Dalang Maidan in Summer, 2014

8. BARLEY

The Barley Network Unit at IIWBR 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 and 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 quality evaluation for the network centres is the most important activity of IIWBR. Updating the package of practices for barley cultivation and standardizing optimum inputs for new genotypes are achieved through agronomic trials. The barley growing areas in country is grouped under four major zones *i.e.* North Western Plains Zone (NWPZ), North Eastern Plains Zone (NEPZ), Central Zone (CZ) and Northern Hills Zone (NHZ) with respect to prevailing climatic conditions and /or the disease/ pest spectrum.

The research efforts of the barley network are also supplemented by IIWBR 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. 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, IIWBR also has linkages with international organizations like ICARDA to facilitate the access to new germplasm of diverse origin from various sources 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 and organized at desired locations under AICW&BIP.

Barley varieties identified

Three new barley varieties namely DWRB 101, RD 2849 and BH 959 were identified during 53rd All India Wheat and Barley Research Workers Meet at Jabalpur (Table 8.1).

Table 8.1. Barley varieties identified during 53rd All India Wheat and Barley Research Workers Meet at Jabalpur

Variety	Pedigree	Production Conditions/ Zone	Potential Yield (q/ha)	Average Yield (q/ha)
DWRB 101	DWR28BCU 73/PL172	Timely sown Irrigated Malt/NWPZ	67.4	50.1
RD 2849	DWRUB 52/PL 705	Timely sown Irrigated Malt/NWPZ	68.5	50.9
BH 959	BH 393/BH 331	Timely sown Irrigated condition/CZ	67.5	49.9

Coordinated yield trials

Out of 119 yield evaluation trials proposed, 109 (91.6%) trials were conducted. Ten trials were either not conducted/failed and data were not received in time. After the analysis, only 94 trials (79.0% of proposed 86.2% of conducted) were found good for reporting. These trials were conducted at 12 main centres and 37 testing centres (including ICAR, SAUs and State Department of Agriculture) during *rabi* 2013-14.

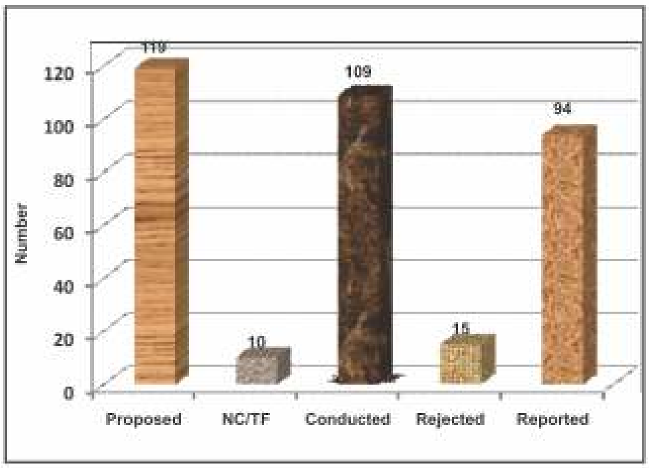


Fig. 8.1. Details of barley coordinated yield trials

In all 124 test entries contributed by 12 centres, were evaluated against 26 checks in the coordinated yield trials under rainfed (plains and hills), Irrigated (plains) and saline soils conditions under timely/ late sown conditions. The promising barley entries were identified in these trials (Table 8.2). The barley entries include malt, feed or dual purposes types and mostly were hulled type with a few hull-less types in northern hills zone.

Table 8.2. Promising genotypes in various barley coordinated trials during 2013-14

Trial Series (AVTs/IVTs)	Promising entries
AVT-MB –TS-NWPZ	PL874, BH976
IVT-MB -TS	DWRB123, DWRB124, DWRB128, RD2891
IVT-DP	KB1369

Zonal monitoring

The teams constituted for monitoring of Barley Network Yield Trials & Nurseries in central zone, NWPZ and NEPZ, visited different locations of different zones at the most appropriate stage of the crop (Table 8.3) and recorded observations about the varietal performance, conduct of trials, disease/ pest incidence and genetic purity of the test entries. On the spot decisions were taken about the rejection of trials and purity of test entries through consensus.

Table 8.3. Visit of the zonal monitoring teams

Zone	Dates	Centres visited
CZ	16-19, February 2015	SK Nagar, Udaipur, Banswara, Bhilwara and Kota
NEPZ	21-23, February , 2015	Dalipnagar, Kanpur, Faizabad, Varanasi, Tissuhi and Mirzapur
NWPZ Team I	25-27 February, 2015	Agra, Mathura, Durgapura, Tabiji, Nav
NWPZ Team II	8-11 March, 2015	Durgapura, Hisar and Ludhiana
NWPZ Team III	10-11 March, 2015	Karnal, Modipuram and Pantnagar

Breeder seed production

A consolidated indent of 862.45q breeder seed of 42 varieties was received from Deputy Commissioner (Seeds), DAC, MoA, Govt. of India. The indent included requirement of 10 states, 2 public sector corporations and private agencies for the season *rabi*, 2013-14 (Fig.8.2). The major proportion of the breeder seed indent was for Seed Association of India (328.25q) followed by Rajasthan state (312q), State Farm Corporation of India, New Delhi (59q), Madhya Pradesh (40q) etc. A total breeder seed for production of 843.10q for 38 varieties was allocated for production at 10 seed producing centres over seven states. In view of availability of high yielding and resistant varieties, breeder seed indent for very old varieties viz. BH 75 (1985) and PL 172 (1987) was not accepted unanimously, while due to unavailability of the nucleus seed, the indent for varieties Dolma and DL 88 could not be honoured.

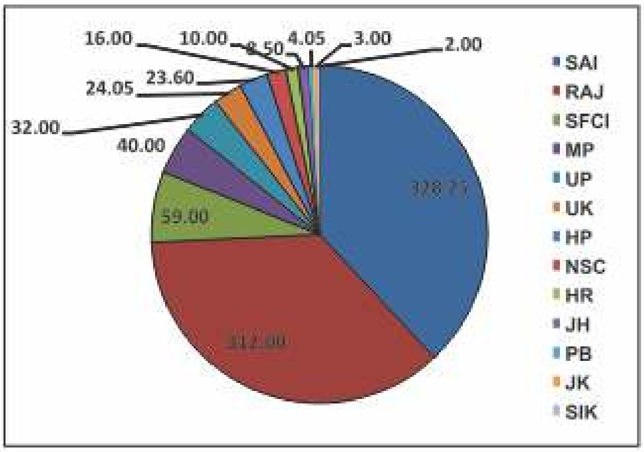


Fig. 8.2. Proportion of various breeder seed indented by various agencies

A net production of 1782.64q breeder seed against allocated varieties was reported, which was surplus (939.54q) in comparison to the allocated quantity. However, breeder seed of the varieties namely HBL 316, HBL 391, K 508, NDB 209, NDB 1020, PRB 502 and UPB 1008 was not produced at their originating centres as per allocation. The maximum production was observed for variety RD 2552 (370 q) followed by RD 2035 (307 q), RD 2715 (224q), RD 2660 (180q) etc. However, a deficit seed production was reported for varieties DWRUB 64 (-9.40q), VL 85 (-8.82q), RD 2786 (-8.00q), RD 2668 (-7.00q) etc. at different production centres.

A total 67.28 q nucleus seed production of 37 varieties was reported. The maximum nucleus seed production was observed for variety PL 426 (7.50q) followed by RD 2552 (5.23 q), RD 2715 (4.52 q), RD 2794 (4.30 q), RD 2592 (3.77 q) etc. In addition, test stock multiplications for the varieties viz. DWRB 92 (141.60q), HUB 113 (17 q), BH 946 (77 q) and BHS 400 (52.80q) were also reported from State Farms Corporation of India Ltd.

Germplasm maintenance exchange and evaluation

Plant germplasm is pre-requisite for any crop improvement programme. Presently, development of modern varieties is the main reason of reducing the variation, due to which varieties become vulnerable to the diseases. Similarly, 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 search the genetic diversity for its continuous improvement. At the IIWBR the following activities were carried out in this regard:

Rejuvenation

Germplasm plays an important role for crop improvement. For utilization of genetic resources in breeding programmes, it becomes necessary to ensure proper storage and viability of the germplasm accessions maintained in the germplasm repository of IIWBR. Rejuvenation of available germplasm is a high priority regular activity. During the crop season, 582 accessions were rejuvenated for maintenance of germplasm under active collection at IIWBR, Karnal. Concurrently, 230 accessions were evaluated for yield and its component traits at IIWBR farm, Hisar. Nine accessions of barley wild species were conserved in mid-term storage during the crop season.

Conservation

A total collection of 8159 barley germplasm accessions are being conserved in mid-term storage (MTS) facility for 6-8 years at 4 ± 2°C temperature with 35 ± 5% relative humidity. During the crop season, new BCU numbers (15) were added in active collections at IIWBR. Simultaneously, 520 accessions of barley germplasm were sent for conservation in natural conditions at Lahul Spiti.

National and International Nurseries

National Barley Genetic Stock Nursery (NBGSN)

The NBGSN including the promising entries from network centres was constituted with 23 entries possessing donors for earliness, overall quality traits, higher test weight, good malting quality, grain plumpness, resistance to brown and black rust, resistance to brown and yellow rust, tolerance to saline/alkaline soils, grain and forage yield and its component traits. The nursery was supplied to all 11 centres under barley network and all centres viz., Bajaura, Durgapura, Faizabad, Hisar, Kanpur, Karnal, Ludhiana, Pantnagar, Rewa and Varansi supplied feedback of its utilization. Most of the entries were utilized by centres in their hybridization programme.

Elite International Barley Germplasm Nursery (EIBGN)

An elite international barley germplasm nursery was constituted with 45 genotypes selected from international trials/nurseries and evaluated at barley network centres. The nursery was supplied to all 11 cooperating centres. This nursery included the 45 testing entries viz., 6 entries each from IBYT-LRA-C and IBYT-LRA-M, 5 entries each from IBYT-HI, INBON and IBYT-MRA, 4 entries each from IBON-HI, IBON-LRA-M and IBON-MRA, 3 entries from ISEBON, 2 entries from INBYT, 1 entry from IBON-LRA-C and six checks namely, RD 2552, RD 2035, BH 902, DWRUB 52, DWRUB 64 and DWRB 73. Most of the entries were utilized by all centres either directly or in hybridization programme. They were also selected for further evaluation and use in breeding programmes. During field day 326 germplasm lines were selected by different breeders and subsequently were also supplied to the respective breeders for utilization in breeding programme.

Malt barley improvement

New varieties developed/released

A two-row malt barley variety DWRB 101for irrigated timely sown conditions of north western plains zone (NWPZ) was identified during 53rd AICW&B Worker's meet held at JNKVV, Jabalpur and subsequently also released during 70th meeting of CVRC. DWRB101 was found superior for grain yield (6.6%) to popular malt barley variety DWRUB 52 and differentiated by molecular markers viz. Bmac213, Bmag382, HVM40, MWG634, GMS61, Bmag337, Bmag500 etc.

Promotion of entries in Barley Network Trial

The entries submitted from the project have performed better in coordinated trials during *rabi*, 2013-14 crop season. The genotype DWRB 118 was evaluated in AVT-LS-MB first year and could not be promoted as DWRB 91 (check) ranked first. In IVT-TS-MB, three entries namely DWRB 123, DWRB 124 and DWRB 128 were evaluated and promoted for AVT-TS-MB during *rabi*, 2014-15. The details of performance of these entries in coordinated yield trials are summarized in Table 8.4.

Table 8.4. Performance of new entries under barley network trials

Genotype	Parentage	Yield (q/ha) (Mean & Range)	Rk	H. days	Tiller/ meter	LB (Ave.)
DWRB 123	DWRUB54/ DWR51	52.5 (36.27-67.26)	1	87	137	13
DWRB 124	DWRUB54/ DWRUB64	50.5 (36.23-64.35)	4	92	154	24
DWRB 128	DWRUB54/ DWRUB75	51.7 (42.79-64.24)	2	90	134	45
DWRUB 52 (c)	DWR17/ K551	49.4 (35.22-60.68)	8	90	137	13
BH 902 (c)	BH495/ RD2552	46.5 (32.99-57.21)	14	91	118	34

New strains contributed to the barley network yield trials (2014-15)

The efforts of the project had resulted in development of new strains which after qualifying in IIWBR Station Trials have been submitted for multi-location yield evaluation trials under Barley Network. During the year, ten new entries which performed better in station trials have been submitted from the project to coordinated trials during 2014-15 crop season (Table 8.5).

Table 8.5. New entries submitted to IVT during 2014-15

Coordinated No. (14-15)	Station Trial No. (13-14)	Trials
DWRB 132	BK 1301	IVT-MB-TS
DWRB 133	BK 1307	IVT-MB-TS
DWRB 134	BK 1308	IVT-MB-TS+LS
DWRB 135	BK 1313	IVT-MB-TS
DWRB 136	BK 1316	IVT-MB-TS+LS
DWRB 137	BK 1321	IVT-FB-IR
DWRB 138	BK 1325	IVT-MB-LS
DWRB 139	BK 1326	IVT-MB-TS
DWRB 140	BK 1329	IVT-MB-LS
DWRB 141	BK 1330	IVT-MB-TS+LS

Evaluation of parental lines and hybridization

A collection of 279 different lines was grown and evaluated for various morphological and agronomic traits as malt barley crossing block. The crossing block consists of genotypes representing diverse sources of yield, malting quality and resistance to diseases. In order to further enrich the collection, 52 new entries from ICARDA and ten exotic lines namely Scrable, Bambina, Passenger, Shakira, Zaraza, Thessa, Brennus, SC138 and 213750 were also included in the crossing block for malting quality and yield evaluation.

During the cropping season, 116 new crosses were attempted for yield, quality, disease/pest resistance, etc. Based on seed availability 94 F_1s were sent for advancement to F_2 and all were recovered from off season nursery. Various sources of resistance (aphid, rusts, blights and nematode) and early maturity have been utilized in hybridization programme. Two x six-row crosses for improvement of various parameters in both types of barleys, along with good malting qualities were also attempted.

During the cropping season, the breeding material in different generations (864 families representing 421 crosses involving several generations from F_1 to F_8) was grown and screened for stripe rust and leaf blights under artificial epiphytotic condition (Table 8.6). The single plant selections were made in different generations for phenotypic appearance, disease reactions. In all, 757 single plants representing 332 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 the desirable grain score, 648 single plant progenies representing 316 crosses were selected for generation advancement.

Table 8.6. Malt barley breeding material grown in rabi 2013-14

Gene-ration	Grown *rabi*, 2013-14		Selected			
			Field Selection		Grain Selection	
	Families	Crosses	Families	Crosses	Families	Crosses
F_8	3	1	1 (B)*	1	-	-
F_7	14	11	8 (B)+3	8	3	3
F_6	201	60	13(B) +124	53	104	47
F_5	148	64	108	56	97	55
F_4	267	146	159	92	146	91
F_3	272	79	210	75	172	73
F_2	60	60	153	47	126	47
F_1	64	64	-	-	-	-
Total	864	421	22 (B)+757	332	648	316

(B) Bulk made for station trials

Further, 22 promising genotypes were bulked for PYT and these 22 new bulks were grown at Lahaul (HP) & Wellington (TN) during the summer nursery 2014. The promising bulks (BK1401 to BK1422) were selected on the basis of grain quality, as well as off season nursery performance for further evaluation for yield and quality in the station trials during *rabi*, 2014-15.

New genetic resources

DWRB127 (BK1222) is an advance malt barley (two-row) high yielding genotype, which was developed by pedigree method (DWR45/DWR46) at IIWBR, Karnal and proposal has been submitted to PGRC, NBPGR for its registration. It was screened for disease resistance at multi-locations for consecutive two seasons viz. *rabi*, 2012-13 and 2013-14 under Initial Barley Disease Screening Nursery (IBDSN) and National Barley Disease Screening Nursery (NBDSN), respectively. During *rabi*, 2012-13, the genotype DWRB127 was evaluated at four locations namely, Bajaura, Durgapura, Dhaulakuan and Ludhiana and immune response (0 reaction) was observed for yellow rust under artificial inoculations. Similarly, during *rabi*, 2013-14, DWRB 127 was again evaluated under artificial inoculation for yellow rust and was found immune (0) at Durgapura, Dhaulakuan, Karnal, Hisar, Almora, Ludhiana and Bajaura centres. DWRB 127 also depicted a very high 1000 grain weight (53.8g) and overall malting quality scores (23/30). Some other yellow rust immune sources (0 reaction under artificial inoculation) namely DWRB 136 (BK 1316), DWRB 137 (BK 1321), DWRB 143 (BK 1333), DWRB 128 (BK 1229) and BK 1348 were also identified. These sources will be again confirmed during *rabi*, 2014-15 for stripe rust resistance under epiphytotic conditions.

Feed and dual purpose barley improvement

Evaluation of parental lines

In order to develop a crossing block for improvement of feed and dual purpose barley, 582 accessions including the germplasm accessions from IIWBR active collection as well as new accessions obtained from exotic sources were evaluated and 280 lines were included in the crossing block. All these selected lines are being further evaluated in the *rabi* season 2014-15 to identify superior parental lines to part of the crossing block. The barley programme has been benefited from this acquisition and some of these lines were used in the hybridization programme. In addition the EIBGN and NBGSN were also put under observation trial to identify suitable parental lines.

Hybridization programme

In order to incorporate yield, quality, disease/pest resistance, smooth awns, wide adaptation and early maturity in six rowed barley, 65 crosses were attempted during the crop season 2012-13. Based on seed availability, 65 F_1s were grown at Lahul spiti for advancement to F_2s but only 58 F_1s could be recovered from off season nursery. Various sources of resistance (rusts and leaf blights) and yield attributes including indigenous and exotic lines have been utilized in hybridization programme. In addition, two rowed and six rowed parental lines were used in crossing programme for generating the variation and improvement of various parameters in both types of barleys (Table 8.7).

Table 8.7. Feed and dual purpose barley breeding material grown in *rabi* 2013-14

Generation	Grown		Selected			
			Field selection		Grain Selection	
	Families	Crosses	Families	Crosses	Families	Crosses
F_4	182	155	138	118	104	95
F_3	274	156	241	129	167	118
F_2	144	141	242	117	112	79
F_1	149	149	-	-	-	-

Screening of huskless barley

The screening of huskless barley comprised of 80 genotypes including 10 Indian released varieties, 21 land races collected from Leh and 49 exotic accessions for agro-morphological traits during *rabi* season 2013-14 at the Seed and Research farm, Hisar, India (Fig. 8.3). The soil of the experimental field was sandy loam in texture, medium in fertility, and slightly alkaline (pH 7.8). The results are briefed in Table 8.8.

Table 8.8. Promising genotypes of huskless barley for yield and its components

Traits	Promising genotypes
Grain/spike (>70)	BHS 352, K 1155, Karan 16, Karan 264, NDB 943, INBYT 17, INBON 51, INBON 109, BCU 6641,BCU 6642 BCU 8094, INBYT-13-HI-19, INBYT-13-HI-20, INBYT-13-HI-25, INBYT-13-HI-17and INBYT-13-HI-5
1000-grains weight (> 45 g)	INBON 35, INBON 36, BCU 6635, BCU 6636,BCU 6637 BCU 7998, INBYT-13-HI-3, INBYT-13-HI-6, INBYT-13-HI-8 and INBYT-13-HI-12
Yield/plot (> 400 g)	Geetanjali, K 1155, Karan 16, Karan 201, Karan 231, INBON 51, INBYT-13-HI-21, INBYT-13-HI-14, INBYT-13-HI-1, INBYT-13-HI-2, INBYT-13-HI-8 and INBYT-13-HI-9

Fig. 8.3. Huskless barley improvement programme

Barley quality

Promising genotypes for grain beta glucan, protein content and thousand grain weight

The promising lines for high and low beta glucan, high protein, high thousand grain weight and lower husk content were compared with 2-row and 6-row barley varieties during the 2013-14 season at Karnal in three replications. These genotypes were also tested at eight locations in NWPZ & NEPZ for respective traits and found to be better than the checks or other genotypes tested. The genotypes 20th IBON 3, BCU 554, DWR 30 and DWRUB 76 have been confirmed for higher beta glucan content (Fig. 8.4), BCU 2030, BCU 277, SLOOP SA WL 3167 and SLOOP VIC VB 9953 for lower beta glucan content (Fig. 8.5), BCU 4966, BK 303 and BK 306 for higher protein content coupled with good bold grain percentage (Fig. 8.6) and BK 1127 for high thousand grain weight (Fig. 8.7). The genotype BK 306 was also evaluated for amino acid composition *vis-a-vis* DWRUB 52. Amino acids glutamate and glutamine constituted the highest concentration followed by proline (Fig. 8.8). The lysine content on g/100 g basis was comparable to DWRUB 52.

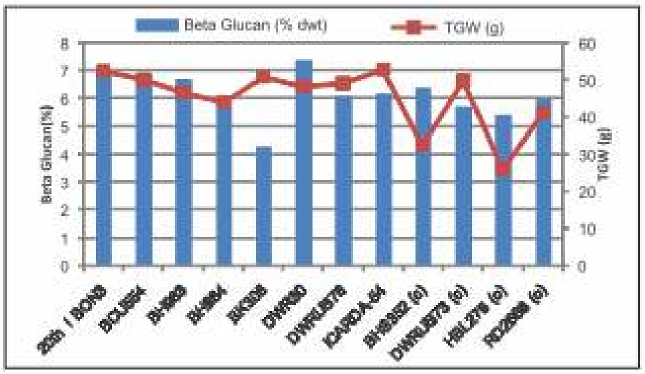


Fig. 8.4. Genotypes with higher grain beta glucan content (% dry weight basis)

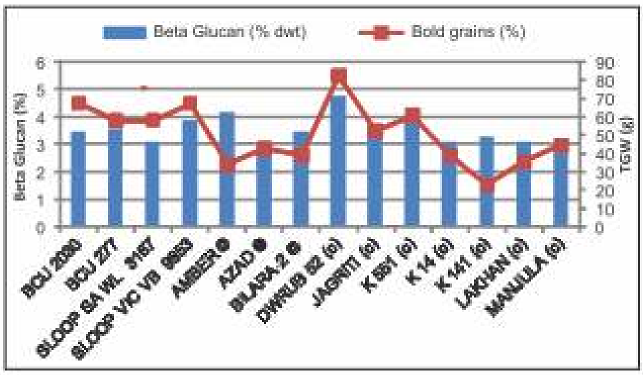


Fig. 8.5. Genotypes with lower grain beta glucan content (% dry wt basis)

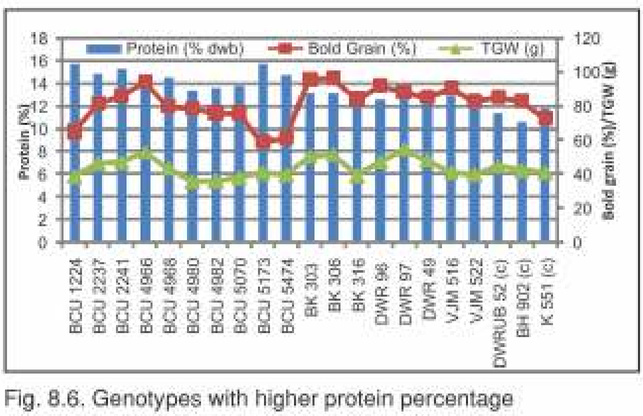


Fig. 8.6. Genotypes with higher protein percentage

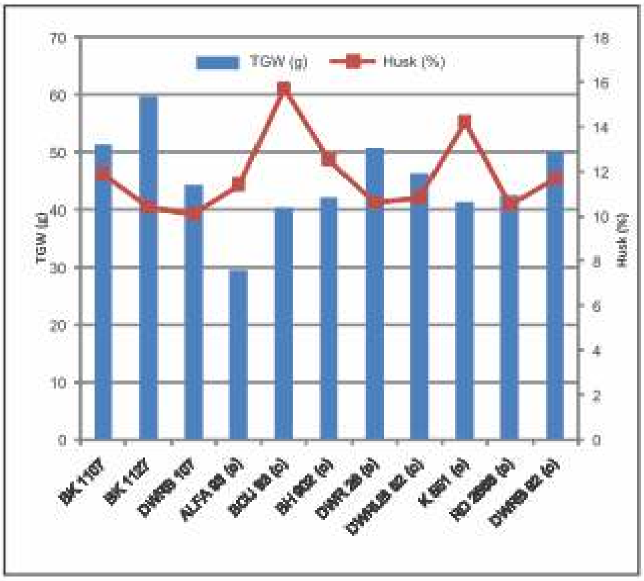


Fig. 8.7. Genotypes with higher thousand grain weight

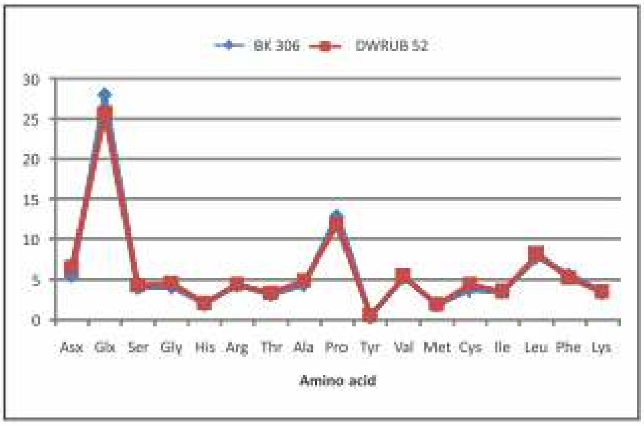


Fig. 8.8. Amino acid composition (g/100 g protein) of BK 306 and DWRUB-52

The genotypes with higher beta glucan were also tested using molecular markers BMAG 500, BMAG 603, HVBKASI and BMAG 382. Preliminary results show that some of these markers need to be further studied.

Evaluation of hull less genotypes for beta glucans and other grain traits

Seven hull less genotypes and six hulled genotypes were evaluated for grain beta glucan content at Karnal and the genotype Dolma had significantly higher content of beta glucans (6.8% dwb) along with reasonably good protein content percentage (14.1 %). However, considering the biochemical and other grain traits, DWR 62 seems to be most promising. This set of genotypes were also grown in Lahaul during the summer of 2013 and maximum beta glucan content was recorded in BHS 352 (6.3%) in hulless genotypes. (Table 8.9)

Table 8.9. Hull less and hulled barley varieties grown during 2013-14 at Karnal

Variety	Hull type	Beta Glucan (% d wt) Karnal	Beta Glucan (% d wt) Lahaul	Protein (% d wt)	Test wt (kg/hl)	TGW (g)	Bold grains (%)	Thin (%)	Yield (g) (2.0 m×3)
BHS 352	HL*	6.1	6.3	12.1	74.0	30.0	18.4	37.0	225.0
DOLMA	HL	6.8	5.0	14.1	74.7	32.5	14.3	41.3	257.7
HBL 276	HL	5.8	5.0	12.7	70.5	35.8	29.2	29.5	349.0
GEETANJLI	HL	5.1	4.9	11.7	77.1	34.8	43.1	13.1	451.7
KARAN -16	HL	4.8	4.7	11.8	73.7	35.8	47.1	9.5	425.3
DWR 62	HL	5.3	4.7	12.2	68.5	34.3	56.3	8.8	466.3
DWR 80	HL	5.1	4.0	12.1	68.5	36.0	67.9	5.9	341.3
NB2	H**	4.8	4.6	11.1	58.3	34.5	58.8	14.0	478.0
NB3	H	5.5	4.3	10.7	63.3	37.8	50.0	13.6	598.0
DWRUB 52	H	4.9	4.5	11.1	69.9	48.8	78.7	1.8	547.0
DWRUB 73	H	6.0	5.6	12.8	68.5	46.4	78.8	3.3	553.0
K551	H	4.4	4.9	11.5	65.1	41.0	73.3	4.4	430.3
BH 902	H	5.5	6.1	10.1	62.1	47.5	90.5	1.9	562.7
LSD (5 %)		0.6	0.8	1.9	7.7	7.8	20.9	11.9	218.5

*HL = Hull Less **H=Hulled

Effect of incorporation of barley flour in making wheat chapati

To study the effect of incorporation of barley flour on chapatti quality, an experiment was conducted taking flour of BHS 352 and DWRUB 73. Flour from two barley varieties (BHS 352 & DWRB 73) were mixed with wheat flour (C 306) in different ratios (5 – 30%).

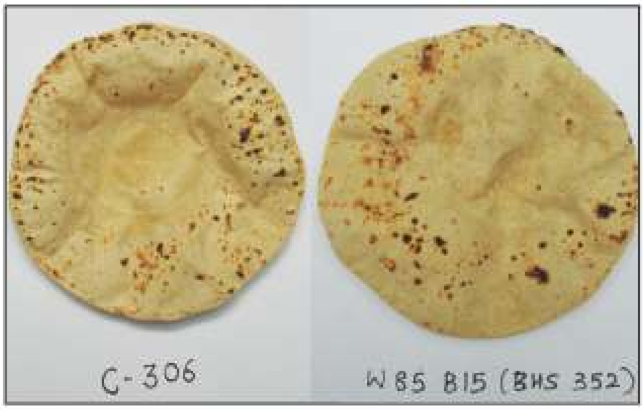


Fig. 8.9. Chapatti prepared from flour of (A) wheat variety C 306 (B) wheat variety C306 (85%)and barley variety BHS 352 (15%)

The chapatis were prepared and their quality scores were calculated (Fig. 8.9). It was observed that more water was required to knead the dough with barley. The taste of the chapattis changed after 5% incorporation of barley flour. Changes in the colour of the dough and chapatti were more prominent with the hulled barley. The overall quality score of chapatti for C 306 decreased from 8.6 to 7.25 at 30% concentration in case of BHS 352 blending and from 8.6 to 6.7 in case of DWRB 73. The beta glucan content of blended chapattis also increased with the increase in proportion of barley flour. Thus, the hulless barley BHS 352 is good for blending with the wheat as the reduction in the chapatti score is much less than the hulled barley DWRB 73. The wet & dry gluten content and gluten index were also estimated using Glutomate (Perten). The wet gluten content of the flour represents the quantity of total gluten in the flour. The gluten content decreased progressively (from 29% to 18%) as the percentage of barley flour was increased

Evaluation of released barley varieties for starch, protein and beta glucan content

A set of 26 varieties grown at IIWBR, Karnal was evaluated for grain starch, protein and beta glucan content (Table 8.10). The genotypic differences in starch content between varieties were non-significant due to significant differences between the replications. However, as such the absolute values differed among varieties. There were significant differences with relation to beta glucan and protein contents. The lowest beta glucan content was obtained in Alfa 93 (3.1 % dwb) followed by varieties of K series (K 551, 560 and 603) and RD 2660. Higher beta glucan was obtained in BHS 352 and RD 2624 (6% or more). Lower beta glucan content is desirable for malt purpose varieties while higher is desirable for health foods like multigrain *atta* etc. Lower values of protein contents were obtained in PL 751 and RD 2552 (< 8.0%), while higher values were obtained in HBL 276 and DWRB 92 (> 11.0 %). There was a negative correlation between starch and protein content, and also between starch and beta glucan content. However, the correlation between protein and beta glucan content was positive.

Table 8.10. Evaluation of CVRC released varieties

Variety	Row type	Hull type	Year of Release	Starch	Beta glucan	Protein	Variety	Row type	Hull type	Year of Release	Starch	Beta glucan	Protein
Alfa 93	2	H	1995	57.6	3.1	10.9	K 560	6	H	1997	58.0	3.8	9.7
BCU 73	2	H	1997	50.1	4.2	9.0	K 603	6	H	2000	56.3	3.7	9.6
BH 902	6	H	2010	61.5	4.8	8.4	NDB 1173	6	H	2005	46.4	5.0	8.6
BHS 352	6	HL	2003	56.5	6.0	10.6	PL 751	6	H	2007	51.9	5.1	7.9
BHS 380	6	H	2010	49.0	4.5	9.5	RD 2503	6	H	1997	48.4	4.5	9.1
DL 88	6	H	1999	48.2	4.7	8.3	RD 2508	6	H	1997	49.4	4.2	9.1
DWR 28	2	H	2002	47.7	5.6	10.4	RD 2552	6	H	1999	50.7	5.3	7.7
DWRB 73	2	H	2011	53.4	5.4	11.0	RD 2624	6	H	2005	53.3	6.1	8.5
DWRB 91	2	H	2013	49.3	5.4	9.9	RD 2660	6	H	2006	49.3	4.0	8.4
DWRB 92	2	H	2013	50.6	4.5	11.6	RD 2668	2	H	2007	47.6	5.6	10.1
DWRUB 52	2	H	2007	54.1	4.7	9.5	RD 2715	6	H	2008	55.3	4.6	8.7
DWRUB 64	6	H	2012	42.7	5.5	8.8	UPB 1008	2	H	2011	49.8	4.7	9.5
HBL 276	6	HL	1999	42.5	5.7	12.1	**LSD (5 %)**				**NS**	**0.4**	**1.0**
K 551	6	H	1997	51.3	3.9	10.4							

Effect of location on malting quality

Five barley cultivars of two row type and two cultivars of six row type grown at six locations spread over north western plains zone and north eastern plains zone during 2013-14 *rabi* season were screened for grain and malt quality parameters. Several grain and malt quality traits were affected by growing location besides the genotypic effect. Among the three biochemical traits investigated, beta glucan and protein content of grain was influenced both by genotype and growing location, however, in the case of amylose content only location effect was significant. Location effect was non-significant in the case of hot water extract and diastatic power (Table 8.11 and Table 8.12).

Table 8.11. Effect of variety on grain and malt quality

Location	Beta Glucan	Amylose	Protein	TGW	TW	Bold	Thin	Fria.	HWE	FR	DP	Wort pH	KI
ALFA93	3.8	28.0	12.5	36.2	60.9	66.9	10.1	70.3	78.2	225.4	115.5	5.8	39.0
DWR28	5.3	27.1	12.6	51.6	60.3	92.7	1.2	61.9	79.1	181.7	115.2	6.0	40.0
DWRUB52	4.8	27.1	11.7	50.1	64.6	84.0	3.2	66.8	81.8	218.0	104.5	6.0	39.8
RD2668	6.0	27.1	12.1	44.0	62.1	64.4	6.1	58.7	80.2	183.0	112.7	6.0	40.3
DWRB92	5.0	28.2	13.4	50.1	62.7	93.3	1.3	59.2	78.7	208.8	111.9	5.8	39.9
K551	4.0	27.7	11.8	42.2	58.4	68.6	12.7	58.1	78.7	251.7	115.2	6.0	38.8
BH902	5.0	26.8	11.0	45.0	58.2	83.5	5.0	55.1	78.8	198.8	113.2	6.0	39.7
LSD (5%)	**0.3**	**NS**	**0.6**	**3.8**	**1.9**	**10.1**	**6.1**	**6.4**	**2.1**	**34.2**	**5.6**	**NS**	**NS**

Table 8.12. Effect of location on grain & malt quality

Location	Beta Glucan	Amylose	Protein	TGW	TW	Bold	Thin	Fria	HWE	FR	DP	Wort pH	KI
KARNAL	4.9	24.9	11.5	47.5	66.4	82.2	5.5	61.0	78.5	233.9	112.2	5.9	39.6
LUDHIANA	5.1	24.4	13.3	43.2	60.7	73.4	10.2	66.5	80.7	182.9	110.6	5.9	39.3
HISSAR	5.3	28.9	12.8	49.6	58.2	88.5	1.9	54.8	78.5	235.0	113.5	5.9	38.7
DURGAPURA	5.0	29.2	12.1	48.3	64.3	79.0	4.5	60.7	80.4	174.3	115.2	6.1	40.5
FAIZABAD	4.2	27.0	12.4	38.8	56.6	65.5	8.8	58.8	78.4	231.0	109.9	5.9	39.5
REWA	4.5	30.2	10.6	46.2	60.1	85.8	3.5	66.7	79.6	200.4	114.3	6.0	40.5
LSD (5%)	**0.3**	**2.0**	**0.6**	**3.5**	**1.8**	**9.4**	**5.7**	**5.9**	**NS**	**31.7**	**NS**	**NS**	**1.2**

Evaluation of grain samples grown at different locations for Malt quality

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. The malt barley varietal trials were conducted in NWPZ during Rabi 2013-14, in two sowing dates as separate sets. The grain samples were received from nine locations (Hisar, Karnal, Bawal, Ludhiana, Bathinda, Durgapura, Mathura, Modipuram and Pantnagar) in timely sown and from six locations (Hisar, Karnal, Ludhiana, Bathinda, Modipuram and Durgapura,) in late sown conditions. This year a total of 368 coded entries were received. There were 16 test entries in IVT (TS) which were analyzed with three checks, while 15 test entries in IVT (LS) were evaluated with three checks. In case of AVT (TS), four entries (BH 976, DWRB 101, PL 874 and RD 2849) with four checks and in AVT (LS) two entries (BH 968 and DWR 118) with four checks were analyzed. Several genotypes were observed as good source for individual grain and malt quality traits (Table 8.13), though they may not have good values for remaining traits.

Table 8.13. Promising entries for various malt quality trait

Traits	Promising entries	
	Timely sown	Late sown
Test Weight	DWR 101, RD 2849	BH 968, DWRB 118
Protein content	PL 874	-
Husk Content	RD 2849	BH 968
Malt Friability	PL 874, RD 2849	
Beta glucan % (< 4.0 %)	-	BH 968
Kolbach Index	DWRB 101	
Over all MQ (Overall score > best check)	BH 987 and DWRB 127	BH 992

Non-malt purpose barley

A total of 821 feed grain samples from various trials and grown at different locations under AICW&BIP were analysed for few physical parameters and protein content. The entries having highest test weight; crude protein and thousand grain weight have been listed in table 8.14.

Table 8.14. Promising feed barley entries for quality traits

No.	Trial	Test weight	Thousand grain weight	Bold grain (%)	Crude protein
1	AVT (Rainfed Barley) – NHZ	BH 352©	BHS 424	VLB 138	UPB 1037
2	AVT (Irrigated Feed Barley) – NWPZ	RD 2035©	BH 946©	BH 946©	RD 2832
3	AVT (Irrigated) – CZ	PL 751©	RD 2786©	RD 2833	RD 2786©
4	IVT (Irrigated Feed Barley)– NWPZ/NEPZ/ CZ	PL 880	BH 981	BH 902©	BH 982
5	IVT (Rainfed Feed Barley) –NEPZ	HUB 232, DWRB 129	NDB 1577	NDB 1577	RD 2884
6	AVT (SAL/ALK) – NWPZ/NEPZ	BH 972	RD 2886	RD2794©	KB 1375
7	IVT (Dual Purpose Barley) – NWPZ/NEPZ/ CZ	NDB 1585	RD 2878	RD 2878	UPB 1041, UPB 1042, HUB 239
8	AVT (Dual Purpose Barley) – NHZ	HBL 276©	BHS 431	HBL 717	BHS 431

Resource management

Evaluation of new genotypes

The evaluation of second year AVT entries was taken up in Northern Hill Zone, North Western Plains Zone and Central Zone. There were five trials with AVT second year entries. The irrigated, timely sown feed and malt barley trials (timely and late sown) were conducted in the North Western Plains. Timely sown feed barley trials were also conducted in Central Zone and Northern Hill Zone. Out of the 24 proposed trials for varietal evaluation, all were conducted and reported. In special trials (Intercropping, date of sowing, sprinkler irrigation, sulphur application, N doses and schedules, phosphorus and potash application and weed management), out of 49 proposed at different locations, 42 were conducted.

The performance of test entry (VLB 130) was evaluated against two checks (BHS 380 and HBL 276) and three nitrogen levels (40, 60 and 80 kg N/ha) at five locations. The test entry VLB 130 and best check HBL 276 were statistically at par at all N levels. The test entry and checks responded up to 80 kg N/ha. The performance of test entries RD 2832 was evaluated against three checks RD 2552, BH 902 and BH 946 at five locations The checks BH 902 and BH 946 were superior to the new entry under normal sown conditions and the check BH

946 was superior under late sown condition. The performance of test entry DWRB 101 and RD 2849 were evaluated against three checks (DWRUB 52, BH 902 and DWRB 92) and the new entries were superior to two row checks, but six row check BH 902 produced highest yield. The performance of test entry BH 968 and the best check DWRB 91 was statistically at par and other two checks (DWRB 73 and DWRUB 64) were inferior to the new entry and best check. The performance of test entries (BH 959 and RD 2833) were evaluated against two checks (PL 751 and RD 2786) under normal and late sown conditions. Test entry BH 959 and the checks PL 751 and RD 2786 were at par and other test entry RD 2833 was inferior to checks.

Refinement of production technologies

Intercropping of mustard and gram in barley **:** Three years pooled data showed that sole crop of mustard recorded highest total equivalent yield followed by barley + mustard. Sole crop of barley and dual purpose barley were at par in total equivalent yield and closely followed by intercropping of mustard in barley.

Fine tuning the date of sowing under changing climates: Four varieties (BH 902, RD 2552, DWRUB 52 and RD 2668) were evaluated against four dates of sowing (starting from last week of October to last week of November, 10 days interval) to fine-tune the sowing dates under changing agro-climatic conditions. First and second dates of sowing were at par and thereafter a significant decrease in yield of all varieties were recorded except BH 902. The yield reduced by 0.06, 6.21 and 17.24 % as the dates advanced by 10 days. Under late sown situations, there was significant decrease in yield of all varieties as the sowing date advanced. Among varieties, DWRB 91 was ranked at first position followed by RD 2508, DWRUB 64 and DWRB 73. The yield reduced by 5.83, 13.2 and 25.8% as the dates advanced.

Timely sown irrigated barley in NEPZ : Four varieties (RD 2552, K 508, K 551 and JB 1) evaluated against four dates of sowing resulted that sowing between 15-24 November was found superior to other dates of sowing. The yield reduced by 12.1 and 20.6% as the dates advanced after 24th November and the yield was also reduced by 8.27% before 15th November sowing.

Timely sown rainfed barley in NHZ : Four varieties (BHS 352, UPB 1008, VLB 118 and HBL 113) evaluated against five dates of sowing (dates starting from 25th October goes up to 25th December, at 15 days interval) shows that the yield increased up to second date of sowing (10-24 November) and after that the yield decreased as the date advanced up to last date (25 Dec. to 09 Jan.) in all varieties except HBL 113 which produced highest yield under third date of sowing (25 November-09 December).

Effect of sprinkler irrigation on yield and quality of barley crop : Sprinkler irrigation initially 20 days after sowing and thereafter at 30 days interval and flood irrigation recorded the better yield as compared to sprinkler irrigation with interval of 15, 20 & 25 days. BH 902 produced was better in 30 days interval and flood irrigation while DWRUB better was in 20 and 25 days sprinkler irrigation.

Effect of S application on productivity and quality : The trial was conducted with an objective to evaluate the effect of sulphur application on yield and quality of barley crop. The results show that sulphur application increased the productivity of all varieties up to 30kg/ha but results were at par at 20 and 30 kg S/ha. BH 902 and DWRUB 52 were more responsive to S as compared to RD 2668.

Effect of mulching and irrigation on yield in NEPZ : The objective of the trial was to compare mulching and non-mulching treatments in respect of productivity of barley and water saving. The experiment was conducted at Kanpur, Rewa, Varanasi with nine treatments of mulching (0, 4 and 6 t mulch/ha) and irrigation (0,1 and 2 irrigation). Pooled results showed that mulch application and irrigation increased the yield significantly. The highest yield was attained with the combination of mulching and two irrigations, although there was no significant difference in yield due to difference in residue load. Significant lower yield were observed in no mulch, no irrigation combination.

Dose and time of nitrogen application in dual purpose barley in NHZ : Grain yield increased significantly with the increase in the level of nitrogen only up to 60 kg N/ha thereafter the yield decreased. The yield of barley was similar at the three N schedules but higher yields were recorded in 1/2 basal+1/2 after rain and 2/3 basal+1/2 after rain as compared to full basal.

Doses of Phosphorus and Potash application in barley in NHZ : The trial was conducted with four doses of phosphorus (0, 20, 30 and 40 kg/ha) and three doses of potash (0, 20 and 40 kg/ha) to optimise doses of phosphorus and potash application. Pooled results revealed that the yield increased significantly with the increase in the doses of phosphorus up to the level of 40 kg/ha at all levels of potash and the yield increased as the dose of potash increased up to 40 kg/ha at all levels of phosphorus except at zero P level. Overall, optimum and higher yield levels were obtained at 40 kg of phosphorus and 40 kg of potash per ha.

Weed management in barley : Among the herbicides, the best treatment is Metsulfuron+Carfentrazone 25g+ NIS 0.2% which produced 1.73 q/ha more as compared to weed infested field. In another trial, the best treatment was Pinoxoden 40g+Carfentrazone 20g which produced 1.29 q/ha more compared to weed infested field.

Conservation agricultural practices to improve quality and grain yield of barley : In the context of sustainable production to mitigate the adverse effect of changing climate, conservation agriculture is the answer. Barley being a less water and nutrient requiring crop, therefore, experiments on CA were conducted on malt barley at farmer's field at Hajwana village of Kaithal district and other on feed barley at IIWBR, Farm, Karnal. Zero till sown barley with rice residue retention @ 6 t or 4 t/ha after direct seeded and un-puddled transplanted rice resulted in significantly higher yield of malt barley. The results of conservation agriculture were encouraging in barley during the first year because of low input requirement.

Conservation Agriculture for quality and yield of barley and wheat in salt affected soils : To evaluate the role of residue retention and different tillage practices in increasing the grain yield of wheat and barley in salt affected soil, an experiment was conducted at IIWBR research farm, Hisar. Residue retention also helped in increasing the yield of barley and wheat in salt affected soils.

Relay cropping in malt and feed barley : Preliminary studies on relaying in standing cotton at zero tillage have shown promising results as it resulted in substantially higher yield than that of the conventional sowing after cotton harvest. In an experiment of relay cropping, yield of malt barley reduced significantly with delay in sowing after D2 (26 Nov-02 December). The reduction in yield on mean basis was 17.1 and 19 percent respectively when sowing was delayed by 15 and 30 days after second December. Similar trend was also observed in feed barley.

Barley crop protection

Barley rust pathotypes distribution

During 2013-14 crop season, thirty five samples of barley rusts received from different parts of India were analyzed at IIWBR, Flwoerdale station, Shimla. Pathotype 1S0 (M) was most frequent followed by pathotype 0S0 (57). In black (stem) rust (*P. graminis f. sp. tritici*), pathotype 79G31 (11) was encountered in all samples.

Seedling resistance test (SRT)

Ninety one lines of EBDSN and 187 lines of NBDSN were evaluated at seedling stage against five pathotypes of barley yellow rust viz. (0S0-1) 24, (0S0)57, 4S0(G),1S0(M), 5S0 (Q) and mixture of *Puccinia striiformis hordei* (Yellow / stripe rust), three pathotypes 79G31(11),62G29(40A) and 19G35(42) of *P. graminis tritici* (Black/ stem rust) and mixture of five isolates of *P. hordei* (Brown/leaf rust) under controlled conditions of greenhouse. Among NBDSN, sixteen lines viz., VLB140, UPB1038, BH902, RD2833, BH902, RD2860, RD2889, RD2890, RD2887, DWRB127, RD2875, RD2552 (C), RD2786 (C), KB1369, RD2883, RD2882 were found resistant to all brown and yellow rusts. in EBDSN, lines VLB132 and RD2786 were resistant to all the rusts.

Adult plant resistance (APR)

Out of 357 entries tested in Initial Barley Disease Screening Nursery (IBDSN), 41 entries were found to be resistant (ACI <10) to stripe rust and 137 entries have ACI less than 10. For stem rust, 73 entries were found to be having HS <10 out of these, 48 were free from stem rust (HS=0). In case of leaf blight screening, 12 entries were found to fall between average score of 23 and highest score of 57 against leaf blight. Out of 187 entries from AVT and IVT yield trials, the entries showing resistance against stripe rust, leaf blight and stem rust are given in Table 8.15.

Table 8.15. Resistance entries identified from various trials

Disease name	Entry name
Stripe rust ACI 0 (17 entries)	DWRB 124, DWRB 127, DWRB 128, DWRUB 64 (C), HUB 113 (C), KB 1369, RD 2552 (C), RD 2715 (C), RD 2833, RD 2874, RD 2880, RD 2883, RD 2886, RD 2887, RD 2889, UPB 1038 and UPB 1040
Leaf blight AV. upto 35 & HS up to 57(20 entries)	BH 972, BH 976, BH 981, BH 983, BH 990, BHS 424, BHS 429, BHS 430, DWRB 111, DWRB 91, HBL 719, KB 1351, NDB 1592, RD 2552, RD 2895, RD 2896, UPB 1031, UPB 1038, VLB 137 and VLB 140
Stem rust (HS= 0) (32 entries)	AZAD (C), BH 902 (C), BH 968, BH 976, BH 989, BH 992, DWRB 101, DWRB 121, DWRB 122, DWRB 123, DWRB 126, DWRB 128, DWRB 92 (C), DWRUB 52 (C), HUB 237, JB 293, KB 1349, NDB 1577, NDB 1580, PL 751 (C), PL 874, PL 880, RD 2786 (C), RD 2877, RD 2878, RD 2880, RD 2891, RD 2893, RD 2894, RD 2895, RD 2897 and UPB 1037

In case of 91 entries screened under Elite Barley Disease Screening Nursery (EBDSN), the confirmed resistance entries against the particular disease is given in Table 8.16.

Table 8.16. Resistance entries identified from Elite Barley Disease Screening Nursery

Disease name	Entry name
Yellow rust ACI = 0 17 entries	HBL 714, DWRB 112, DWRB 116, HBL 713, RD 2552, RD 2786, RD 2853, RD 2854, RD 2858, RD 2861, RD 2863, RD 2865, RD 2866, RD 2867, RD 2868, VLB 132 and VLB 135
Yellow rust ACI = 0<1 16 entries	DWRB 111, BH 977, BH 979, BHS 420, BHS 380, DWRB 117, DWRB 121, HBL 712, RD 2830, RD 2832, RD 2833, RD 2856, RD 2857, RD 2862, RD 2864 and RD 2869
Leaf blight Average upto 35 & Highest score up to 57 (5 entries)	DWRB 112, DWRB 113, DWRB 115, DWRB 116 and VLB 133
Powdery mildew up to 3 (11 entries)	BH 979, BHS 380, BHS 416, DWRB 91, K 508, K 551, RD 2035, RD2552, VLB 118, VLB 130 and VLB 133

Chemical control of barley foliar blight can be achieved by seed treatment with Vitavax @ 3g/Kg followed by spraying with Tilt / Folicur @ 0.1%. For chemical control of stripe rust, spraying with Tilt @0.1% and Bayleton @0.1% recorded lower disease severity and higher yield is found to be effective.

Screening of barley entries against foliar aphids

The differential reaction of aphids on entries showed the availability of biotypes of barley foliar aphids in various locations. At Karnal, the three entries HUB 233, PL 882 and JB 292 were found to be moderately resistant and rest of them were susceptible (grade 4) or highly susceptible (grade 5) to barley aphid. For chemical control of foliage feeding barley aphids (*Rhopalosiphum maidis*) clothianidin 50 WDG @ 15 g.a.i./ha(1.27) was compared to other chemicals and found to be promising in reducing aphid population.

Screening of NBDSN barley entries against CCN

The entries viz., BH 959, BH 980, DWRB 121, DWRB 125, DWRB 127, DWRB 91 (C), DWRUB 64 (C), KB 1367, NDB 1577, NDB 1758, PL 751 (C), RD 2035 (C), RD 2832, RD 2833 and RD 2877 showed resistance against CCN.

Leaf blight resistance studies in barley

RIL population (RD 2503 X BCU 76) was screened with previously identified closely linked molecular markers (Bmac213 and ABG59) to validate the applicability of these identified markers for leaf blight resistance. Molecular marker Bmac213 was found closely linked with Rcs-qtl-1H-1 at proximal end (0.0 cM) on IH chromosome of barley.

Characterization of quality traits in barley

Populations of ten crosses were advanced in off-season nursery (Dalang Maidan) for genetic studies of beta-Glucan in barley. Barley genotypes identified in barley quality screening nursery (BQSN) for low and high beta glucan content were characterized with gene specific/closely linked SSR and CAPS molecular markers. SSR marker Bmag382 and HvBKVS1were found closely linked with high beta glucan content in barley (Fig. 8.10).

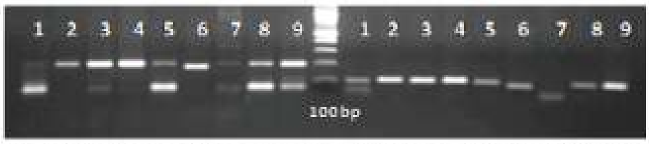
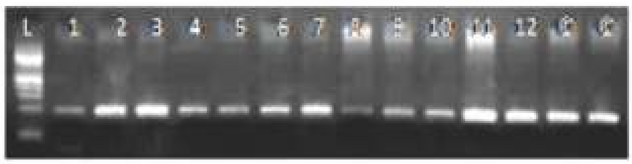


Fig. 8.10 Sample Screening (1-9) BCU554, BK306, DWR30, DWRUB76, ICARDA54, BHS352, DWRB73,HBL276, RD2668 with HvBKVS1 and Bmag382

Similarly, these genotypes were screened with gene specific/closely linked molecular markers for quality traits (Protein and starch content). Marker HvWaxyG and HvBKVS1 were found efficient to discriminate BQSN entries for low protein and high starch content (Fig. 8.12).

HvWaxyG (7H), 169 bp

Well 1: CARAFE, 2: DWR80, 3: DWR62, 4: DWRUB55, 5 : KARAN 741, 6 : SK9, 7 : SK17, 8: SK18, 9: ALFA 93 (c), 10: BCU93 (c), 11: BH 902 (c) 12 : DWR28 (c), 13: DWRUB52 (c), 145: K551 (c), 15: RD2668 (c), 16: DWRB 92 (c), 17: Ladder (100 bp)



HvBKAS1 (2HL) 197 bp

Well 1 : ladder 100 bp, 1 : BCU1224, 2: BCU2237, 3: BCU2241, 4: BCU4966, 5: BCU4968, 6: BCU4980, 7: BCU4982, 8: BCU5070, 9: BCU5173, 10: BK 303, 11: DWR 96, 12: DWR49, B13: H 902 (c), 14: K551 (c)

Fig. 8.12. Sample screening with Marker HvWaxyG and HvBKVS1

New Initiatives

Preliminary work has been started in collaboration with the private industry for working out the feasibility of in producing barley based biscuits (Fig.8.13).

Fig. 8.13. Barley based biscuits

9. SEED AND RESEARCH FARM, HISAR

The following activities were undertaken at IIWBR Seed and Research Farm, Hisar in measuring about 200 ha.

1. Possession was taken from CIRB, Hisar in May, 2013.
2. Green manuring was conducted in 28 acres of land by sowing Dhaincha during Kharif season of 2013 (June end to September, 2013).
3. Contour mapping and digital layout work was started in October 2013.
4. Fields were leveled in October 2013 and work continued till January 2014.
5. Experimental trials were sown on 68 acres (Wheat (43 acres) and Barley (25 acres)) of land. Details of Rabi and Kharif crop sown at Hisar Farm are given in table 9.1 and table 9.2.
6. One shallow tube well was installed.
7. Reclamation process of salinity affected fields is in progress.
8. Plantation of trees on borders is in progress.

Wheat crop at Hisar farm

Table 9.1. Details of Rabi crops sown at Hisar Farm during 2013-14

Sr.No.	Name of Crop	Areas(acres)	Production(q)
1.	Barley	7.14	57.60
2.	Sarson	1.0	2.56
3.	Wheat	53.45	75.00
			92.40
			50.00
			75.00
4.	Wheat straw chaffed (Tudi)	Wheat+ Barley	408.30
5.	Barley	30.00	Sown for soil reclamation

Table 9.2. Details of Kharif crops sown at Hisar Farm during 2014

Sr.No.	Name of Crop	Areas (acres)	Production(q)
1.	Experimental crop in Barley block (Rice, cotton, arhar, bajra, maize, moong,etc.	3.78	2.82
2.	Rice Pusa-1509 HKR-126 CSR-30	14.02	105.75 50.00 15.94
3.	Moong	30.00	0.75
4.	Cotton	19.13	24.00
5.	Guar	31.93	
6.	Jowar	32.54	460.00
7.	Bajra	20.92	
8.	Dhaincha	73.83	For green manuring

Barley crop at Hisar farm

Rice crop near maturity at Hisar farm

Cotton crop at Hisar farm

10. MEETINGS/WORKSHOPS, SPECIAL ACTIVITIES AND TRAINING ORGANIZED

Special Activities

ICAR Foundation Day

July 16, 2014: The ICAR-IIWBR celebrated 86[th] ICAR foundation day. To mark the occasion, an inter school debate competition was organized for students of class IX and X on the topic "Why student should opt agriculture stream"? An interface meeting of farmers and industry partner was also organized to mark the occasion.

Director IIWBR distributing certificates and mementos to students and teachers

Borlaug's Contribution Remembered

September 12, 2014: The ICAR-IIWBR remembered Dr. NE Borlaug on his fifth death anniversary in a meeting organized at Karnal. Dr. Indu Sharma, Director, IIWBR briefed the house about the life history and contribution of Dr. Borlaug. The meeting also led to discussion on an article "Tribute to saint who did miracle to wheat" published in Hindu. Further scientists from institute shared their experiences during the visit of Dr. Borlaug to India.

Swachh Bharat Abhiyan

October 2, 2014: The Swachh Bharat Abhiyan started at the ICAR-IIWBR on October 2, 2014 by Oath Taking Ceremony. All the staff members took swachh bharat cleanliness oath, followed by intensive cleaning of campus, residential and adjoining areas. Under this Abhiyan, separate bins have been kept at residential colony for green waste, which is being picked by the animal raisers daily. The impact of abhiyan is visible on staff as well as on casual labourer, as they have developed habit of picking and putting the waste material in the dust-bin and keeping the premises clean.

Director Dr. Indu Sharma addressing the staff during Swachh Bharat Mission

Staff cleaning outside the institute's premises area

Foundation Day

September 9, 2014: The institute celebrated its foundation day. Dr. RG Saini, Invited Professor and Coordinator, Centre for Biosciences, Central University of Punjab, Bathinda was the chief guest and delivered the foundation day lecture on "Rust Resistance Genes in Wheat - Identification, Status and Challenges".

Chief guest Dr. RG Saini inaugurating the exhibition during foundation day

Rabi Kisan Mela

October 30, 2014: Rabi *Kisan Mela* was organized at Karnal. Prof. RC Sharma, Centre Coordinator, Centre for Environmental Science and Technology, was the Chief Guest, while Dr. AK Srivastva, Director NDRI was the guest of honour. Dr. Indu Sharma, Director of the Institute while welcoming the Chief Guest and farmers briefed about the achievements and technologies developed by the institute. Exhibition were laid by various ICAR institutes, state agricultural /horticultural department, industry partners and farmers groups. About 1200 farmers from different parts of UP, Haryana and Punjab participated in the event.

Chief Guest Prof. RC Sharma along with Dr. AK Srivastva, Director NDRI at IIWBR stall during Rabi Kisan Mela

Chief Guest Prof. RC Sharma addressing the gathering during Rabi Kisan Mela

Invited Lecture

December 12, 2014: An invited lecture on Poor quality water irrigation for sustainable crop production was delivered by Dr. R K Yadav, Pr. Scientist, ICAR-CSSRI, Karnal.

MV Rao Lecture

December 15, 2014: Dr. Surinder Kumar Vasal, World Food Prize winner delivered the Dr. MV Rao Lecture on "Breeding methodologies in cross pollinated crops that are relevant to self pollinated crops".

Dr. SK Vasal delivering the Dr. MV Rao Lecture

Meetings/Workshops

ICAR-ICARDA Regional Information Workshop

May 19-22, 2014: The Regional Information workshop of South Asian nations (Nepal, Bangladesh, Bhutan and India) under the ICAR-ICARDA CRP 3.6 Dryland Cereals partnership project was held at the institute under the chairpersonship of Dr. Indu Sharma, Director, IIWBR, Karnal.

Site Visit of DBT Experts to IIWBR, Karnal

May 23, 2014: The institute organized a site visit of DBT experts (Dr. RK Agarwal, CCMB, Hyderabad; Dr. SR Bhat, NRCPB, New Delhi and Dr. ON Tiwari, DBT, New Delhi) under R&D project *"Phenotyping of mapping population at hot spots and tagging of major QTLs associated with spot blotch resistance in wheat"*. The committee appreciated the work of IIWBR and expressed satisfaction on the overall progress made under this project.

DBT experts interacting with the scientists at the institute

53rd All India Wheat and Barley Research Workers' Meet

August 22-25, 2014: The 53rd All India Wheat and Barley Research Workers' meet was jointly organized by the ICAR-Institute of Wheat and Barley Research (ICAR-IIWBR), Karnal and Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur at Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur. The meet was inaugurated by Dr. Swapan K Datta, DDG (CS), ICAR, while Dr. JS Sandhu, Agricultural Commissioner (Govt. of India) and Dr. MM Upadhyay, Agriculture Production Commissioner, Govt. of Madhya Pradesh were the special guest. Dr. VS Tomar, Vice Chancellor, JNKVV, Jabalpur presided the inaugural session. In the meet, around 350 delegates representing different national and international research institutes, universities, private companies and local farmers participated.

Dignitaries on the dias

Based on deliberations and discussions during various technical sessions, plan of research for crop season 2014-15 was finalized. A one day International Seminar on "Enhancing Wheat & Barley Production with special emphasis on Nutritional Security" was also organized during the meet, in which, eminent scientists from international research organizations presented their research on various issues of wheat and barley improvement. During the meet, 7 wheat (5 aestivum and two durum) and 3 barley varieties were identified for release by the Varietal Identification Committee of Wheat and Barley.

Dr. SK Datta, Dr. JS Sandhu, Dr. VS Tomar and Dr. Indu Sharma inaugurating the meet by lighting the lamp

Dignitaries releasing the publication

Interactive Workshop on Wheat and Barley Aphids and their Management

November 24, 2014: The interactive workshop on wheat and barley aphids and their management was organized by CIMMYT South Asia Office, Nepal and IIWBR at Karnal. Dr. Indu Sharma, Director, IIWBR, Dr. AK Joshi, Regional Co-ordinator, CIMMYT-South Asia Office-Nepal, Dr. CP Srivastava, Head, Dept of Entomology, BHU and Prof. (Dr.) Urs Wyss, University of Kiel, Germany interacted with the Entomologists of AICW&BIP centres.

Resource persons along with participants of interactive workshop on Wheat and Barley Aphids and their management

Institute Management Committee (IMC)

November 12, 2014 & March 27, 2015: The XX and XXI IMC meetings were held under the chairperson of Dr. (Mrs.) Indu Sharma, Director, IIWBR, Karnal. The following members attended the XXI meeting:

1	Dr. IS Solanki, ADG(FFC), ICAR, New Delhi	Member
2	Dr. PC Mishra, ADR and PS (Wheat), JNKVV, Wheat Res. Station, Powarkheda	Member
3	Dr. VS Sohu, Sr. Wheat Breeder & Zonal Coordinator, Department of Pl. Breed. & Genetics, PAU, Ludhiana	Member
4	Dr. SS Atwal, Head, ICAR-IARI RS, Karnal	Member
5	Dr. Satish Misra, Sr. Genetics & Head, Agharkar Research Institute, Pune	Member
6	Sh. Mithilesh Kumar, Sr. FAO, ICAR-NDRI, Karnal.	Member
7	Sh. Ved Pal, H.No. 377-R, Model Town, Karnal	Member
8	Sh. JS Paul, Administrative Officer, ICAR-IIWBR, Karnal	Member Secretary

Institute management committee meeting in March 27, 2015

Institute Research Committee (IRC) meeting

December 18-19, 2014: The meeting of XXI Institute Research Committee (IRC) held under the Chairmanship of Project Director, Dr. (Mrs.) Indu Sharma, to review the progress of ongoing research projects (RPP II) for the period of 2014. The new research projects (RPP I) were also discussed at the end of the meetings. The Dr. BS Tyagi, Member Secretary provided all the logistics support during the meeting.

Institute research committee meeting on December 18-19, 2014

Pre ICAR-BISA Work Plan Meeting

December 23, 2014: Pre ICAR-BISA work plan meeting was organized at Indian Institute of Wheat and Barley Research, Karnal in which line of collaboration with BISA was discussed with co-operators.

Meeting on Benchmarking Varieties of Important Agricultural and Horticultural Crops in India

February 05, 2015: A one day meeting on "Benchmarking varieties of important agricultural and horticultural crops in India" was convened at IIWBR, Karnal. This special meeting was chaired by Dr. S Ayyappan, Secretary, DARE and Director General, ICAR and co-chaired by Dr. JS Sandhu, Deputy Director General (Crop Sciences), ICAR; and Dr Indu Sharma, Director, IIWBR, Karnal. Dr. HS Gupta, Director General, BISA and Sh. Sudhir Bhargava, Member, Governing Body, ICAR were the guest of honour. The presentations were made by the respective speakers for different crops (Wheat, Rice, Maize, Millets, Pulses, Oilseeds, Fruits, Vegetables, Potato and Soybean) and delegates interacted on various issues requiring attention on scientific deliberations and famers' interest.

Dr. S Ayyappan, Secretary, DARE and Director General, ICAR, Sh. Sudhir Bhargava, Member Governing Body, ICAR, Dr. HS Gupta, Director General, BISA and Dr. JS Sandhu, Deputy Director General (Crop Sciences), ICAR along with participants of the meeting

Review Meeting of CSISA

February 24, 2015: Review meeting of Cereal System Initiative for South Asia (CSISA) –Wheat Breeding objective 4 was held at the ICAR-IIWBR, Karnal.

Research Advisory Committee meeting

February 27, 2015: The 19th Research Advisory Committee meeting was held at the ICAR-Indian Institute of Wheat and Barley Research, Karnal. The following members attended the meeting:

1	Dr. SK Sharma, Former Director, NBPGR, New Delhi, Former Vice Chancellor CSK HPKVV, Palampur (HP)	Chairman
2	Dr. HS Nainawatee, Former ADG (Education), ICAR, New Delhi	Member
3	Dr. Ashutosh Sarker, Project Coordinator-ICARDA, New Delhi	Member
4	Dr. BN Patil, Associate Director Research, UAS-Dharwad	Member
5	Dr. GS Mahal, Former Director (Seed), PAU, Ludhiana	Member
6	Dr. GS Deol, Former Head, Pathology Division, PAU, Ludhiana	Member
7	Shri Ved Pal, Progressive Farmer & IMC Member, IIWBR, Karnal	Member
8	Dr. Indu Sharma, Director, IIWBR, Karnal	Member
9	Dr. BS Tyagi, Principal Scientist, IIWBR, Karnal.	Member Secretary

RAC chairman Dr. SK Sharma and other RAC members visiting the farm at IIWBR

Trainings

IIWBR Karnal

July 6 – August 21, 2014: Forty five days training program on "Basic techniques of DNA Fingerprinting for Molecular Characterization of Wheat Genotypes" was organized for officials of Haryana State Seed Certification Agency, Panchkula.

September 19, 2014: Imparted training to representative of Pepsico India Ltd. on Oat Production Technology.

October 28-30, 2014: Training-cum-workshop on "Tracking barley and lentil improved cultivars adoption in India" was organized. During the meeting, elicitation of adoption of barley varieties in actual at farmers field was done by the experts. Experts from IIWBR, HAU, State Agricultural Department, KVKs, and ICRISAT participated in the programme.
November 21 and 26, 2014: Imparted Training to the Agriculture Development Officers/ Block Agricultural Officers on relay cropping of wheat/ barley in cotton at HAMETI, Jind.

IIWBR Regional Station Dalang Maidan

August 5-7, 2015 : A training programme on "Modern Cultivation of Seed Potato, Wheat and Agro-forestry" was organized jointly by IIWBR, RS, Dalang Maidan, CPRI, Shimla and NRC Agro-forestry, Jhansi for the farmers of Lahaul valley during August 5-7, 2014. By this training, 44 farmers gained practical knowledge on wheat, potato and forestry trees especially willow tree. Scientists from IIWBR, Karnal, CPRI, Shimla and NRC Agro-forestry, Jhansi imparted the knowledge and discussed with farmers on all aspect of farmer's interest.

Scientists imparting training to local farmers

FLDs : Facilitation of Front Line Demonstration (FLD) for popularizing wheat in Lahaul Valley of Himachal Pradesh was done during summer 2014. In the eight villages of Lahaul valley (Khangsar, Nukar, Jagla, Bargul, Angroop, Dalang and Teeling) 20 Front Line demonstrations were conducted to demonstrate the improved wheat variety HS 375 (HIMGIRI) and its production technologies including chemical weed control technologies in wheat. This variety is recommended for very high altitude area of Himachal Pradesh.

Wheat and Barley Field Day

March 27, 2015: The "Wheat and Barley Field-Day" was organized with the objective that scientist from various co-operating centres can make spot assessment and selection of the germplasm lines of wheat and barley from various international nurseries planted at IIWBR, Karnal. More than 50 scientists from various cooperating centres actively participated in selection of wheat and barley material.

11. EXTENSION ACTIVITIES

Farmer's day/Awareness programmes

April 30, 2014: Organised "Barley cultivation awareness programme" for Agriculture Extension officers of Haryana at CCS HAU, Hisar.

December 23, 2014: A training-cum-awareness programme on "Protection of Plant Varieties and Farmers' Rights Act, 2001" was organized by IIWBR in collaboration with ICAR Research Complex for NEH Region, Tripura Centre at Lembucherra, Agartala, Tripura under the chairmanship of Mr. D Chakraborti, Chief Conservator of Forest, Govt. of Tripura. Around 120 farmers including 45 women representatives from various villages of various districts of Tripura attended the programme.

February 09, 2015: Organized awareness programme on "Yellow Rust Management" in Bakana, Yamunanagar (Haryana). Around 150 farmers participated in the programme.

February 22, 2015: "Farmers' Day" at wheat front line demonstration site in village Jadoli, Karnal was organized. Nearly 100 farmers participated.

March 02, 2015: The ICAR-Indian Institute of Wheat and Barley Research organized a training -cum awareness programme on "Protection of Plant Varieties and Farmers' Rights Act 2001 (PPV&FRA)" at Agricultural Research Station-Niphad, Nasik under the chairmanship of Dr. TA More, Hon'ble Vice Chancellor, MPKVV, Rahuri, while Dr. RS Patil, Director Research, MPKVV was the guest of honour. More than 100 farmers from Yevla and Niphad areas attended the programme.

March 08-09, 2015: Organized "Barley cultivation" awareness programme in village Mundru, Sikar district, Rajasthan (March 8, 2015) and village Etawa Bhopji, Chomu district (March 9, 2015) in collaboration with SAB MILLERS. Around 250 farmers participated in the programme.

March 17, 2015: A training-cum-awareness programme on "Protection of Plant Varieties and Farmers' Rights Act, 2001" was organized by IIWBR at Morena (MP).

March 28, 2015: A training-cum-awareness programme on "Protection of Plant Varieties and Farmers' Rights Act, 2001" was organized by IIWBR at Nanihari village, District Saharanpur under the chairpersonship of Dr. RR Hanchinal, Chairperson PPV&FRA, while Dr. Indu Sharma, Director, ICAR-IIWBR was the guest of honour. About 120 progressive farmers of different villages of Shaharanpur participated in this programme.

Dr. RR Hainchinal, Chairperson PPV&FRA along with Dr. Indu Sharma Director, IIWBR examining the rice seed conserved by farmers at Sharanpur

Exhibition organized/participated

October 18, 2014: Exhibited institute's technology during exhibition at NDRI, Karnal.

October 30, 2014: Organized exhibition during Rabi Kisan Mela at IIWBR, Karnal.

November 12, 2014: Participated in District level Kisan Mela at Sonipat.

November 13, 2014: Exhibited institute's technology at Village Rasulpur, Muzaffarnagar, U.P.

November 14, 2014: Exhibited institute's technology at Village Barwala, Muzaffarnagar, U.P.

November 27, 2014: Exhibited institute's technology during District level Kisan Mela at NDRI, Karnal.

February 03-06 2015: Exhibited institute's technology during XII Agricultural Science Congress at NDRI, Karnal.

February 25-27, 2015: Exhibited institute's technology during National Dairy Mela at NDRI, Karnal.

Shri KD Kamboj, Hon'ble Minister of Food & Supplies, Govt. of Haryana visiting institute's stall during dairy mela

March 09, 2015: Exhibited institute's technology during Rabi Kisan Mela at CSSRI, Karnal.

March 10-12, 2015: Exhibited institute's technology during Pusa Krishi Vigyan Mela at IARI, New Delhi.

March 18, 2015: Exhibited institute's technology during Buffalo Mela at CIRB, Hisar.

March 28, 2015: Participated and Exhibited institute's technology during Fasal Vichar Gosthi organized by IFFCO at Dabri ki kalan, Karnal.

Training programmes organized for farmers at IIWBR, Karnal

July 27, 2014: 'Gujarat me Gehoon Ki Unnat Kheti' to the 50 farmers of Junagarh.

August 23, 2014: 'Gujarat me Gehoon Ki Adhunik Kheti' to the 52 farmers of Junagarh.

September 02, 2014: 'Recent Wheat Production Technologies' to 52 farmers of Bharatpur, Rajasthan.

Training to farmers from Rajasthan

September 05-06, 2014: 'MP ke liye Unnat Gehoon Utpadan Prodyogiki' to 11 farmers of Bhopal, MP.

September 18-19, 2014: 'Anand, Gujarat ke liye Gehoon Utpadan ki Vaigyani Vidhi' to 43 farmers of Anand, Gujarat.

September 22, 2014: 'Chhattisgarh me Gehoon ki Vaigyanik Kheti' for 43 farmers to Chhattisgarh.

November 18, 2014: 'Punjab me Gehoon ki Vaigyanik Kheti' to 20 farmers of Bhatinda, Punjab.

November 26, 2014: 'Recent Wheat Production Technologies' to 25 progressive farmers selected by PNB.

November 26, 2014: 'Entrepreunership Development in Wheat' to 38 Agroclinic students.

December 15, 2014: 'Recent Wheat Production Technologies for Gujarat' to 43 farmers from Patan district of Gujarat.

Lecture delivered by Scientists during extension programme

July 25, 2014: Dr. Anuj Kumar delivered lecture on 'Extension Management in ICAR' during training programme on 'Extension Methodology for Effective Transfer of Technology' organized at EEI, Nilokheri.

September 25, 2014: Dr Randhir Singh delivered a lecture on 'Extension skill for faster adoption of DSR' and 'CA based RCTs' during National training cum workshop on 'Principles and Practices of Direct seeded Rice' at CCSHAU, Uchani.

October 16, 2014: Dr Randhir Singh delivered a lecture on "Wheat production technologies" in Kisan Pathsala organized by Haryana Gyan Vigyan Samiti in Furlak village.

October 22, 2014: Dr. MS Saharan delivered lecture on Disease Management in Kisan Mela organized by CSSRI, Karnal at village Siwanamal (Jind).

October 30, 2014: Dr. MS Saharan delivered lecture on Disease Management in Rabi Kisan Mela organized by IIWBR, Karnal.

November 10, 2014: Dr. Anil Khippal delivered lecture on 'Conservation Agriculture' and imparted training to the farmers at Pashu Vigyan Kendera, Kaithal.

November 13, 2014: Dr. Anuj Kumar delivered lecture on 'Extension and Training Management in ICAR' during training programme on 'Training for Impact' organized at EEI, Nilokheri.

November 14, 2014: Dr. Anil Khippal delivered lecture on 'Spray Technology' and imparted training to the farmers at KVK, Karnal.

November 18, 2014: Dr. Anil Khippal delivered lecture on 'Vermi-compost' in a training programme organized by KVK, Karnal.

November 21, 2014: Dr. Anuj Kumar delivered lecture on 'Extension Management' and 'Use of ICVT in Extension' during training programme on 'Managerial Skills for Extension Personnel' organized at EEI, Nilokheri.

December 01, 2014: Dr Randhir Singh delivered a lecture on "Approaches to improve crop productivity and ensure livelihood security of farmers in salt affected areas" during training programme organized by CSSRI, Karnal.

December 02, 2014: Dr. Anil Khippal delivered lecture on 'Spray Technology' and imparted training to the farmers at KVK, Karnal.

December 03, 2014: Dr. Sendhil R delivered lectures on 'WTO - Genesis and Perspectives' and 'WTO vis-à-vis Indian Agricultural Economy' at EEI, Nilokheri.

December 08, 2014: Dr Randhir Singh delivered a lecture on "Wheat production technologies" in Awareness programme in village Kulwehri organized by Central Cooperative Bank and NABARD.

December 04, 2014: Dr. Anuj Kumar delivered lecture on 'Impact of WTO on Wheat Farming' and 'WTO and Protection of Plant Varieties and Farmers, Right Act (PPV&FRA)' during training programme on 'WTO and its Implications in Agriculture' organized at EEI, Nilokheri.

February 20, 2015: Dr. Anil Khippal delivered lecture on 'Rabi Crop Production Technology' and 'Conservation Agriculture' to the input dealers of KRIBHCO at KVK, NDRI, Karnal.

January 06 2015: Dr. Anuj Kumar delivered lecture on 'Role of Leadership in Extension' and 'Techniques of Identifying Progressive Farmers' during training programme on 'Motivational Skills for Forestry Extension' organized at EEI, Nilokheri.

January 15, 2015: Dr. Anuj Kumar delivered lecture on 'ICT in Transfer of Technology' and 'Cyber Extension' during training programme on 'ICT in Agriculture' organized at EEI, Nilokheri.

February 02, 2015: Dr. Anuj Kumar delivered lecture on 'Extension Management' and 'Use of ICVT in Extension' during training programme on 'Managerial Skills for Extension Personnel' organized at EEI, Nilokheri.

February 26, 2015: Dr. Anuj Kumar delivered lecture on 'E Communication' and 'Extension and Training Management' during training programme on 'Extension and Training Management' organized at EEI, Nilokheri.

Capacity building programme on barley cultivation

Capacity building of farmers and women on barley cultivation and its use as forage crop was organized at Jhajjar, Rewari and Bhiwani Districts of Haryana on February 16-18, 2015, at PVK, Kaithal on 28.2.2015, at Hisar, Fatehabad and Sirsa Districts of Haryana on March 2-4, 2015, at Rasin (Karnal) on 10.03.2015, at Lamba Kheri (Kaithal) on 11.3.2015, at Sehrda, Jind on 18.3.2015, Balu, Kaithal on 21.3.2015 and Kheri Chopta, Hisar on 22.3.2015.

Radio/TV Talk

May 1, 2014: Dr. Randhir Singh delivered the TV talk on 'Grain Storage' from Krishi Darshan, Delhi Doordarshan, New Delhi.

May 30, 2014: Dr. Anil Khippal delivered the live programme on 'Agriculture related problems and their solutions' from All India Radio, Rohtak.

October 09, 2014: Dr. Anil Khippal delivered the TV talk on 'Barley as fodder crop' from Delhi Doordarshan.

October 20, 2014: Dr. Randhir Singh delivered the TV talk on 'Improved wheat varieties' from Krishi Darshan, Delhi Doordarshan, New Delhi.

Novemeber 28, 2014: Dr. Anil Khippal delivered the live programme on 'Agriculture related problems and their solutions' from All India Radio, Rohtak.

December 23, 2014: Dr. Randhir Singh delivered the TV talk on 'Yellow Rust Management' from Krishi Darshan, Delhi Doordarshan, New Delhi.

March 19,2015: Dr. Indu Sharma gave the live interview on 'Unseasonal rain and its impacts on rabi crop' to ET NOW, Times Television Network, Times Global Broadcasting Company Limited, Mumbai.

SMS Service to Farmers

IIWBR collaborated with IFFCO to send messages to the farmers through mobile phone. The message on wheat varieties, yellow rust and weed control strategies in wheat and barley crops were sent to the farmers.

Advisory Service

The farmers were advised on various aspects of wheat and barley production technologies. About 350 farmers/entrepreneurs were provided replies to queries and in person. Large number of queries were received on weed control, yellow rust, yellowing of crop and their management.

"Drought Management Advisory" were issued to around 50 farmers of Sambhali and Brass village, Karnal on July 15, 2014 and around 40 farmers of Paliwas village, Hisar on July 18, 2014.

Visit Coordinated

Date	Visitors
28.04.2014	38 students from College of Agril., Lal sot, Dosa, (Raj.)
27.05.2014	23 farmers from Bhavnagar (Guj.)
11.06.2014	05 Dairy Farming trainees from NDRI, Karnal (Har.)
24.07.2014	50 farmers from Gujarat
08.08.2014	188 B.Sc.(Ag.) students from Annamalai Univ.
12.08.2014	149 B.Sc.(Ag) students from Annamalai Univ.
16.08.2014	56 farmers from Bathinda (Punjab)
20.08.2014	187 B.Sc.(Ag) students from Annamalai Univ.
22.08.2014	109 Institute of Agril. students from TNU
23.08.2014	52 farmers from Junagarh (Guj.)
02.09.2014	20 farmers from Bharatpur (Raj.)
05.09.2014	10 farmers from Bhopal (M.P.)
08.09.2014	148 B.Sc.(Ag) students from Annamalai Univ.
09.09.2014	11 farmers from Vidisha (M.P.)
16.09.2014	150 B.Sc.(Ag) students from Annamalai Univ.
20.09.2014	54 women farmers from Deesa (Guj.)
20.09.2014	40 farmers from Ahmedabad (Guj.)
26.09.2014	52 farmers from Mahisagar (Guj.)
10.10.2014	151 B.Sc.(Ag) students from Annamalai Univ.
12.10.2014	44 farmers from Bilaspur, Chhattisgarh
13.10.2014	15 Animal Nutrition Students from NDRI, Karnal
16.10.2014	107 students from APAC, Kalarai village (TN)
16.10.2014	50 students of various schools of Karnal
16.10.2014	42 farmers from Chhattisgarh
16.10.2014	6 farmers from Lucknow (U.P.)
22.11.2014	42 farmers from Karauli (Raj.)
24.11.2014	8 farmers from Lucknow (U.P.)
28.11.2014	50 students from CARD, New Delhi
13.12.2014	30 farmers from Junagarh (Guj.)
15.12.2014	43 farmers from Patan (Guj.)
17.12.2014	30 farmers from Somnath (Guj.)
17.12.2014	16 farmers from Sahja (M.P.)
17.12.2014	35 farmers from Jhunjhunu (Raj.)
17.12.2014	40 farmers from Alwar (Raj.)
26.12.2014	50 farmers from Sri Ganganagar (Raj.)
01.01.2015	40 farmers from Bharatpur (Raj.)
06.01.2015	32 farmers from Bidisha (M.P.) under ATMA
07.01.2015	42 farmers from Sawai Madhopur (Raj.) under RKVY
16.01.2015	6 agriculture and veterinary officers from EEI, Nilokheri (Har.)
19.1.2015	33 farmers from Bidisha under ATMA
22.01.2015	35 farmers from Sri Ganganagar (Raj.)
22.01.2015	16 farmers from Una (H.P.) under ATMA
12.02.2015	20 trainee farmers from U.P.
12.02.2015	11 farmers from Koria, Chhattisgarh
12.02.2015	20 farmers from Rasulpur Jatan (U.P.)
19.02.2015	50 farmers from Saharanpur (U.P.) under ITC
19.02.2015	22 farmers from US Nagar (Uttarakhand)
19.02.15	32 farmers from Agra (U.P.) under ATMA
19.02.2015	17 farmers from Pratapgarh (U.P.) under ATMA
22.02.2015	20 farmers from US Nagar (Uttarakhand)
22.02.2015	20 farmers from US Nagar (Uttarakhand)
23.02.2015	21 farmers from Ahemadabad (Guj.) under ATMA
23.02.2015	24 farmers from Dehradun (Uttarakhand) under ATMA
25.02.2015	21 farmers from Kisan Club, Karnal (Har.)
26.02.2015	24 farmers from Bidisha (M.P.) under ATMA
28.2.2015	16 farmers from Bidisha (M.P.) under ATMA
02.03.2015	51 farmers from Patan (Guj.)
04.03.2015	6 ARS probationers from NAARM, Hyderabad
10.03.2015	40 farmers from Nalkheda, Borod (M.P.)
12.03.2015	35 farmers from Rajgarh (M.P.)
13.03.2015	47 B.Sc. Hort. students from Mandsaur (M.P.)
14.03.2015	50 farmers from NFL, Kurukshetra (Har.)
16.03.2015	20 farmers from Datia (M.P.)
16.03.2015	10 farmers from Shajapur (M.P.) under ATMA
21.03.2015	32 farmers from Shajapur (M.P.)
21.03.2015	06 farmers from Kinnaur (H.P.)
25.03.2015	40 Agri. Ext. officers from CARD, New Delhi
31.03.2015	24 B.Sc. Biotech. students from DAV College, Amritsar (Punj.)

12. AWARDS AND RECOGNITIONS

Panjabrao Deshmukh Outstanding Woman Scientist Award

Dr. Indu Sharma, Director, IIWBR received the Panjabrao Deshmukh Outstanding Woman Scientist Award-2013 for developing inoculation technique for the identification of stable sources of Karnal Bunt resistance and incorporating Karnal bunt resistance in high-yielding wheat varieties.

Lal Bhahadur Shastri Outstanding Young Scientist Award

Dr. Pradeep Sharma, Senior Scientist (Biotechnology) received the prestigious Lal Bhahadur Shastri Outstanding Young Scientist Award-2013 for his research on post- transcriptional gene regulation by small RNAs under adverse climatic condition, which is critical for understanding and improving stress tolerance in crop plants.

Prof. Mahatim Singh Memorial Award

Dr. Rajinder Singh Chhokar, Senior Scientist (Agronomy) received the Prof. Mahatim Singh Memorial Award-2014 for his significant research contribution in the field of weed management in wheat based cropping system with special emphasis on herbicide resistance management, wheat agronomy and conservation agriculture.

Dr. RS Chhokar receiving Prof. Mahatim Singh Memorial Award-2014 from Dr. GP Singh

Dr. RK Arora Best Paper Award

Indian Society of Plant Genetic Resources conferred Dr. RK Arora best paper award to Drs. D Mohan, RK Gupta and BS Tyagi on March 05, 2015 for their paper "Meddling wheat germplasm to augment grain protein content and grain yield" published in Indian Journal of Plant Genetic Resources during the year 2013.

Indian Potato Association Gold Medal

Dr. Dinesh Kumar has been awarded Indian Potato Association Gold Medal for the best paper published in Potato Journal during the year 2010.

Best Poster Award

Drs. R Selvakumar, PS Shekhawat, RPS Verma, Vishnu Kumar, Joginder Singh, Anil Khippal, Rekha Malik, Dinesh Kumar, AS Kharub and Indu Sharma received Best Poster Award for the poster entitled "Exotic sources for barley stripe rust resistance" on the occasion of XII Agricultural Science Congress-2015 at ICAR- NDRI, Karnal during February 3-6, 2015.

Drs. Vikas Gupta, Satish Kumar, CN Mishra, Raj Kumar, Vinod Tiwari and Indu Sharma received Best Poster Award for the poster entitled "Development of double haploids in wheat using wheat and maize system" on the occasion of XII Agricultural Science Congress-2015 at ICAR- NDRI, Karnal during February 3-6, 2015.

Fellow of the Society for Advancement of Wheat Research

Society for Advancement of Wheat Research (SAWR) has honoured Drs. Indu Sharma, RK Gupta, Vinod Tiwari, R Chatrath, RK Sharma, RPS Verma, SC Bhardwaj, AS Kharub, Randhir Singh, MS Saharan, Sushila Kundu, Devinder Mohan, Gyanendra Singh, Sewa Ram, SC Tripathi, Ratan Tiwari, BS Tyagi, Raj Kumar, Satyavir Singh, Sindhu Sareen, SC Gill, Rekha Malik, RS Chhokar, Anuj Kumar and SK Singh with SAWR Fellow in a society meeting held at Jabalpur on August 22, 2014.

Dr. JS Sandhu awarding SAWR fellow to Dr. Indu Sharma

Fellow Award of Indian Potato Association

Dr. Dinesh Kumar has been elected Fellow of the Indian Potato Association (IPA), Shimla.

Fellow of Indian Society of Genetics and Plant Breeding

Dr. SK Singh has been honoured with Fellow of the Indian Society of Genetics and Plant Breeding.

Best Article Published in Swarnima

Drs. RK Sharma, RS Chhokar, Randhir Singh and Anuj Kumar conferred the best article award for their paper titled 'Dhan- Gehoon Phasal Chakra Mein Zero Taknique: Punravalokan Evam Sambhanayien' published in the fifth issue of Swarnima.

Honoured for the development of wheat variety *DBW 88*

Dr. Ratan Tiwari and his team (Drs. V Tiwari, Rajender Singh, SK Singh, R Chatrath, G Singh, BS Tyagi, Raj Kumar, CN Mishra, MS Saharan and Indu Sharma) have been honoured during 53rd All India Wheat and Barley Research Worker's meet at Jabalpur for the development of the wheat variety ***DBW 88*** for irrigated timely sown conditions of North Western Plains Zone (NWPZ).

Honoured for the development of wheat variety *DBW 90*

Dr. Ravish Chatrath and his team (SK Singh, V Tiwari, MS Saharan, Sewa Ram, Ratan Tiwari, G Singh, Raj Kumar, BS Tyagi, Satish Kumar, Vikas Gupta and Indu

Dr. Ravish Chatrath and his team receiving memento from Dr. SK Datta for the development of the wheat variety DBW 90

Wheat and Barley Research Worker's meet at Jabalpur for the development of the wheat variety ***DBW 90*** for irrigated late sown conditions of North Western Plains Zone (NWPZ).

Best worker's award

During the foundation day, Mr. Surinder Singh in technical officer category, Mr. RP Sharma in technical category, Shri Roop Ram in administrative category and Sh. Bhoop Ram in skilled staff category were bestowed with best workers award for the year 2013-14 on September 9, 2014.

Dr. RG Saini giving best worker award to Mr. RP Sharma

Ph. D.

Dr. Rajendra Kumar, Sr. Tech. Officer, IIWBR has been conferred Ph.D. degree in Agricultural Botany by CCS University, Meerut for his work "Genetic diversity for morpho-physiological traits for heat tolerance in Indian wheat cultivars".

Ms. Anukriti Verma has been awarded Ph.D. degree on the topic "Molecular characterization of phytase in wheat" from Kurukshetra University, Kurukshetra, India. She completed her thesis under the supervision of Dr. Sewa Ram, Principal Scientist, IIWBR.

Certificate of recognition

Dr. Sewa Ram, Principal Scientist received the *certificate of recognition* from the Director, IIWBR for institutional services in drafting EFC document and as In-charge PME Cell during the Institute's Foundation day (September 09, 2014).

Dr. Sendhil R received the *certificate of recognition* (3 no.) from the Director IIWBR during the Institute's Foundation day (September 09, 2014). These certificates were given for publishing highest number of research articles in peer reviewed journals during 2013-14; getting the competitive LI-LMI grant from the Agricultural & Applied Economics Association (AAEA) Trust, USA; and institutional services like managing the online content of 'Journal of Wheat Research', instrumental in publishing the e-Newsletter on 'Wheat Scenario - A Snippet' and database management.

Dr. SK Singh received the *certificate of recognition* for oral presentations and Co-Chairing Track 5 (Crop Breeding & Genetics) & Track 11 (Sustainable practices for Agriculture) sessions during 3rd International Conference on Agricultural & Horticultural Sciences at Hyderabad, October 27 – 29, 2015.

Visiting Faculty/Expert

Dr. Randhir Singh involved as an expert in evaluating research project submitted to Haryana Kisan Ayog.
Dr. Randhir Singh, Dr. Anuj Kumar and Dr. Sendhil R were honoured as a visiting faculty of Extension Education Institute, Nilokheri. Dr. Randhir Singh, Dr. Satyavir Singh and Dr. Anuj Kumar were invited as experts in the student's Credit Seminar of Dairy Extension Education, NDRI.

Dr. Sendhil has been associated for teaching 'Advanced Agricultural Marketing and Price Analysis (3+0)' to Ph.D. Students and 'Agricultural Development and Policy Analysis (2+0) to M.Sc. Students at ICAR-National Dairy Research Institute.

Sports

In Cycle race, Sh. Ramu Shah was winner in the inter zonal sports meet organized at NDRI, Karnal.

13. DISTINGUISHED VISITORS

IIWBR, Karnal

April 01, 2014: Mr. DS Raghu and Mr. Kaibalya Pradhan, Members of Commission for Agricultural Cost and Prices, Ministry of Agriculture, Govt. of India visited the institute to know about the research programme on Wheat and Barley.

April 01, 2014: Dr. Santosh Kumar Singh, Agricultural Specialist, Department of Agricultural Research and Education, Ministry of Agriculture, Govt. of India visited the institute to discuss wheat production outlook during 2013-14.

April 08, 2014: Ms. Johanna Unger from Sweden visited the institute and farmers field.

May 14, 2014: Dr. Reda Ibrahim Nadomara and Dr. Ashraf Sami Hassanin from Agricultural Research Centre, Egypt visited the institute and interacted with the scientists.

May 19, 2014: Dr. A Sarker, Regional Coordinator, ICARDA Regional Office-New Delhi along with Dr. RPS Verma from ICARDA-Morocco visited the institute and participated in Regional Information Workshop on Barley under ICAR-ICARDA CRP project 3.6.

May 23, 2014: Dr. RK Agarwal, CCMB, Hyderabad and Dr. SR Bhat, NRCPB, New Delhi and Dr. ON Tiwari, DBT, New Delhi visited the institute and reviewed the project DBT sponsored project.

May 26-27, 2014: Dr. Eric Huttner, Research Programme Manager, ACIAR, Canberra visited the institute.

May 27, 2014 : Dr. SK Datta, DDG Crop Sciences, ICAR visited the institute and chaired the plenary session of Annual Science Meeting of Indo-Australian (ICAR-ACIAR) Program on Marker Assisted Wheat Breeding.

June 27, 2014: Dr. Sanjaya Rajaram World Food Prize 2014 winner visited the institute and interacted with scientists.

Dr. Indu Sharma, Director, IIWBR and Dr. AK Srivastva, Director, NDRI congratulating Dr. Sanjaya Rajaram on getting World Food Prize

September 09, 2014: Dr. RG Saini, Invited Professor and Coordinator, Centre for Biosciences, Central University of Punjab, Bathinda visited the institute as chief guest of foundation day.

September 22, 2014: Mr. RK Mohan, Managing Director, Jayakrishna Flour Mills Pvt. Ltd. Thirumangalam visited the institute.

October 30, 2014: Prof. RC Sharma, Centre Coordinator, Centre for Environmental Science and Technology, visited the institute as the Chief Guest of Rabi Kisan Mela.

November 18, 2014: Dr. Silvie Minturn Brouder and Dr. Rasheed Sulaiman Vadakkel – Wheat CRP Independent Evaluation Team Members visited the institute.

November 24, 2014: Dr. AK Joshi, Regional Co-ordinator, CIMMYT-South Asia Office-Nepal, Dr. CP Srivastava, Head, Dept of Entomology, BHU and Prof. (Dr.) Urs Wyss, University of Kiel, Germany visited the institute and interacted with the Entomologists of AICW&BIP centres.

November 29, 2014: Dr. SK Datta (DDG Crop Science), ICAR visited the institute and interacted with scientists.

Dr. S K Datta interacting with scientists

December 09, 2014: Mr. Arnoud from Boortmalt Private Limited visited the contractual barley varietal evaluation trials at the ICAR-IIWBR farm.

December 15, 2014: Dr. SK Vasal, World Food Prize Winner visited the institute and delivered the Dr. MV Rao Lecture.

December 18-20, 2014: Dr. Hide Omae, Dr. Mariko Shono and Dr. Masato Oda from Japan International Research Center for Agricultural Sciences, Japan visited the institute regarding feasibility study project.

February 03, 2015: Dr. Sanjaya Rajaram, Wheat Breeder and 2014 World Food Prize Laureate, Resource Seeds International, Mexico & India visited the experimental fields at ICAR-IIWBR and interacted with the Scientists.

February 03, 2015: Dr. Birpal Singh, Director, CPRI, Shimla visited the institute and seen the different lab. and field facilities.

February 04, 2015: Dr. Gurbachan Singh, Chairman, ASRB and Dr. Sudhir Bhargava, Member, Governing Body, ICAR visited the experimental field and laboratory.

Dr. Gurbachan Singh, Chairman, ASRB visiting the experimental fields and interacting with scientists

February 05, 2015: Dr. S. Ayyappan, Secretary DARE & DG, ICAR and Dr. JS Sandhu Deputy Director General (Crop Sciences), ICAR visited the IIWBR in the meeting "Benchmarking varieties of important agricultural and horticultural crops in India" convened at IIWBR, Karnal.

Dr. S. Ayyappan, Secretary DARE & DG, ICAR visiting IIWBR

Dr. Indu Sharma welcoming Dr. JS Sandhu, DDG (Crop Science), ICAR and Dr. HS Gupta, DG -BISA and for meeting

February 06, 2015: Dr. Thomas Lumpkin, DG-CIMMYT, Dr. HS Gupta, DG-BISA and Dr. Etienne Duveiller visited the experimental fields at ICAR-IIWBR and interacted with the Scientists.

Dr. Thomas Lumpkin, Dr. HS Gupta and Dr. Etienne Duveiller visiting the farm and interacting with scientists

February 11 -13, 2015: Dr. Eric Murhii and Dr. John Foulkes from University of Nottingham visited IIWBR under SCPRID BBSRC-DBT project.

February 15-16, 2015: Dr. Philippo Bassi, Durum breeder from ICARDA, Morocco visited the institute and saw the international nurseries and trials at Karnal.

February 15-18, 2015: Dr. Ian King from University of Nottingham visited IIWBR, Karnal to discuss the experimentation under the project "*Exploitation of Inter-specific Biodiversity for Wheat Improvement*". The Project is under the collaboration of BBSRC-DBT-ICAR. The IIWBR is the partner and conducting experiments at Hisar and Karnal locations. He appreciated the research programs being under taken by IIWBR.

February 23, 2015: Dr. Ravi Singh from CIMMYT and Dr. Jesse Poland form KSU visited IIWBR, Karnal and Dr. Jesse Poland delivered a talk on "Genomic selection in wheat".

March 08-13, 2015: Dr. Shobha Sivasankar, Director, Dryland Cereals (ICRISAT) and Dr. RPS Verma, Barley Breeder, ICARDA reviewed and monitored CRP 3.6 Dryland cereals programme.

March 27, 2015: Dr. IS Solanki, ADG(F&FC), visited the institute and interacted with the scientists.

March 30, 2015: Dr. JP Tandon, Ex -ADG (F&FC), ICAR alongwith Dr. DS Mishra, Joint Registrar, PPV&FRA visited institute and conducted monitoring of DUS trials.

DWR Regional Station, Shimla

May 17, 2014: Dr. Indu Sharma, Director, IIWBR, Karnal visited the centre.

May 21, 2014: Dr. B Pokhrael, NARC, Nepal, Dr. Reshma Sultana, Bangladesh Agriculture Research Institute, Gazipur, Bangladesh and Dr. Yadunath Bajgai, Research and Development Centre, Bajo Wangdue Phodrang, Bhutan visited the centre.

May 30, 2014: Dr. HS Bariana, PBI, Cobbitty, Australia visited Flowerdale, Shimla.

June 27, 2014: Dr. YS Ahlawat, Principal Scientist (Retd.) IARI, New Delhi visited Flowerdale, Shimla.

December 12, 2014: Dr. RPS Verma, Barley Breeder, ICARDA and Dr. AS Kharub, PI (Barley), IIWBR, Karnal visited the station.

DWR Regional Station, Dalang Maidan

June 28-29, 2014: Dr. RP Dua, ADG(F&FC) along with Dr. Indu Sharma, Director, IIWBR, Karnal visited the centre and interacted with the local farmers and apprised them of the support in the form of training for their benefit.

August 05-07, 2014: Dr. SK Dhyani, Director, National Research Centre for Agro-forestry, Jhansi visited the station and imparted training to farmers.

DWR Research and Seed Production Farm, Hisar

November 29, 2014: Dr. SK Datta (DDG Crop Science), ICAR visited the fields at IIWBR Research and Seed Produciton Farm, Hisar.

February 11, 2015: Shri Dushyant Chautala Ji, Hon'ble Member of Parliament, visited IIWBR Hisar Farm and interacted with the scientists.

Dr. SK Datta inaugurating the irrigation system at IIWBR farm, Hisar

Shri Dushyant Chautala Ji, Hon'ble Member of Parliament planting sapling at IIWBR Research Farm, Hisar

14. TRAINING AND CAPACITY BUILDING

Trainings

The Institute was allocated annual budget of Rs 6.00 lakh for human resource development, which was utilized for training and capacity building of the institute scientific, technical and administrative staff. Five scientists were provided opportunity of upgrading their knowledge outside the country whereas another eight scientists attended training within the country. Two administrative personals were also attended training programme pertaining to official administrative and financial procedures.

Outside country

Name	Title	Duration
Drs. AS Kharub & Jogendra Singh	Training workshop on Genotyping and Association mapping of multiple traits in Barley and Selection of barley Germplasm at Rabat, Morocco	April 23-26, 2014
Dr. Hanif Khan	Endeavour Research Fellowship-2014 at Plant Breeding Institute, Cobbitty University of Sydney, Australia	June 16 – December 15, 2014
Drs. R Selvakumar and OP Gangwar	Standardization of stem rust field notes and germplasm evaluation, with discussions on stripe and leaf rust held at Kenya Agricultural Research Institute (KARI) Research Station, Njoro, Kenya	September 23 - October 3, 2014

Within Country

Name	Title	Duration
Dr. Pradeep Sharma	Training on Management Development Programme on IPR in Biotechnology at NAARM, Hyderabad	June 16-21, 2014
Drs. Anil Khippal & RP Meena	Training programme at ISRO, Ahmadabad under DWR-ISRO collaborative project	July 7-18, 2014
Mr. Anil Kumar	CSP for Official Procedure	June 9-20, 2014
Drs. Sudheer Kumar and Subhash Katare	Refresher course on "Agriculture research management" at NAARM, Hyderabad	July 14 – 26, 2014
Dr. Ratan Tiwari	Training on Management Development Programme on Leadership development at NAARM, Hyderabad	July 15-26, 2014
Dr. R Selvakumar	International programme on pest risk analysis at National Institute for Plant Health Management, Hyderabad	September 1-5, 2014
Dr. Sendhil R	Regional Training and Awareness Programme on J-Gate@CeRA at NASC Complex, New Delhi	September 29, 2014
Mr. Ramesh Kumar	CSP for Official Procedure	October 21–November 1, 2014
Dr. Sendhil R	CAFT programme on "Recent Advances in Survey Design and Analysis of Survey Data using Statistical Software" at IASRI, New Delhi	October 28 – November 17, 2014
Dr. Sindhu Sareen	Analysis of experimental data at NAARM, Hyderabad	November 10 – 15, 2014

Annual training plan (ATP) for the period 2015-16 and 2016-17

As per ICAR guidelines, training calendar was prepared and plan was made for their country level training during 2015-16 and 2016-17.

Scientific staff

Name of the Scientist	Designation	Training Course	Place	Duration
Dr. Arun Gupta	Principal Scientist – Economic Botany	Sustainable Management of Plant Genetic Resources	NBPGR, New Delhi	Two-week
Dr. Joginder Singh	Principal Scientist – Plant Breeding	Refresher Course on Agricultural Research Management	NAARM, Hyderabad	Two-week
Dr. R Sendhil	Scientist – Agric. Economics	Developing Winning Research Proposals in Agricultural Research	NAARM, Hyderabad	One-week
Dr. Randhir Singh	Principal Scientist – Agric. Extension	Impact Assessment of Agricultural Extension	NAARM, Hyderabad	One-week
Dr. CN Mishra	Scientist – Plant Breeding	Winter/ summer school, plant breeding and biometrics/ statistics/ biotic or abiotic stresses s	Any SAU or ICAR institute	Three-week
Dr. Vikas Gupta	Scientist – Plant Breeding	Winter/ summer school, plant breeding and biometrics/ statistics/ biotic or abiotic stresses	Any SAU or ICAR institute	Three-week
Dr. Sneh Narwal	Senior Scientist – Biochemistry	Advance proteomic techniques	DBT/ ICAR	Three-week
Dr. Satyavir Singh	Principal Scientist – Agric. Extension	Developing Winning Research Proposals in Agricultural Research	NAARM, Hyderabad	One-week
Dr. Anuj Kumar	Senior Scientist – Agric. Extension	Quantitative Techniques for Business Managers and Social Scientists (under TBI Project)	NAARM, Hyderabad	One-week
Dr. Satish Kumar	Scientist – Plant Breeding	Winter/ summer school, plant breeding and biometrics/ statistics/ biotic or abiotic stresses	Any SAU or ICAR institute	Three-week

Technical staff

Name	Designation	Training Course	Place	Duration
Sh. Rajinder Kumar Sharma	Technical Officer	Faculty Development Programme on Educational Technology	NAARM, Hyderabad	One-week
Sh. Rajinder Singh	Technical Officer	Agricultural Knowledge Communication	NAARM, Hyderabad	One-week
Sh. JK Pandey	Technical Officer	Agricultural Knowledge Communication	NAARM, Hyderabad	One-week
Dr. Subodh Kumar	Technical Officer	Competency Enhancement Program	NAARM, Hyderabad	Two-week
Sh. Yogesh Sharma	Technical Officer	ASP.NET with C#	NIELIT, Mohali	Six-week
Sh. Ravinder Singh	ACTO	Agricultural Knowledge Communication	NAARM, Hyderabad	One-week
Sh. Rajkumar	Technical Officer	Competency Enhancement Program	NAARM, Hyderabad	Two-week
Sh. Rajinder Kumar Gola	Technical Officer	Competency Enhancement Program	NAARM, Hyderabad	Two-week
Sh. Chandra babu	Technical Officer	ASP.NET with VB.NET	NIELIT, Mohali	Six-week

Administrative staff

Name	Designation	Training Course	Place	Duration
Sh. Sunil Kumar	LDC	Establishment Rules	ISMT, New Delhi	One-week
Sh. Sunil Kumar	Assistant	Administrative Vigilance	ISMT, New Delhi	One-week
Sh. Anil Verma	LDC	MS Office Suite	ISMT, New Delhi	One-week
Sh.Rramesh Chand	UDC	Purchase Management	ISMT, New Delhi	Three-days
Mrs. Promila	Assistant	Pension & Retirement Benefits	ISMT, New Delhi	Three-days
Sh. Krishan Pal	UDC	Workshop on Fixation cases	ISMT, New Delhi	Three-days
Sh. Ramesh Kumar	Assistant	Establishment Rules	ISMT, New Delhi	One-week
Sh. Mahavir Singh	UDC	MS Office Suite	ISMT, New Delhi	One-week

Capacity Building

Apart from the training programme, large number of scientists attended various symposium, workshop, conference and meeting with in country and outside the country. The details have been given in following tables:

Outside Country

Name	Title/purpose	Duration
Dr. Rekha Malik	Presented a paper on Localization of genomic region conferring corn leaf aphid resistance in barley in the workshop on 21st Biennial International Plant Resistance to Insects held at Marrakech, Morocco	April 14-18, 2014
Dr. Indu Sharma	Visited Bhutan Agriculture Research Centres and help Bhutanese colleagues to organise their wheat breeding activities and collaboration with India in order to address the disease prevalent there specially rust	April 21-25, 2014
Dr. Ratan Tiwari	Visited farmer's fields, research stations at various locations in Morocco under ICAR-ICARDA work plan	May 12-17, 2014
Dr. R Selvakumar	First International Workshop on Barley Leaf Diseases; Salsomaggiore Terme, Italy	June 3-6, 2014
Dr. RK Sharma	6th World congress on conservation agriculture, held at Winnipeg, Manitoba, Canada	June 22-25, 2014
Dr. Raj Kumar	Food & Agribusiness Management Program at College of Agriculture and Life Sciences, Cornell University, Ithaca, New York, USA	July 21 – August 1, 2014
Dr. Sendhil R	Presented a paper on "Performance and Relevance of Wheat Futures Market in India - An Exploratory Analysis" in the 2014 Annual Agricultural & Applied Economics Association meeting at Minneapolis, US	July 27-29, 2014
Drs. RK Gupta, V Tiwari, RK Sharma, R Chatrath, R Singh, MS Saharan, SC Bhardwaj, RS Chhokar, CN Mishra, Satish Kumar	Annual Review & Work Plan Meeting of CSISA and BMZ projects at Kathmandu, Nepal	September 10-14, 2014
Dr. SK Singh	Expert Working Group Jamboree of the Wheat Initiative and G20 Wheat Initiative Research Committee meeting at Paris, France	September 29 - October 1, 2014
Dr. Indu Sharma	World Food Prize Ceremony held at Des Moines, Iowa (USA)	October 13-20, 2014
Drs. Sewa, Ram, Sonia Sheoran and Mamrutha HM	Launch conference of Heat and Drought Wheat Improvement Consortium (HeDWIC), CIMMYT at Frankfurt, Germany	December 2-4, 2014
Dr. K Venkatesh	Wheat Global Partner Meeting and Wheat Management Committee meeting, Istanbul	December 8-11, 2014
Dr. Sneh Narwal	Female Leadership in Science at San Diego, USA	January 7-9, 2015
Drs. Randhir Singh and AS Kharub	Planning Meeting for Phase II CGIAR Research Programme on Dryland Cereals at Adis Ababa, Ethiopia	March 16-20, 2015
Dr. Pramod Prasad	DRRW Wheat Rust Surveillance Workshop" at Kathmandu, Nepal	March 16-25, 2015
Dr. SC Bhardwaj	DRRW Wheat Rust Surveillance Workshop at Kathmandu, Nepal	March 20-23, 2015
Drs. Pradeep Sharma and Mamrutha HM	International wheat yield potential workshop, CIMMYT field day and DBT-BBSRC project meeting at CIMMYT, Obregon, Mexico	March 23-29, 2015

Within Country

Name	Title/purpose	Duration
Dr. Indu Sharma	Field Day at Bisa Farm Ladowal (Ludhiana)	April 3, 2014
Dr. Indu Sharma	Interactive Conference of the Vice Chancellors and Directors at NASC Complex, New Delhi	April 28, 2014
Dr. Indu Sharma	Meeting of EFC for 'Consortia Research Platform on Water' at Krishi Bhawan, New Delhi	April 29, 2014

Name	Title/purpose	Duration
Dr. Indu Sharma	Meeting on EFC document of 'CRP on Biofortification' at ICAR, Krishi Bhawan, New Delhi	April 30, 2014
Drs. Sushila Kundu and A Gupta	Wheat and Barley Field day at NBPGR Regional Station, Bhowali	May 19, 2014
Drs. AS Kharub, R Singh, D Kumar, J Singh, A Kumar, R Selvakumar, A Khippal, V Kumar and Sendhil R	Regional Information Workshop under ICAR-ICARDA CRP 3.6 barley Project, at Directorate of Wheat Research, Karnal	May 19-22, 2014
Dr. Randhir Singh	Haryana State Food Security Mission Executive Committee meeting	May 26, 2014
Dr. Indu Sharma	69th meeting of the Central Sub Committee on Crop Standards, Notification and Release of varieties for agricultural crops at VPKAS, Almora	June 2, 2014
Dr. Indu Sharma and MS Saharan	Foundation Day Lecture of the National Academy of Agricultural Sciences at NASC Complex, New Delhi	June 5, 2014
Dr. Indu Sharma	Director's Conference at New Delhi	June 6, 2014
Dr. Satyavir Singh	Seminar on 'Agro-Ecology and Farmers" at Panchayat Bhawan, Karnal organized by Haryana Vigyan Manch	June 22, 2014
Dr. Indu Sharma	Brain Storming Session on "Take it to Farmers-The Farmers' Rights through Awareness" held at NASC Complex, New Delhi	June 24, 2014
Dr. Indu Sharma	Workshop to revise IPM packages held at National Institute of Plant Health Management, Rajendernagar, Hyderabad	June 25, 2014
Dr. Indu Sharma	Curtain Raiser Meet for the 7th International Wheat Seminar and delivered a talk on "Global Wheat Scenario" at Assocom Institute of Bakery Technology and Management (AIBTM), Chennai	June 26, 2014
Dr. Randhir Singh	Punjab State Food Security Mission Executive Committee meeting	July 3, 2014
Dr. Indu Sharma	Scientific Advisory Committee (SAC) meeting of the Krishi Vigyan Kendra (KVK) of National Dairy Research Institute	July 5, 2014
Drs. Indu Sharma and SK Singh	12thPlan EFC meeting of IARI scheme at ICAR New Delhi	July 9, 2014
Dr. Indu Sharma	PGR Export Facilitation Committee Meeting in the NBPGR, New Delhi	July 10, 2014
Dr. Indu Sharma	XII plan EFC meeting at New Delhi regarding consortia platform on conservation agriculture	July 15, 2014
Drs. SC Tripathi, MS Saharan, S Kumar, SC Gill, Sneh Narwal, SK Singh, A Khippal, Sonia Sheoran, V Gupta and K Venkatesh	1st formal meeting of the NAAS, Karnal chapter at Animal Biotechnology Centre, NDRI, Karnal.	July 26, 2014
Drs. Indu Sharma, RK Gupta, V Tiwari, R Chatrath, RK Sharma, Sushila Kundu, AS Kharub, R Singh, SC Bhardwaj, G Singh, BS Tyagi, MS Saharan, A Gupta, D Kumar, S Singh, J Singh, SK Singh, R Selvakumar, A Khippal, S Katare, V Kumar, K Venkatesh Mamrutha HM and Sendhil R	53rd All India Wheat and Barley Workers' Meet at JNKVV, Jabalpur and International Seminar on Enhancing Wheat and Barley Production with special emphasis on Nutritional Security held at JNKVV, Jabalpur	August 22-25, 2014
Dr. Jogender Singh	National Group Meet: Rabi 2014-15 (AICRP on Forage Crops), held at PAU, Ludhiana	August 26-27, 2014
Dr. Randhir Singh	Scientific Advisory Committee Meeting, KVK, Ujha, Panipat	August 29, 2014
Dr. Sushila Kundu	XXVII Meeting of Plant Germplasm Registration Committee held at NBPGR, New Delhi	September 4, 2014
Dr. Indu Sharma	7th International Seminar on "Wheat and Wheat Products – New Technologies & Marketing Opportunities" held at Sheraton Park Hotel and Towers, Chennai (India)	September 2-3, 2014

Name	Title/purpose	Duration
Dr. Indu Sharma	Interact meet of Dr. Jose Graziano da Silva, Director General, FAO with leaders of Indian NARES, Vice Chancellors of Agricultural Universities, senior officers in the Ministry of Agriculture and ICAR at AP Shinde Symposium Hall, NASC, New Delhi	September 8, 2014
Dr. Indu Sharma	IPNI Research Cooperators' Meet-2014 at UAS, Dharwad	September 16, 2014
Drs. Indu Sharma, R Chatrath, MS Saharan, P Sharma and Sendhil R	7th International Agriculture Leadership Summit 2014 at Hotel Taj Palace, New Delhi	September 27, 2014
Drs. Dinesh Kumar and Sendhil R	Regional Training and Awareness Programme on J-Gate@CeRA at NASC Complex, New Delhi	September 29, 2014
Dr. Indu Sharma	Workplan meeting of the project "Development of heat tolerant wheat for South Asia" under ARCADIA-CIMMYT-ICAR-USAID at NBPGR, New Delhi	September 29, 2014
Dr. Anil Khippal	International Seminar on Ayurvet Knowledge at New Delhi	October 8 -9, 2014
Drs. Vinod Tiwari and Sushila Kundu	Plant Genome Saviour Award meeting at NASC, New Delhi	October 16, 2014
Dr. MS Saharan	Strategy meeting on Stripe rust and Karnal bunt management organized at Lucknow	October 16, 2014
Dr. Randhir Singh	Interface meeting of SAU-ICAR at NDRI, Karnal	October 18, 2014
Mr. Ramesh Kumar	CSP for Official Procedure	October 21–November 1, 2014
Drs. SK Singh and K Venkatesh	3rd International Conference on Agriculture and Horticulture at HICC, Hyderabad	October 27-29, 2014
Drs. Indu Sharma, SK Singh and Vishnu Kumar	National Symposium on Crop Improvement for inclusive Sustainable Development, held at PAU, Ludhiana.	November 7-9, 2014
Dr. Indu Sharma	XXIII meeting of ICAR Regional Committee No. V held at PAU, Ludhiana	November14-15, 2014
Dr. Randhir Singh	Meeting on "Increasing wheat productivity in Haryana" with Sh. OP Dhankar, Minister of Agriculture, Haryana	November 11, 2014
Dr. Sushila Kundu	Workshop on Capacity Building for the implementation of ITPGRFA in India held at Deendyal Research Institute, Chitarakoot, Satna	November 17-18, 2014
Dr. Anil Khippal	District level Kisan Mela organized by Agriculture Department, Govt. of Haryana and delivered lecture on conservation agriculture	November 27, 2014
Dr. Sendhil R	IEG-IFPRI Conference on "Innovation in Indian Agriculture: Ways Forward" at India International Centre, New Delhi	December 4-5, 2014
Dr. Sushila Kundu	Indo-German Bilateral Cooperation Meeting on Protection of Plant Varieties and Breeders Rights at NASC Complex, N. Delhi	December 16, 2014
Dr. Indu Sharma	Inaugural session of one week short course on "Management of Frost and Prolonged Foggy Weather" at CSSRI, Karnal as Chief Guest	December 17, 2014
Dr. Sendhil R	Workshop of ICAR-MoFPI Project on "Assessment of Harvest and Post-Harvest Losses of Major Crops/Commodities in India" at UAS-Bengaluru	January 08, 2015
Dr. Anil Khippal	Field day at Pundri, Kaithal	January 10, 2015
Drs. Indu Sharma and Anuj Kumar	BISA Workplan Meeting at NAAS complex, New Delhi	January 12, 2015
Drs. Indu Sharma and Gyanendra Singh	Brain storming session on "Optimizing Talent Search for the National Agricultural Research & Education System (NARES) organised by ASRB at NDRI, Karnal	January 16, 2015
Dr. Indu Sharma	Meeting to review status of management of yellow rust and to discuss strategies for control of karnal bunt in wheat at Chandigarh	January 20, 2015
Dr. Sendhil R	National Seminar on "Climate Change and Agrarian Economy: An Indian perspective" held at UAS, Dharwad	January 22-23, 2015
Dr. MS Saharan	Strategy meeting on Karnal bunt management at Bhopal.	January 18, 2015

Name	Title/purpose	Duration
Drs. Sushila Kundu, R Singh, AS Kharub, D Kumar, A Gupta, S Singh, J Singh, Rekha Malik, SK Singh, R Selvakumar, Anuj Kumar, A Khippal, Sonia Sheoran, Vishnu Kumar, K Venkatesh, Mamrutha HM, and Sendhil R	XII Agricultural Science Congress on Sustainable Livelihood Security for Smallholder Farmers held at ICAR-NDRI, Karnal	February 3-6, 2015
Dr. Indu Sharma	Presented a lead paper on "Wheat production in relation to climate change and chaired the session on "The Challenges of Climatic Drift on Productivity of Wheat in India" in National Seminar at Junagadh	February 13, 2015
Dr. Sushila Kundu	DUS review meeting at GAU, Junagadh	March 9-10, 2015
Dr. Indu Sharma	Meeting of the Central Sub Committee on Crop Standards, Notification and Release of varieties for agricultural crops under the Chairmanship of DDG (CS) at Krishi Bhawan, New Delhi	March 10, 2015
Dr. Indu Sharma	Inaugural function of Youth Festival at NDRI, Karnal	March 18, 2015
Dr. Indu Sharma	Meeting at NBPGR, New Delhi on transfer of DNA samples of Wheat to University of Liverpool, U.K.	March 25, 2015

15. RESEARCH PROJECTS

Institute's 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
	Crop Improvement		
DWR/RP/10-2 Germplasm Improvement through pre- breeding			
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 and Hanif Khan
DWR/RP/10-2.3	Development of doubled haploids in wheat	Vikas Gupta	Satish Kumar, CN Mishra, Raj Kumar and 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, 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, Sewa Ram and Arun Gupta
DWR/RP/10-3.3	Wheat Improvement for warmer areas of the country	SK Singh	BS Tyagi, V Tiwari, RK Gupta, Pradeep Sharma, DP Singh, RS Chhokar, K Venkatesh and 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 (on study leave), Jogender Singh and Vishnu Kumar
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 characterization of Indian wheat for assaying stem rust resistance gene(s)	Rekha Malik	Hanif Khan and 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 and Mamrutha HM
DWR/RP/10-5.5	Development and utilization of TILLING population for important traits of agronomic importance	Rajender Singh	Sneh Narwal and Sonia Sheoran
DWR/RP/10-5.6	Genetic studies on abiotic stress tolerance in wheat	Sindhu Sareen	BS Tyagi and Pradeep Sharma
DWR/RP/10-6	Improvement of wheat seed multiplication ratio through agronomic, pathological and technology interventions	Raj Kumar	RS Chhokar and DP Singh
	Barley Network		
DWR/RP/10-7 Improvement of barley varieties, protection and production technologies			
DWR/RP/10-7.1	Barley improvement for malting quality and resistance to prevalent biotic / abiotic stresses	Vishnu Kumar	R Selvakumar, Dinesh Kumar and Jogendra Singh

Project No.	Project Title	PI	Associate/s
DWR/RP/10-7.2	Improvement of barley for feed and dual purposes	Jogendra Singh	Vishnu Kumar, R Selvakumar and Anil Khippal
DWR/RP/10-7.3	Molecular markers assisted improvement of barley for disease, pest and malt quality	Rekha Malik	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	OP Gangwar
DWR/RP/10-7.6	Resource management in barley for enhancing productivity and quality	AS Kharub	Dinesh Kumar and Anil Khippal
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/10-8.5 (RRS Shimla)	Monitoring variability in wheat and barley rusts and rust resistance in wheat and barley	SC Bhardwaj	OP Gangwar, Hanif Khan and Pramod Prasad
Resource Management **DWR/RP/10-9 Resource conservation, diversification, integrated nutrient, water and weed management for the sustainability of rice-wheat system** system			
DWR/RP/10-9.1	Resource conservation agriculture practices for the sustainability of rice-wheat system	RK Sharma	SC Gill, RS Chhokar and 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	SC Gill and Raj Pal Meena
0DWR/RP/10-9.3	Effective nutrient management strategies for enhanced productivity and profitability of rice-wheat system	SC Gill	RK Sharma, RS Chhokar, Raj Pal Meena and Anita Meena
DWR/RP/10-9.4	Effective weed management strategies in wheat	RS Chhokar	RK Sharma, SC Gill and Rajender Singh
DWR/RP/10-9.5	Developing strategies for increased water use efficiency in wheat crop	Raj Pal Meena	SC Tripathi
Quality and Basic Sciences **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, and OP 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
Social Sciences **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 and Anuj Kumar
DWR/RP/10-11.2	Factors affecting wheat yield in western U.P.	Satyavir Singh	Randhir Singh, Anuj Kumar and R Sendhil
DWR/RP/10-11.3	Impact assessment of resource conservation technologies in wheat in Haryana	Anuj Kumar	

Project No.	Project Title	PI	Associate/s
	Computer Section		
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/10-12.3	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	
	Project initiated after 2010		
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	OP Gangwar, R Tiwari
DWR/RP/11-1.3	Race dynamics, epidemiology and genetics of resistance in yellow rust of wheat and barley	OP Gangwar	SC Bhardwaj
DWR/RP/12-1.1	Genetics of resistance and pyramiding of diverse rust resistance in wheat material	Hanif Khan	SC Bhardwaj, OP Gangwar and Pramod Prasad
DWR/RP/12-1.2	Physiological specialization, genetics of rust resistance in black rust of wheat and polymorphism in wheat rust pathogens	Pramod Prasad	SC Bhardwaj, OP Gangwar and Hanif Khan
DWR/RP/12-1.3	Estimation of total factor productivity and returns to investment on wheat and barley research	R Sendhil	
DWR/RP/13-1.1	Incorporation of novel gene(s) for resistance to stripe rust,powdery mildew karnal bunt and loose smut in wheat	Satish Kumar	Indu Sharma, Vikas Gupta, R Selvakumar
DWR/RP/13-1.2	Development of core collection of wheat germplasm	Arun Gupta	S Kundu
DWR/RP/13-1.3	Conservation agriculture for climate change mitigation and improving the Productivity of various cropping systems	Anil Khippal	AS Kharub, RK Sharma, D Kumar, RS Chookar, R Selvakumar, Ashwani Kumar (IARI RS, Karnal)
DWR/RP/13-1.4	Studies on variability, host resistance and management of smut diseases of wheat	Sudheer Kumar	Sneh Narwal, Satish Kumar and K Venkatesh
DWR/RP/13-1.5	Design Development & maintenance of content management System (CMS) based web application for DWR	Suman Lata	Kamal Batra (IARI)

Institute's Foreign collaborative projects

	Title of the project	Name of sponsoring agency	Name of the PI concerned	Budget (Rs)			
				Opening Balance	Receipt (2014-15)	Expenditure (2014-15)	Balance
1	Increasing the productivity of the wheat crop under conditions of rising temperatures and water scarcity in South Asia	Die Bundesministerium für Wirtschaftliche Zusammenarbeit und Entwicklung (BMZ), Germany	Dr. Indu Sharma,	15,83,242	17,45,823	12,81,574	20,47,491
2	Maximizing the potential for sustainable and durable resistance to the wheat yellow rust pathogen under Sustainable Crop Production for International Development (SCPRID)	John Innes Centre,U.K,. Dept. of Biotechnology, Govt. of India, New Delhi	Dr. SC Bhardwaj	14,70,656	-	5,29,951	9,40,705

3	Improving productivity of wheat through enhanced Nitrogen Use Efficiency	CRP-WHEAT (CIMMYT)	Dr. K Venkatesh	26,71,312	-	8,20,318 (10,45,201) 1865519	8,05,793
4	Molecular marker technologies for faster wheat breeding in India	ACIAR	Dr. Ravish Chatrath	-2,34,371	4,89,371	2,55,000	-
5	Biofortification of wheat	HarvestPlus / IFPRI	Dr. Ravish Chatrath	-86,407	5,98,514	-1,42,963 (6,85,366) 542403	-30,296
6	Exploitation of inter-specific biodiversity for wheat improvement	DBT-ICAR-BBSRC-DFID and BMGF joint call under SCRPID	Dr. Indu Sharma	55,61,597		55,97,400 (1,50,000) 5747400	-1,85,803
7	Global alliance for Improving food scurity nutrition and economical growth for the world most vulnerable poor	ICAR ICARDA CRP 3.6 Dryland Cereals	Dr. AS Kharub	-1,18,256	12,66,925	11,48,669	-
8	High yielding, stress tolerance, good quality wheat varieties for current and future cereal systems in South Asia	CIMMYT CSISA	Dr. Ravish Chatrath	4,54,744	18,21,671	8,13,949	14,62,466
9	CRP-Dryland cereals project on barley	ICRISAT	Dr. AS Kharub	-	19,20,555	7,16,138	12,04,417
10	Development of heat tolerant wheat for south asia	CIMMYT	Dr. Sindhu Sareen	-	98,97,597	45,71,824	53,25,773

Value in parenthesis indicate budget released for other centres

Project funded by other agencies

S.No.	Title of the project	Name of the funding agency	Duration	Budget (Rs.)			
				Opening Balance	Receipt (2014-15)	Expenditure (2014-15)	Balance
1	DUS project on wheat under central scheme for implementation of PVP legislation	PPV&FRA, New Delhi	Continuing since 2000	2,25,042	10,21,958	12,34,234	12,766
2	Frontline Demonstration (FLD)	DAC, New Delhi	Annual Basis	-	36,93,000	33,82,670	3,10,330
3	Puccinia triticina genomics network on De Novo genome sequencing, fitness, variation and pathogenicity	DBT, New Delhi	5 years	5,986	-	3,17,218	-3,11,232
4	Phenotyping of mapping populations at hot spots and tagging of major QTLs associated with spot blotch resistance in wheat	DBT, New Delhi	3 years	-7,20,890	17,54,400	11,76,102	-1,42,592
5	DUS project in barley	PPV&FRA, New Delhi	Annual basis	1,29,392	3,50,608	4,04,787+ 29,562*	45,651
6	Cloning and characterization of genes in response to leaf rust infection in bread wheat	DBT, New Delhi	24-09-2013 to 23-09-2016	2,86,424	-	1,33,275	1,53,149
7	Plan for wheat rust detection and forewarning using combination of spatial level meteorological and satellite remote sensing data	ISRO	2013-14	4,49,759	-	3,13,796	1,35,963
8	Aptamer probes for detection of celiac disease epitopes of gluten in commercial varieties of .Indian wheat	DBT	2014-15	-	6,21,200	3,76,172	2,45,028

S. No.	Title of the project	Name of the PI	Date of start, date of end (if known)	Budget (Rs)			
				Opening Balance	Receipt (2014-15)	Expenditure (2014-15)	Balance
9	National Project on Transgenics in Crops	Dr. Ratan Tiwari	Continuing from 2005-06	7,14,496	6,76,000	13,86,900	3,596
10	Seed production in Agricultural Crops and Fisheries under DSR	Dr. Raj Kumar	Continuing from 2006-07	5,38,829	2,75,000	3,49,636	4,64,193
11	Intellectual Property and Technology Management (IP & TM)	Dr. D. Mohan	Annual Basis	-	10,50,000	8,46,848	2,03,152
12	Crop simulation studies to understand the effect of moisture and terminal stress on growth and yield of wheat	Dr. RK Sharma	3 years under NBSFARA	25,39,829	5,43,987	22,49,013	8,34,803
13	Development of diagostic kit for detction of Karnal bunt and loose smut of wheat	Dr. MS Saharan	2014-15	-	31,23,992	10,33,858	20,90,134
14	CRP on Bioinformatics	Dr. Ratan Tiwari	2014-15	-	6,70,000	3,84,322	2,85,678
15	CRP on Biofortification	Dr. Sewa Ram	2014-15	-	11,75,000	6,65,025	5,09,975
16	CRP on Agro-biodiversity	Dr. Sushila Kundu	2014-15	-	5,00,000	4,72,304	27,696
17	Strategic research component of NICRA	Dr. Sindhu Sareen	2014-15	-	19,15,000	2,72,122	16,42,878
18	Transgenic in Crops - NPTC	Dr. HM Mamrutha	2014-15	-	1,00,000	96,346	3,654

*Refunded to funded agency

16. PUBLICATIONS

Research Papers

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17. हिन्दी कार्यक्रमों पर विवरण

वर्ष 2014–15 के दौरान संस्थान 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।

- इस संस्थान की राजभाषा कार्यान्वयन समिति की चार तिमाही बैठकें (26.04.2014, 07.08.2014, 02.12.2014 तथा 30.01.2015) को आयोजित की गई, जिनमें संस्थान द्वारा राजभाषा हिन्दी की प्रगति पर चर्चा की गई। संस्थान की कार्यान्वयन समिति द्वारा सुझाए गये अधिकतम मुद्दों पर प्रगति सराहनीय रही।
- संस्थान में **हिन्दी पखवाड़ा** (15–30 सितंबर, 2014) का आयोजन किया गया जिसमें संस्थान के सभी अधिकारियों/कर्मचारियों ने भाग लिया। इस दौरान सभी वर्ग के अधिकारियों/कर्मचारियों के लिए भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल में प्रतियोगिताओं का आयोजन किया गया तथा विजेताओं को हिन्दी पखवाड़ा के समापन समारोह (05.11.2014) के अवसर पर निदेशक, डॉ. इन्दु शर्मा द्वारा सम्मानित किया गया।
- **गेहूँ एवं जौ स्वर्णिमा** के छठे अंक जो **''कृषि में उत्पादन एवं आय बढ़ाने की नवीनतम व समसामयिक तकनीकें''** विषय पर आधारित है का प्रकाशन किया गया।
- प्रत्येक तिमाही की रिपोर्ट समयबद्ध एवं नियमित रुप से भारतीय कृषि अनुसंधान परिषद, कृषि भवन, नई दिल्ली को भेजी जा रही है।
- **गेहूँ एवं जौ संदेश** का प्रकाशन नियमित रुप से किया जा रहा है।

नराकास बैठकों का आयोजन

- नराकास, करनाल की समीक्षा बैठक 29.05.2014 तथा 22.12.2014 को पी.एन.बी. (मंडल कार्यालय) अरबन एस्टेट, करनाल में आयोजित हुई जिसमें निदेशक डॉ. इन्दु शर्मा, डॉ. आर.के. गुप्ता प्रमुख अन्वेषक एवं आधारभूत विज्ञान एवं डॉ. अनुज कुमार, प्रभारी अधिकारी हिन्दी ने भाग लिया।

कार्यशाला का आयोजन

- **''राजभाषा में कार्य करना कितना सरल''** विषय पर दिनांक 23.06.2014 को कार्यशाला का आयोजन किया गया।
- **''होमियोपैथ जीवन का आधार एवं कुछ अनछुए पहलू''** पर दिनांक 19.09.2014 को एक कार्यशाला का आयोजन किया गया।
- **''हिन्दी में कहानी लेखन''** विषय पर दिनांक 27.12.2014 को कार्यशाला का आयोजन किया गया।

''होमियोपैथ जीवन का आधार एवं कुछ अनछुए पहलू'' पर दिनांक 19.09.2014 को हुए कार्यशाला के चित्र

तालिका : राजभाषा पखवाड़ा के दौरान आयोजित प्रतियोगिताएं एवं विजेताओं की सूची।

श्रेणी / वर्ग	प्रतियोगिता का नाम	पुरस्कार	विजेता
तकनीकी	भाषण	प्रथम पुरस्कार	श्री राम कुमार
		द्वितीय पुरस्कार	श्री ओ.पी. ढिल्लों
		तृतीय पुरस्कार	श्री जे.के. पाण्डेय, श्रीमति सुनीता जसवाल
		प्रोत्साहन पुरस्कार	श्री ओम प्रकाश, श्री पी. चन्द्रा बाबू
शोध सहायक	खुला मंच : क्या महिलाओं को 50% आरक्षण देना उचित है?	प्रथम पुरस्कार	श्रीमति रेणु शर्मा
		द्वितीय पुरस्कार	डॉ. यशपाल सिंह
		तृतीय पुरस्कार	श्री गिरिश चन्द्र पाण्डेय
		प्रोत्साहन पुरस्कार	श्री पंकज कुमार
सभी वर्ग	गीत गायन	प्रथम पुरस्कार	डॉ. रतन तिवारी
		द्वितीय पुरस्कार	श्री कृष्ण कुमार
		तृतीय पुरस्कार	डॉ. सत्यवीर सिह
		प्रोत्साहन पुरस्कार	श्री रमेश चन्द, श्रीमति हिमानी, श्रीमति आरती
वैज्ञानिक	आशुभाषण	प्रथम पुरस्कार	डॉ. ज्ञानेद्र सिंह
		द्वितीय पुरस्कार	डॉ. सुभाष गिल
		तृतीय पुरस्कार	डॉ. बी.एस. त्यागी
		प्रोत्साहन पुरस्कार	डॉ. सोनिया श्योरान
सभी वर्ग	अंताक्षरी	प्रथम पुरस्कार	डॉ. रतन तिवारी, डॉ. रेखा मलिक, डॉ. सोनिया श्योरान, श्रीमती ज्ञान अनेजा, श्री भाल सिंह,
		द्वितीय पुरस्कार	डॉ. सुभाष गिल, डॉ. आर.एस. छोकर, डॉ. राजपाल मीना, श्री ओम प्रकाश, श्री मदन लाल
		तृतीय पुरस्कार	श्री राजेन्द्र सिंह तोमर, श्री रामकुमार, श्री जे.के. पाण्डेय, श्री प्रवेश कुमार, श्री धीरज राणा
		प्रोत्साहन पुरस्कार	श्रीमति रेणु शर्मा, श्रीमति आरती, श्री गिरिश चन्द्र पाण्डेय, श्री पंकज कुमार, श्री कमल शर्मा, डॉ. एस.के. सिंह, श्री सुनील कुमार, श्री अमित सैनी, श्री दवेन्द्र शर्मा, श्री दीपक शर्मा
कुशल सहायक कर्मचारी	हिन्दी सुलेख	प्रथम पुरस्कार	श्रीमती सुमन थापा
		द्वितीय पुरस्कार	श्री हरिन्द्र कुमार
		तृतीय पुरस्कार	श्री अमन कुमार
		प्रोत्साहन पुरस्कार	श्री बीरुराम, श्री नन्दन सिंह
प्रशासनिक	हिन्दी सुलेख	प्रथम पुरस्कार	श्री अशोक कथूरिया
		द्वितीय पुरस्कार	श्री सुनील कुमार
		तृतीय पुरस्कार	श्री कृष्ण पाल
		प्रोत्साहन पुरस्कार	श्री महावीर सिंह

डॉ ज्ञानेन्द सिंह, आशुभाषण प्रतियोगिता में प्रथम पुरस्कार

डॉ. रतन तिवारी, गीत गायन में प्रथम पुरस्कार से सम्मानित

अंताक्षरी प्रतियोगिता में प्रथम पुरस्कार से सम्मानित दल

श्री जे.के. पाण्डेय, भाषण प्रतियोगिता में तृतीय पुरस्कार से सम्मानित

श्री अशोक कथुरिया, हिन्दी सुलेख प्रतियोगिता में प्रथम पुरस्कार से सम्मानित

श्रीमती सुमन थापा, हिन्दी सुलेख प्रतियोगिता में प्रथम पुरस्कार से सम्मानित

श्रीमती रेणु शर्मा, खुला मंच प्रतियोगिता में प्रथम पुरस्कार

हिन्दी उत्सव में बाल–भवन के बच्चों की भागीदारी

क्षेत्रीय केंद्र, शिमला

सितम्बर 16, 2014: केंद्र द्वारा हिंदी दिवस मनाया गया। इस दिन हिंदी को बढ़ावा देने के लिए पारस्परिक विचार विमर्श किये गए तथा स्टाफ के सदस्यों ने अपने विचार रखे। राष्ट्रपति, भारतीय कृषि अनुसंधान परिषद तथा गृह मंत्री, भारत सरकार के संदेश को पढ़ कर सुनाया गया। दिन प्रतिदिन की गतिविधियों में हिंदी को बढ़ावा देने के प्रयासों पर चर्चा की गई। पूर्व वर्ष के दौरान की गयी उपलब्धियों पर संतोष महसूस किया गया।

18. PERSONNEL

Director
Indu Sharma, Ph.D.

Crop Improvement
V Tiwari, Ph.D., Pr. Scientist & PI
Ravish Chatrath, Ph.D., Pr. Scientist
Sushila Kundu, Ph.D., Pr. Scientist
Gyanendra Singh, Ph.D., Pr. Scientist
Ratan Tiwari, Ph.D., Pr. Scientist
BS Tyagi, Ph.D., Pr. Scientist
Arun Gupta, Ph.D., Pr. Scientist
Sindhu Sareen, Ph.D., Pr. Scientist
Raj Kumar, Ph.D., Pr. Scientist
Rekha Malik, Ph.D., Pr. Scientist
SK Singh, Ph.D., Sr. Scientist
Rajender Singh, Ph.D., Sr. Scientist
Pradeep Sharma, Ph.D., Sr. Scientist
Sonia Sheoran, Ph.D., Scientist
Satish Kumar, Ph.D., Scientist
Charan Singh, M.Sc., Scientist (on study leave)
Karnam Venkatesh, Ph.D., Scientist
CN Mishra, Ph.D., Scientist
HM Mamrutha, Ph.D., Scientist
Vikas Gupta, Ph.D., Scientist
Om Prakash, Ph.D., Asst. CTO
BK Meena, Ph.D., Sr. TO
Ravinder Singh, B.Tech., Sr. TO
Rajendra Kumar, Ph.D., Sr. TO
Raj Kumar, TO
Om Prakash, TO
Rahul Singh, Sr. TA
Suresh Kumar, Sr. TA
Rajesh Kumar, Sr. TA
Bhal Singh, TA
Ronak Ram, TA
Ramesh Pal, SSS
Aman Kumar, SSS

Crop Protection
DP Singh, Ph.D., Pr. Scientist
(on deputation to ITEC assignment at Guyana)
MS Saharan, Ph.D., Pr. Scientist & PI
Sudheer Kumar, Ph.D., Pr. Scientist
R Selvakumar, Ph.D., Sr. Scientist
Subhash Katare, Ph.D., Sr. Scientist
Mangal Singh, Ph.D., Sr. TO
Ishwar Singh, TO
Lok Raj, TA
Hem Lata, Stenographer
Nandan Singh, SSS

Resource Management
RK Sharma, Ph.D., Pr. Scientist & PI
SC Tripathi, Ph.D., Pr. Scientist
SC Gill, Ph.D., Pr. Scientist
RS Chhokar, Ph.D., Pr. Scientist
Raj Pal Meena, Ph.D., Sr. Scientist
Anita Meena, Ph.D., Scientist
PHP Verma, M.Sc., Sr. TO
Ram Kumar Singh, M.Sc., Sr. TO
Rajinder Pal Sharma, Sr. TA
Sukh Ram, TA
Desh Raj, SSS

Quality and Basic Sciences
RK Gupta, Ph.D., Pr. Scientist & PI
Devender Mohan, Ph.D., Pr .Scientist
Sewa Ram, Ph.D., Pr. Scientist
Sneh Narwal, Ph.D., Sr. Scientist
OP Gupta, M.Sc., Scientist (on study leave)
VK Sehgal, M.Sc., Sr. TO
Sunita Jaswal, TO
Jamuna Devi, TA
Ishwar Singh, TA

Social Sciences
Randhir Singh, Ph.D., Pr Scientist & PI
Satyavir Singh, Ph.D., Pr. Scientist
Anuj Kumar, Ph.D., Sr. Scientist
Sendhil R, Ph.D., Scientist
JK Pandey, M.Sc., Asst. CTO
Rajendra Singh, M.Sc., Sr. TO
Ramesh Chand, Ph.D., Sr. TO
Rajinder Kumar Sharma, TO
Paramjeet Singh, SSS

Barley
AS Kharub, Ph.D., Pr. Scientist & PI
Dinesh Kumar, Ph.D., Pr. Scientist
Jogendra Singh, Ph.D., Pr. Scientist
Lokendra Kumar, Ph. D., Sr. Scientist
Anil Khippal, Ph.D., Sr. Scientist
Vishnu Kumar, Ph.D., Scientist
Sant Kumar, Sr. TO
Yogesh Kumar, M.Sc., Sr. TO
Madan Lal, TO
Shanti Devi, SSS

Computer Science and Statistics
Ravish Chatrath, Ph.D., Pr. Scientist & Incharge
Ajay Verma, Ph.D., Pr. Scientist
Suman Lata, Ph.D., Sr. Scientist
Yogesh Sharma, M.Sc. (CS), Sr. TO
Surender Singh, Sr. TO
P Chandrababu, M.Sc.(CS), Sr. TO
Bhim Sen, SSS

Director's Cell
Gyan Aneja, PS to Project Director

Finance Management
Anil Agrawal, F&AO (up to 17.06.2014)
Jagdish Chander, F&AO
Promila Verma, Asst.
Krishan Pal, UDC
Naresh Kumar, LDC
Suman Thapa, SSS
Ramu Shah, SSS

Administration
JS Paul, AO
Anil Kumar, AAO
Sher Singh, Asst.
Ramesh Kumar, Asst.
Sunil Kumar, Asst.
Sushila, UDC
Ramesh Kumar, UDC
Mahabir Singh, LDC
Anil Kumar, LDC
Sunil Kumar, LDC
Yashwant Singh, SSS
Guman Singh, SSS

Library
Dinesh Kumar, Incharge
Abhay Nagar, M.Lib. & Inf. Sci, Sr. TO
Harender Kumar, SSS

Farm Section
Gyanendra Singh, Incharge
Surendra Singh, M.Sc., Sr. TO
Amar Singh, Driver, TA
Vinod Khokhar, Driver, Tech.
Hari Prasad, SSS

Landscape Section
Rajender Kumar Sharma, TO
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, Ph.D., Pr. Scientist & Incharge
Hanif Khan, Ph.D., Scientist
Om Prakash Gangwar, Ph.D., Scientist
Pramod Prasad, Ph.D., Scientist
SB Singh, Asst. CTO
Subhodh Kumar, Ph.D., Sr. TO
Baldev Singh, Sr. TA
Udai Singh, Sr. TA
Swroop Chand, Tech.
Jaspal Singh, AAO Shanti Devi, AAO
Roop Ram, PA
Chaman Lal, SSS
Om Prakash, SSS
Sant Ram, SSS
Bhoop Ram Verma, SSS
Bhoop Ram Thakur, SSS

Regional Station, Dalang Maidan, Lahaul & Spiti
RP Meena, Ph.D., Incharge
Nand Lal, Sr. Tech.

19. STAFF POSITION & FINANCE

Staff Position as on March 31, 2015

Scientific cadre strength

Designation	Sanctioned	Filled	Vacant
DWR, Karnal			
Project Director	1	1	-
Principal Scientist	6	4	2
Senior Scientist	11	7	4
Scientist	28	30	-2
Barley Network, Karnal			
Principal Scientist	1	1	-
Senior Scientist	1	1	-
Scientist	7	5	2
DWR Regional Station, Shimla			
Principal Scientist	1	-	1
Scientist	4	4	-
DWR Regional Station, Dalang Maidan			
Scientist	2	-	2
Total	**61+1**	**52+1**	**11(-2)**

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	4*	2
UDC	3	4*	-
LDC	5	3	2
PS	1	1	-
PA	1	1	-
Steno Gr III	1		1
Total	**22**	**17**	**5**
B. DWR Regional Station, Shimla			
AAO	2	2	-
Steno Gr III	1	1	-
Total	**3**	**3**	**-**
Total (A+B)	**25**	**20**	**5**

*One post of UDC filled against vacant post of assistant

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)	1	1	-
Total (A+B+C)	**48**	**48**	**-**

Skilled supporting staff cadre strength

Station	Sanctioned	Filled	Vacant
DWR, Karnal	20	17	3
DWR Regional Station, Shimla	11	5	6
DWR Regional Station, Dalang Maidan, Lahaul & Spiti	2	-	2
Total (A+B+C)	**33**	**22**	**11**

Summary

Cadre	Sanctioned	Filled	Vacant
Project Director	1	1	
Scientific	61	52	9
Technical	48	48	-
Administrative	25	20	5
Skilled supporting staff	33	22	11
Total staff	**168**	**143**	**25**

Budget allocation and expenditure (Rupees Lakhs), 2014-15

Head	Allocation	Expenditure
Plan-DWR	670.00	669.97
Plan-AICW&BIP	1675.00	1675.00
Non Plan	1590.75	1590.25
Total	3935.75	3935.22

20. JOININGS, PROMOTIONS, TRANSFERS AND RETIREMENTS

Joining

Sh. Ashok Kathuria, AFAO	w.e.f. 06.09.2014
Sh. Sunil Kumar, LDC	w.e.f. 21.11.2014
Dr. Lokendra Kumar, Sr. Scientist (Plant Breeding)	w.e.f. 26.11.2014
Sh. Naresh Kumar, LDC	w.e.f. 22.01.2015(A.N.)

Promotions

Dr. Subodh Kumar promoted from TO to Sr.TO	w.e.f. 22.07.2011
Dr. Hanif Khan promoted from Sci. to Sci.(Sr. Scale)	w.e.f. 07.01.2012
Dr. RS Chhokar promoted from Sr. Sci. to Pri. Sci.	w.e.f. 07.04.2013
Dr. Satish Kumar promoted from Sci. to Sci.(Sr. Scale)	w.e.f. 21.04.2013
Dr. Jogendra Singh promoted from Sr. Sci. to Pri. Sci.	w.e.f. 02.06.2013
Sh. Sukh Ram promoted from Sr. Tech. to Tech. Asst.	w.e.f. 06.08.2013
Dr. Ajay Verma promoted from Sr. Sci. to Pri. Sci.	w.e.f. 13. 09.2013
Sh. Rajesh Kumar promoted from TA to Sr. TA	w.e.f. 09.10.2013
Dr. Rekha Malik promoted from Sr. Sci. to Pri. Sci.	w.e.f. 30.10.2013
Smt. Jamuna Devi promoted from TA to Sr. TA	w.e.f. 11.11.2013
Sh. Baldev Singh promoted from TA to Sr. TA	w.e.f. 12.11.2013
Sh. Uday Singh promoted from TA to Sr. TA	w.e.f. 18.11.2013
Sh. Roop Ram promoted from Steno. to P.A.	w.e.f. 23.01.2014
Dr. RP Meena promoted from Sci.(Sr. Scale) to Sr. Sci.	w.e.f. 30.03.2014
Sh. Jagdish Chander promoted from AFAO to FAO	w.e.f. 01.05.2014

MACP granted

Sh. Guman , SSS	w.e.f. 04.09.2014.
Sh. Ramesh Pal, SSS	w.e.f. 05.09.2014.
Sh. Bhim Sain, SSS	w.e.f. 05.09.2014

Transfers

Sh. Anil Agarwal, FAO transferred to NDRI, Karnal	w.e.f. 17.06.2014

Retirements

Dr. Sushila Kundu, Principal Scientist	w.e.f. 31.03.2015

Acknowledgements

On behalf of the Institute, the 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. JS Sandhu DDG (Crop Science), Dr. SK Datta, ex-DDG (Crop Science), Dr. IS Solanki, ADG (FFC) and Dr. RP Dua, ex- ADG (FFC) are gratefully acknowledged. The combined efforts of all the Principal Investigators of the institute in publication of this report is appreciated. The contribution of scientists, technical, administrative, finance and supporting staff is acknowledged.

ANNEXURE I

Results-Framework Document (R F D)for Indian Institute of Wheat and Barley Research, Karnal

(2013-2014)

Section 1
Vision, Mission, Objectives and Functions

Vision

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

Mission

Sustainable growth of wheat and barley production through research and extension initiatives supported by infrastructural and policy measures.

Objectives

1. Germplasm enhancement and development of improved cultivars
2. Development and identification of appropriate crop production & protection technologies
3. Technology dissemination and capacity building

Functions

Coordination of multidisciplinary research in wheat and barley breeding, agronomy, crop protection, quality and technology dissemination; germplasm conservation and exchange; linkage with national and international institutions for providing impetus to research activities; human resource development.

Section 2
Inter se Priorities among Key Objectives, Success Indicators and Targets

S.No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target/Criteria Value				
							Excellent	Very good	Good	Fair	Poor
							100%	90%	80%	70%	60%
1	Genetic enhancement and development of improved cultivars	50	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	10	3200	3000	2800	2600	2400
				Entries tested in AIC W&BIP trials for multi-location testing	Number	10	620	600	580	560	540
				Lines identified for unique traits	Number	8	30	25	20	16	12
			Development of improved cultivars	Entries contributed for AIC W&BIP multilocation trial	Number	8	50	45	40	30	20
				Varieties identified for release	Number	6	12	10	8	6	4
			Seed production programme	Breeder seed produced	Weight Quintals	7	25000	24000*	22000	20000	18000
				Truthfully labeled# seed produced	Weight Quintals	1	110	100	80	60	40
2	Development and identification of appropriate crop production & protection technologies	24	Development and testing of new technologies	New technologies tested	Number	12	16	15	14	12	10
				Technologies recommended	Number	12	8	7	5	4	3

3	Technology dissemination and capacity building	15	Demonstrations conducted	Front line demonstrations conducted	Number	10	850	800	700	650	600
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	5	5	4	3	2	1
	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	2	15/05/2013	16/05/2013	17/05/2013	20/05/2013	21/05/2013
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/2013	02/05/2013	05/05/2013	06/05/2013	07/05/2013
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80
			Prepare an action plan for Innovation	On-time submission	Date	2	30/07/2013	10/08/2013	20/08/2013	30/08/2013	10/09/2013
	Improving internal efficiency/ responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	2	100	95	90	85	80
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80

Section 3
Trend values of the Success Indicators

S. No.	Objectives	Actions	Success indicator(s)	Unit	Actual values for FY 2011-2012	Actual values for FY 2012-2013	Target values for FY 2013-2014	Projected values for FY 2014-2015	Projected values for FY 2015-2016
1	Genetic enhancement and development of improved cultivars	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	3200	3100	3000	3100	3200
			Entries tested in AIC W&BIP trials for multi-location testing	Number	610	590	600	610	620
			Lines identified for unique traits	Number	26	27	25	28	29
		Development of improved cultivars	Entries contributed for AIC W&BIP multilocation trial	Number	48	48	45	47	49
			Varieties identified for release	Number	12	12	10	11	12
		Seed production programme	Breeder seed produced	Weight Quintals	41600	37440	24000*	25000	26000
			Truthfully labeled seed produced*	Weight Quintals	110	110	100	110	110
2	Development and identification of appropriate crop production & protection technologies	Development of new technologies	New technologies tested	Number	16	15	15	15	16
			Technologies recommended	Number	8	7	7	6	7
3	Technology dissemination and capacity building	Demonstrations conducted	Front line demonstrations conducted	Number	1000	730	800	820	850
		Farmers/ Extension officials training programmes organized	Trainings organized	Number	5	6	4	5	6

Efficient Functioning of the RFD System	Timely submission of Draft RFD (2013-14) for approval	On-time submission	Date	--	--	16/05/2013	--	--
	Timely submission of Results for RFD (2012-13)	On-time submission	Date	--	--	02/05/2013	--	--
Administrative Reforms	Implement ISO 9001 as per the approved action plan	% Implementation	%	--	--	95	--	--
	Prepare an action plan for Innovation	On-time submission	Date	--	--	10/08/2013	--	--
Improving internal efficiency /responsiveness / service delivery of Ministry / Department	Implementation of Sevottam	Independent Audit of Implementation of Citizen's Charter	%	--	--	95	--	--
		Independent Audit of implementation of public grievance redressal system	%	--	--	95	--	--

* With regard to indent and production of breeder seed, there was higher indent and production during 2011-12. However, indent of breeder seed has been reduced to 22000 quintals of wheat and barley during 2012-13 by DAC, Government of India to rationalize breeder seed requirements in the country. This was done to discourage very old varieties which have now become susceptible to diseases particularly rusts.

#Production of Truthfully Labelled seed depends on the availability of newly identified variety.

Section 4
Acronyms

S. No.	Acronym	Description
1	AIC W&BIP	All India Coordinated Wheat & Barley Improvement Programme
2	DAC	Department of Agriculture and Cooperation
3	DARE	Department of Agricultural Research & Education
4	DWR	Directorate of Wheat Research
5	FLD	Front Line Demonstration
6	ICAR	Indian Council of Agricultural Research
7	SAUs	State Agricultural Universities

Section 4
Description and Definition of Success Indicators and Proposed Measurement Methodology

S.No.	Success Indicator	Description	Definition	Measurement	General Comments
1	Breeding and germplasm lines evaluated	Source material for the improved varieties to be evaluated	Material generated from the basic germplasm	Number of lines evaluated	--
2	Entries tested in AIC W&BIP trials for multi-location testing	Multilocation testing of advanced lines generated during breeding for yield and other traits	Superior lines identified as new variety for release	Number	--
3	Lines identified for unique traits	Diverse germplasm lines have unique traits for yield components, disease resistance and quality traits	Germplasm lines with unique traits identified for use in breeding	Number	--
4	Entries contributed for AIC W&BIP multilocation trials	Multilocation testing of advanced lines generated by DWR	Superior lines identified for release for cultivation	Number	--
5	Varieties identified for release	Breeding lines tested along with checks in multi-location trials through All India Coordinated Research Projects and the best performing entries compared to checks are identified as new improved varieties for release	Best performing entries identified as a new variety for release	Number of such varieties identified	Targets for varieties identified given in Section 2 and their respective trend values in Section 3 may vary as the identification of varieties depend upon the availability of superior material with respect to yield, biotic and abiotic resistance/ tolerance over the existing varieties

6	Breeder seed produced	Produce from nucleus and breeder seed is the starting point in seed chain of producing quality seeds for farmers	Breeder seed is the starting point in seed chain which is multiplied /converted in to foundation /certified seed	Quantity produced (Quintals)	Quantity may vary as per indent from DAC
7	Truthfully labelled seed produced	To propagate new variety in short period of time in farmers field, truthfully labelled seed is produced	Faster propagation of newly developed variety in farmer's field	Quintals	Production of truthfully labelled seed depends on the newly identified variety
8	New technologies tested	New technologies developed for resource management and disease control are tested for their suitability	Better technologies identified for wheat and barley improvement	Number	--
9	Technologies recommended	Identified technologies are recommended for large scale application in farmer's field	Better technologies identified for improving efficiency in resource utilization and higher production	Number	--
10	Front line demonstrations conducted	Trials and demonstrations conducted for technology testing and proving the technology potential for production	On-farm trials aims at testing new technologies under farmer's condition and management, by using farmers own practice as control. Frontline demonstration is the field demonstration conducted on farmers field under the close supervision of scientists	Number	The number of FLDs depend on indent by DAC
11	Trainings organized	Capacity building activities related to knowledge and skill improvement/development programmes conducted for farmers, rural youth and extension personnel	Training is a process of acquisition of new skills, attitude and knowledge in the context of preparing for entry into a vocation or improving productivity in an organization or enterprise	Number	--

Section 5
Specific Performance Requirements from other Departments

Location Type	State	Organisation Type	Organisation Name	Relevant Success Indicator	What is your requirement from this organisation	Justification for this requirement	Please quantify your requirement from this Organisation	What happens if your requirement is not met.
Central Government		Department	DAC	Breeder seed produced	Indent for quantity of breeder seed	Variety wise indent for breeder seed	Quantity of breeder seed is produced as per the indent	Less or more quantity of breeder seed will be produced
State/Central Government		Agricultural Universities	SAUs	Entries tested in AIC W&BIP trials for multi-location testing	To conduct trials	Trials are conducted across the country	Number of trials are decided in wheat workshop annually	Development of new varieties and technologies will hamper

Section 6
Outcome / Impact of activities of the organization

S. No.	Out Come/Impact of the organization	Jointly responsible for influencing this outcome / impact with the following department (s) / ministry(ies)	Success Indicators	Unit	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016
1	Enhancement in wheat productivity	DARE, SAUs and State agriculture departments	Wheat productivity	% increase	5.2*	-2#	2	2	2
2	Enhancement in barley productivity	DARE, SAUs and State agriculture departments	Barley productivity	% increase	5.0*	0#	2	2	2

- There are year to year variations in wheat and barley productivity because of fluctuations in weather conditions during the crop season. However, there is continuous enhancement in wheat and barley productivity in India on long term basis. Therefore, target is 2% enhancement in wheat and barley productivity per annum.
- It was exceptionally favourable weather conditions during 2011-12 and hence higher growth in productivity.

\# During 2012-13, due to heavy rains & flooding, there was crop lodging in some areas which resulted in the decline in crop productivity.

Annual (April 1, 2013 to March 31, 2014) Performance Evaluation Report in respect of RFD 2013-2014 of RSCs i.e. Institutes

S. No.	Objectives	Weight	Actions	Success indicators	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.*	Reasons for shortfalls or excessive achievements, if applicable
							Excellent	Very good	Good	Fair	Poor					
							100%	90%	80%	70%	60%		Raw score	Weighted score		
1	Genetic enhancement and development of improved cultivars	50	Evaluation of genetic material	Breeding and germplasm lines evaluated	Number	10	3200	3000	2800	2600	2400	3100	95	9.5	103.3	
				Entries tested in AIC W&BIP trials for multi location testing	Number	10	620	600	580	560	540	650	100	10	108.3	
				Lines identified for unique traits	Number	8	30	25	20	16	12	32	100	8	128.0	
			Development of improved cultivars	Entries contributed for AIC W&BIP multilocation trial	Number	8	50	45	40	30	20	60	100	8	133.0	
				Varieties identified for release	Number	6	12	10	8	6	4	16	100	6	160.0	It depends on the number of proposals submitted
			Seed production programme	Breeder seed produced	Weight Quintals	7	25000	24000	22000	20000	18000	27500	100	7	114.6	
				Truthfully labeled seed produced	Weight Quintals	1	110	100	80	60	40	160	100	1	160.0	Depends on the availability of newly identified variety
2	Development and identification of appropriate crop production & protection technologies	24	Development and testing of new technologies	New technologies tested	Number	12	16	15	14	12	10	18	100	12	120.0	
				Technologies recommended	Number	12	8	7	5	4	3	8	100	12	114.3	

S. No.	Objectives	Weight	Actions	Success Indicators	Unit	Weight	Target / Criteria Value					Achievements	Performance		Percent achievements against Target values of 90% Col.*	Reasons for shortfalls or excessive achievements, if applicable
							Excellent	Very good	Good	Fair	Poor					
							100%	90%	80%	70%	60%		Raw score	Weighted score		
3	Technology dissemination and capacity building	15	Demonstrations conducted	Front line demonstrations conducted	Number	10	850	800	700	650	600	740	84	8.4	92.5	
			Farmers/ Extension officials training programmes organized	Trainings organized	Number	5	5	4	3	2	1	6	100	5	150	
	Efficient Functioning of the RFD System	3	Timely submission of Draft RFD (2013 14) for approval	On-time submission	Date	2	15/05/2 013	16/05/201 3	17/05/2 013	20/05/2 013	21/05/2 013	25/04/2 013	100	2		
			Timely submission of Results for RFD (2012-13)	On-time submission	Date	1	01/05/2 013	02/05/201 3	05/05/2 013	06/05/2 013	07/05/2 013	26/04/2 013	100	1		
	Administrative Reforms	4	Implement ISO 9001 as per the approved action plan	% Implementation	%	2	100	95	90	85	80	100	100	2		
			Prepare an action plan for Innovation	On-time submission	Date	2	30/07/2 013	10/08/201 3	20/08/2 013	30/08/2 013	10/09/2 013	23/07/2 013	100	2		
	Improving int ernal efficiency/ responsiveness / service delivery of Ministry / Department	4	Implementation of Sevottam	Independent Audit of Implementation of	%	2	100	95	90	85	80	100	100	2		
				Independent Audit of implementation of public grievance redressal system	%	2	100	95	90	85	80	100	100	2		

Total Composite Score: 97.9

Temperature Controlled Phenotyping Facility

Laser Land Leveller for Resource Conservation

A view of Wheat & Barley Summer Nursery at Dalang- Madan, HP

भाकृअनुप
ICAR

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

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