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All India Coordinated Wheat and Barley Improvement Project

PROGRESS REPORT 2015-16

Vol. V

GENETIC RESOURCES

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Correct Citation:
Anonymous 2016. Progress Report of All India Coordinated Wheat & Barley Improvement Project 2015-16, Vol. V, Genetic Resources. Eds: BS Tyagi, Arun Gupta, Charan Singh, Vinod Tiwari, Indu Sharma, RK Gupta and GP Singh. ICAR-Indian Institute of Wheat and Barley Research, Karnal, India. pp. 57

Issued on the occasion of 55th All India Wheat & Barley Research Workers' Meet held at CCS HAU., Hisar, Haryana during August 21-24, 2016

ACKNOWLEDGEMENTS

One of the objectives of the All India Coordinated Wheat and Barley Improvement programme is to provide wheat germplasm to all the cooperators as we acknowledge that Plant Genetic Resources are essential for a robust breeding programme. The wheat germplasm field day was organized at Karnal on March 27, 2016 in which breeders and other scientists from different institutes made full use of the opportunity to select new germplasm lines.

The scientists of the Crop Improvement division deserve all appreciation for constituting the various national nurseries and facilitating compilation of data received from different centres in the country. The efforts put in by Dr BS Tyagi for planting the various national and international trials/nurseries at Karnal farm and facilitating the organization of wheat germplam field day are very praise worthy. The Genetic Resources Unit of the institute undertakes acquisition, conservation, characterization of germplasm and maintains a large repository of indigenous and exotic stocks. In this regard the contribution made by Dr Arun Gupta, and Dr Charan Singh are very praise worthy for providing valuable support to the cooperating centres, conservation of identified genetic stocks and assisting centres in the registration of varieties with the PPV&FRA.

I express my sincere thanks to Drs PC Sharma and AK Singh, CSSRI, Karnal for organizing salinity/alkalinity tolerance screening nursery. Contribution made by the Drs RK Gupta and D Mohan (Quality section) in organizing the QCSN and analyzing quality parameters of lines in NGSN, EIGN and NDSN is acknowledged. The institute has focused on creation of new variability and application of molecular approaches to support the crop improvement programme through well-designed research projects at Karnal and Flowerdale, Shimla. The input provided by concerned scientists in this regard is appreciable.

Thanks are due to the technical and supporting staff of the institute namely Om Prakash, Suresh Kumar, Ronak Ram and Ramesh Pal for help rendered in constitution and dispatch of various nurseries. I specially acknowledge the help rendered by Rahul Singh and Vineet Kumar in compilation of this report. I thank Dr Ajay Verma and Bhim Sain for producing multiple copies of this Progress Report.

I hope this document will prove immensely useful to all the wheat research workers.

(Vinod Tiwari)
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CONTENTS

PART A

EVALUATION OF NATIONAL AND INTERNATIONAL NURSERIES

National Genetic Stock Nursery

SK Singh, Suresh Kumar, RP Gangwar, RK Gupta and Vinod Tiwari

National Genetic Stock Nursery (NGSN) is considered as "suggested crossing block" and is constituted with the objective to provide genetic stocks and new germplasm for yield components, disease resistance and quality traits to cooperating centres under AICW&BIP for utilization in wheat improvement programmes. The NGSN comprising 60 lines including *T. aestivum* (56) and *T. dicoccum* (4) was provided to 30 centres. The bread wheat entries were categorized as disease resistant (27), elite lines from NGSN (11), new agronomic bases (8) and yield component lines (7) and Karnal bunt resistant genetic stocks (7). *T. dicoccum* entries represented disease resistant stocks.

The nursery was conducted in augmented design with two checks Sonalika and HD2967 which were accommodated once in a block of 20 entries. An infector row was also included for observing disease incidence. The data were recorded on yield component traits days to heading, days to maturity, plant height (cm), tillers/m, grain number/spike, 1000-grains weight (g) and spike length (cm). Quality analysis of these entries was done at IIWBR, Karnal for processing and nutritional quality traits. The data booklets were received from 29 locations except Gwalior where nursery failed due to hailstorm damage. Pooled analysis of data was done for various traits and mean values (Table 6) were considered for identification of promising genotypes for various traits.

Performance of entries for yield component traits

Based on the pooled mean, the promising genotypes showing better performance for different traits were identified. Zone-wise analysis was made for the traits and on the basis of defined selection criteria (better than the respective best checks), promising genotypes showing excellent performance were selected (Table.1). Among these genotypes, some having better performance for three or more traits were identified as potential donors for further use in wheat improvement in zone specific programmes (Table1). Entries PHSL 10 in NHZ; PHSL 5, PHSL 10 and GW 2010-288 in NWPZ; PHSL 10 in NEPZ; PHS 1106, PHSL 5 and PHSL 10 in CZ; HD 3095 and LBPY 11-2 in PZ showed better performance for three or more traits. Among these, PHSL 5 and PHSL 10 showed promise in two or more zones.

Table 1: Zone wise promising genotypes for various yield component traits

Traits	Range	Mean	Criteria	Promising Entries	Best check
Northern Hills Zone (Almora, Malan)					
Days to heading	102-123	112	<105	PHSL 5, PHSL 10(102), PHS 1106(103)	Sonalika (106)
Days to maturity	153-173	162	≤155	HW 1099(153), PHSL 10(155)	Sonalika (159)
Plant height (cm)	75-112	91	<80	DBW 93(75), PBW 658, KBRL 82-2(78), DDK 1045, MACS 5031, HW 5237, HD 3095(79)	HD 2967 (87)
Tillers /m	18-102	62	>90	HW 4013(102), HUW 668(92), DBW 90, HPW 381(91)	Sonalika (67)
Grains /spike	22-69	47	>60	JS 6-1(69), HW 1900 (65), HW 5237(62), HW 5235(61)	HD 2967 (48)
1000-gr. wt. (g)	30-59	44	>55	PHSL 5(59), LBPY 11-9, UP 2847, PHS 1106 (56)	HD 2967 (43)
Spike length (cm)	8-13	10	>12	JS 6-1, GW 2010-288(13)	HD 2967 (11)
North Western Plains Zone (Ludhiana, Gurdaspur, Hisar, Durgapura, Pantnagar, IIWBR-Karnal, CSSRI-Karnal)					
Days to heading	84-106	94	<88	PHSL 11 (84), PHSL 10, UP 2843, GW 432(86), PHSL 5 (87)	Sonalika (88)

Days to maturity	137-148	140	<138	PHSL 11, PHSL 10, LBPY 11-8, PHSL 5, GW 432(137)	Sonalika (138)
Plant height (cm)	79-118	97	<85	HD 3095(79), LBPY 11-8, DBW 93 (83)	HD 2967 (98)
Tillers /m	56-161	112	>150	MACS 5031(161), KBRL 81-1(154)	Sonalika (121)
Grains /spike	44-72	54	>65	JS 6-1(72), GW 2010-288 (65)	HD 2967 (60)
1000-gr wt. (g)	29-52	39	>45	PHSL 5 (52), GW 2010-288(47), Raj 4304(46),	HD 2967 (37)
Spike length (cm)	9-15	11	>12	GW 2010-288(15), JS 6-1, PHSL 5(14), UP 2847, LBPY 11-2, NW 5013, GW 2011-346, PHSL 10, HPW 381(13)	HD 2967 (11)
North Eastern Plains Zone (Sabour, Ranchi, Faizabad, Varanasi, Kalyani, Coochbehar)					
Days to heading	67-88	77	<70	PHS 1106, PHSL 5, LBPY 11-8(67), PHSL 10, PHSL 11, UP 2843, LBPY 11-2(69)	Sonalika (74)
Days to maturity	110-122	115	≤110	PHSL 11 , PHSL 10 , LBPY 11-8, HD 3095(110)	Sonalika (113)
Plant height(cm)	71-97	84	<75	HD 3095(71), HW 4013, DBW 93(74)	Sonalika (83)
Tillers /m	41-113	82	>100	HW 4013(113), DDK 1044 (112), HW 5224(111), DDK 1045(106), HS 578(103), KBRL 80-3 (101)	HD 2967 (89)
Grains /spike	32-76	50	>65	JS 6-1(76), GW 2010-288, HW 1900(69)	HD 2967 (60)
1000-gr. wt.(g)	27-43	34	>40	PHSL 10 (43), GW 2010-288(41)	Sonalika (36)
Spike length(cm)	9-14	10	>12	JS 6-1(14), GW 2011-346 (13)	HD 2967 (11)
Central Zone (Indore, Bilaspur, Vijapur, Junagadh, Jabalpur, Powerkheda, Sagar, Kota, Bhavnagar)					
Days to heading	63-80	70	<65	UP 2843(63), PHS 1106 , PHSL 10 , HD 3095(64)	Sonalika (65)
Days to maturity	105-118	111	<107	LBPY 11-2(105), PHSL 11 , PHSL 5, PHSL 10 , PHS 1106 , Raj 4304 (106)	Sonalika (110)
Plant height (cm)	73-113	88	<80	HD 3095(73), HW 5237(77), HW 5235, Raj 4324(78), DBW 93(79)	Sonalika (88)
Tillers /m	89-133	112	>125	K 1006(133), DBW 107(129), GW 432, HW 1099(127), UP 2872(126)	HD 2967 (117)
Grains /spike	40-64	52	≥60	HW 1900(64), HPW 360, JS 6-1(62), PHSL 11 (60)	HD 2967 (59)
1000-gr. wt. (g)	31-53	41	≥50	PHSL 5 (53), LBPY 11-9(52), Raj 4304(51), PHS 1106 , LBPY 11-2(50)	Sonalika (42)
Spike length (cm)	9-13	10	>12	PHSL 5, PHSL 10 , JS 6-1, GW 2010-288, UP 2847, GW 2011-346(13)	HD 2967 (10)
Peninsular Zone (Dharwad, Niphad, Akola, Pune)					
Days to heading	52-76	65	≤55	LBPY 11-2(52), LBPY 11-8(53), UP 2843(54), HD 3095(55)	Sonalika (62)
Days to maturity	100-116	109	<105	LBPY 11-2(100), LBPY 11-8(101), HD 3095, Raj 4324 (103), UP 2843, GW 2011-346(104)	Sonalika (110)
Plant height (cm)	61-96	76	<65	Raj 4324 (61), HD 3095, HW 5237(63)	Sonalika (73)
Tillers /m	48-121	81	>105	HW 4013 (121), KBRL 81-1(113), HW 1099, KBRL 80-3(107)	HD 2967 (95)
Grains /spike	37-59	47	>55	UP 2847 (59), HW 1900, DBW 110(57), KBRL 80-3(56)	HD 2967 (50)
1000-gr.wt.(g)	29-51	39	>45	PHSL 5 (51), LBPY 11-2(50), LBPY 11-9(49), PHS 1106, PHSL 10 , Raj 4304(46)	Sonalika (37)
Spike length(cm)	8-12	10	>11	PHSL 5 (12)	HD 2967 (10)

dic-T. dicoccum; Value in parenthesis indicates the values of the traits

Trait-wise analysis indicated better performance of PHSL 10 and UP 2843 for early heading; PHSL 10 for early maturity; HD 3095 and DBW 93 for dwarf plants, HW 1900 and JS 6-1 for grain number per spike; PHS 1106, PHSL 5 and LBPY11-9 for 1000-grains weight and JS 6-1 and GW 2011-346 for spike length in atleast four mega zones. Based on overall performance across the zones, the promising genotypes showing better performance than the best checks were also identified. Some of the promising genotypes having excellent performance are listed in Table 2. Genotypes PHS1106, PHSL 5, PHSL10, LBPY 11-2, LBPY 11-8 and GW 2010-288 showed better performances for three or more traits in combination compared to the respective best checks.

Table 2: Superior genetic stocks for yield component traits in NGSN during 2015-16

Characteristics	Criteria	Promising Genotypes	Best check
Days to heading	<75	PHSL 11, UP 2843 (72), PHS 1106, PHSL 10, LBPY 11-2, LBPY 11-8 (73), PHSL 5, GW 432 (74)	Sonalika(75)
Days to maturity	<120	PHSL 11, LBPY 11-8 (118), PHSL 10, PHSL 5, PHS 1106, LBPY 11-2 (119)	Sonalika(120)
Plant height (cm)	<80	HD 3095 (74), RAJ 4324, DBW 93, LBPY 11-8, HW 5237 (79)	Sonalika (88)
Tillers/m	>115	HW 4013 (120), MACS 5031 (dic.), HW 1099 (dic.), (118), DDK 1044 (dic.), KBRL 81-1 (116)	Sonalika (104)
Grains /spike	>60	JS 6-1, HW 1900 (64), GW2010-288 (61)	HD2967 (58)
1000-gr.wt. (g)	>45	PHSL 5 (50), LBPY 11-9 (48), RAJ 4304 (47), PHS 1106, LBPY 11-2, GW2010-288, GW 2011-362, PHSL 10 (46)	Sonalika (40)
Spike length (cm)	>11	JS 6-1, PHSL 5, GW2010-288 (13), UP 2847, GW 2011-346, PHSL 10, NW 5013, PHS 1106, LBPY 11-2, HPW 381 (12)	HD2967 (11)

dic-dicoccum; Value in parenthesis indicates the values of the traits

Eleven entries namely HD 3098, RAJ 4270, PBW 658, HI 1579, HPW 360, PHS 1106, PHSL 5, PHSL 10, PHSL 11, GW2010-288 and NW 5013 showed high utilization during 2014-15 and thus, were repeated during 2015-16 crop season. Among these, PHS1106, PHSL 10 and PHSL 5 again showed better performance for early heading and maturity, 1000- grains weight and spike length whereas GW2010-288 showed high grain number, 1000-grains weight and longer spikes. HD 3098, RAJ 4270, PBW 658, HI 1579, HPW 360 and NW 5013 could not perform better for any of the trait.

Disease resistance

Response of genotypes against various rusts and foliar diseases forms an important component of NGSN screening and utilization. Disease reaction for black rust was recorded at Junagarh, Vijapur, Powarkheda, Indore and Wellington whereas brown rust was recorded at Gurdaspur, Ludhiana Pantnagar, Karnal,Vijapur, Indore, Powarkheda, Junagadh, Pune, Dharwad and Wellington. Yellow rust was recorded at Almora, Malan, Pantnagar, Dhaulakuan, Gurdaspur, Ludhiana, Hisar and Karnal. Based on highest reactions and ACI, genotypes exhibiting resistant response under natural conditions were identified. Leaf blight data from Kanpur, Faizabad, Sabour, Coochbehar, Kalyani and Pune was considered for identification of resistant sources. The promising genotypes showing resistances under field condition across the locations are listed in Table 3.

Table 3: Genotypes showing resistance to diseases in NGSN under field conditions

Disease	Resistant	Moderately resistant
Black rust	HW 4013, HW 5237, DBW 90, KBRL 79-2, KBRL 80-3, KBRL 81-1, KBRL 82-2, KBRL 83-3	KRL 348, VL 3001, HW 4042, DDK 1044 (dic), HD 3098, PBW 658, HPW 360, GW 2010-288, DBW 88, K 1006, DBW 110
Brown rust (North)	PBW 660, HW 5235, Raj 4324, UP 2843, VL 3001, HW 1900, HW 4042, HW 5237, HS 578, Raj 4270, HI 1579, K 1006, NW 5054, DBW 107, DBW 110, DBW 93, LBPY 11-8, GW 2011-346	-
Brown rust (South)	HW 4013, UP 2872, HW 5237	HPW 381, HD 3095, GW 432, DDK 1044 (dic), KBRL 82-2
Yellow rust	HD 3098, HI 1579	HD 3121
Leaf blight	PBW 660, Raj 4250, UP 2872, HW 5224, KBRL 77-1, KBRL 78-2, KBRL 82-2	UP 2847, KRL 348, HI 1579, K 1006, KBRL 80-3, KBRL 81-1

dic- T. dicoccum

Processing and nutritional quality

All the bread wheat entries and checks were also analysed for processing quality parameters viz., test weight (kg/hl), protein content (%), sedimentation value (ml), grain hardness index as well as nutritional quality parameters like iron and zinc content (ppm) during the year 2015-16. A wide range was observed for these quality parameters indicating existence of variability for these traits among the genotypes. Promising genotypes for various quality traits were identified (Table.4) for further utilization in wheat improvement programmes.

Table 4: Promising genotypes for processing and nutritional quality traits in NGSN

Traits	Range	Mean	Criteria	Promising Entries	Best check
Test wt. (kg/hl)	72.3-84.0	80.9	≥83.0	KBRL 82-2, HUW 668, DBW 71, PBW 660, JAUW 598	Sonalika (82.7)
Protein content (%)	8.8-14.0	11.1	>12.5	DBW 93, K 1006, HW 4013, PHSL 11, GW 2011-362, DBW 107 and PHSL 10	Sonalika (10.7)
Sedimentation value (ml)	34-60	46	>55	UP 2872, VL 3001, HD 3098, DBW 88, DBW 90, NW 5054	HD 2967(60)
Grain hardness index	39-88	66	>80	KBRL 80-3, KBRL 81-1, KBRL 79-2, KBRL 83-3	HD 2967(67)
			<45	HPW 381	
Iron (ppm)	31.4-43.6	38.3	>42.0	GW2010-288, PHS 1106, K 1006, PBW 660, DBW 90	Sonalika (36.4)
Zinc (ppm)	27.7-42.8	35.5	>41.0	RAJ 4250, K 1006, DBW 93, LBPY 11-9, PBW 660, HD 3095	Sonalika (37.2)

Utilization of genotypes

The utilization report was received from 24 centres whereas Dhaulakuan, Varanasi, Kota, Jabalpur, and Bhavnagar did not supply utilization report. The pooled utilization report indicated overall 26.0% utilization by these 24 centres for selection as genotype or as parents in hybridization (Table 5). Out of 24 centres, 10 centres used these entries as direct selections indicating 13.5% utilization. On the other side, 21 centres utilised these lines as parent in hybridization programmes having utilization of 24.1%. It was found that all the entries were utilized by either of the centres for different purposes. Bread wheat entries showed 27.4% utilization and maximum utilization was observed for yield component lines (33.3%) followed by disease resistant lines (29.9%), elite lines from previous NGSN (28.0%) and new agronomic bases (22.9%). Genotypes HPW 381, PBW 660, Up2843, UP 2847, LBPY 11-2, LBPY 11-9, HI 1588 and HW 5224 were the most utilized. Among the centres, maximum utilization was done by Sagar (43) followed by Pune (32), Durgapura (31), Sabour (24), Powarkheda (24), Vijapur (20) and Coochbehar (20) centres. *T. dicoccum* entries showed 6.3% utilization and these were utilised by Dharwad and Pune centres for hybridization purpose whereas Sabour centre made selection from entry DDK 1044 for direct utilization.

Table 5:Utilization of genetic stocks in NGSN during 2015-16

Category	Entries	Utilization Frequency (%)		
		Hybridization	Selection	Overall
T. aestivum				
Disease resistance	23	141 (29.2)	32 (13.9)	165 (29.9)
Elite lines from NGSN	11	57 (24.7)	19 (17.3)	74 (28.0)
New agronomic base	8	35 (20.8)	9 (11.3)	44 (22.9)
Yield component lines	7	42 (28.6)	15 (21.4)	56 (33.3)
KB resistant genetic stocks	7	24 (16.3)	5 (7.1)	29 (17.3)
Sub total	56	299 (25.4)	80 (14.3)	368 (27.4)
T. dicoccum				
Disease resistance	4	5 (6.0)	1 (2.5)	6 (6.3)
Total	60	304 (24.1)	81 (13.5)	374 (26.0)

Values in parenthesis are % utilization

Table 6: Mean Performance of entries in NGSN during 2015-16

SN	Genotypes	Agronomic traits							Processing quality				Nutritional quality	
		Days to heading	Days to maturity	Plant ht. (cm)	Tillers /m row length	Grains per spike	1000-gr. wt. (g)	Spike length (cm)	Test Weight (kg/hl)	Protein Content (%)	Sedimen. Value (ml)	Grain Hardness Index	Iron (ppm)	Zinc (ppm)
1	HPW 381	86	127	93	110	53	36	12	79.4	9.5	49	40	33.7	32.7
2	PBW 660	85	125	92	101	51	40	10	83.0	10.9	49	71	42.3	41.1
3	HD 3095	75	120	74	105	44	39	9	82.2	10.8	47	64	39.7	41.1
4	HUW 668	77	122	81	106	45	39	10	83.4	11.1	44	64	39.6	32.8
5	HW 1099 (dic.)	84	124	87	118	43	37	9	-	-	-	-	-	-
6	HW 5235	80	124	81	91	53	35	10	80.4	11.6	44	74	38.6	35.6
7	JAUW 598	79	124	89	103	53	39	11	83.0	11.1	39	66	35.8	37.4
8	RAJ 4324	77	121	79	109	46	38	9	82.0	11.3	52	72	38.0	34.1
9	UP 2843	72	121	85	94	52	38	10	81.5	11.0	53	72	35.9	34.2
10	UP 2847	80	123	97	83	55	43	12	79.8	9.9	38	60	34.1	33.0
11	UP 2871	76	123	91	92	51	41	10	81.8	9.5	55	61	31.4	33.5
12	RAJ 4250	75	121	88	95	48	41	11	80.6	8.8	34	58	41.6	42.8
13	GW 432	74	121	87	104	49	40	10	80.8	9.1	49	61	38.0	36.6
14	HI 1588	75	121	85	104	45	39	10	81.4	9.9	47	72	42.0	33.2
15	HW 4013	83	126	84	120	42	33	9	81.0	12.9	38	78	41.4	39.5
16	UP 2872	77	123	91	99	48	41	10	80.5	11.1	57	75	37.0	30.2
17	KRL 348	84	124	90	99	54	37	9	81.3	11.1	53	63	41.1	37.2
18	VL 3001	80	124	89	88	54	40	10	82.2	9.9	57	64	41.1	34.5
19	HW 1900	84	126	85	89	64	37	10	81.8	9.6	42	80	38.1	38.0
20	HW 4042	86	127	83	98	55	35	9	80.5	10.3	42	72	40.5	40.1
21	HW 5237	80	123	79	98	56	34	10	80.7	11.7	42	77	38.4	37.2
22	MACS 5031(dic.)	86	124	85	118	47	36	10	-	-	-	-	-	-
23	DDK 1044 (dic.)	86	125	85	116	44	36	9	-	-	-	-	-	-
24	DDK 1045 (dic.)	85	124	87	109	45	36	10	-	-	-	-	-	-
25	HS 578	85	125	105	111	51	37	9	82.7	11.7	45	72	40.5	40.9
26	HD 3121	81	123	94	109	48	39	10	80.5	11.1	50	60	37.7	38.5
27	HW 5224	78	121	90	112	48	38	10	81.2	10.6	55	72	38.3	32.8
28	HD 3098	82	124	92	98	54	41	11	82.4	10.1	57	62	31.8	33.4
29	RAJ 4270	75	121	87	92	47	42	10	80.0	10.4	48	51	38.7	35.6
30	PBW 658	82	123	83	101	53	38	11	80.3	10.2	52	66	35.4	30.8
31	HI 1579	86	125	90	96	54	39	10	81.7	9.8	52	61	37.0	36.9
32	HPW 360	90	129	87	82	60	32	11	72.3	11.9	45	79	33.1	32.5
33	PHS 1106	73	119	95	76	53	46	12	80.2	11.3	39	58	43.0	35.0
34	PHSL 5	74	119	107	64	52	50	13	78.3	12.3	42	69	37.6	34.4

35	PHSL 10	73	119	97	73	53	46	12	78.6	12.6	40	68	40.4	35.1
36	PHSL 11	72	118	93	88	55	43	11	79.3	12.9	49	58	40.9	34.2
37	GW 2010-288	76	121	90	69	61	46	13	78.2	12.1	45	63	43.6	32.1
38	NW 5013	81	123	97	94	53	41	12	82.3	11.7	35	63	41.5	40.8
39	DBW 88	82	123	89	98	58	40	11	82.6	11.3	57	65	41.2	32.7
40	DBW 71	78	121	86	102	49	38	11	83.4	10.9	42	63	36.4	32.7
41	DBW 90	80	122	87	107	50	37	10	80.8	11.2	57	75	42.2	33.8
42	K 1006	81	123	89	113	50	38	10	80.0	13.2	36	77	42.7	41.9
43	NW 5054	81	123	99	105	53	41	11	80.0	12.3	56	58	38.2	35.2
44	DBW 107	77	122	88	105	51	39	10	81.6	12.7	44	69	41.6	33.7
45	DBW 110	82	123	91	93	53	40	10	79.7	12.4	53	61	36.0	33.0
46	DBW 93	81	123	79	106	51	36	9	81.8	14.0	45	75	40.2	41.9
47	GW 2011-362	77	121	97	94	48	46	11	79.3	12.8	39	69	41.2	34.6
48	RAJ 4304	75	120	88	91	44	47	11	78.4	12.1	41	62	37.2	36.5
49	LBPY 11-2	73	119	92	96	47	46	12	80.8	11.7	34	54	39.2	40.8
50	LBPY 11-8	73	118	79	98	47	41	9	78.7	11.5	45	56	35.4	37.6
51	LBPY 11-9	76	120	90	80	50	48	10	81.0	11.8	36	56	39.6	41.4
52	JS 6-1	80	121	96	80	64	39	13	79.0	11.4	40	67	40.1	34.0
53	GW 2011-346	77	120	85	87	50	42	12	81.6	11.7	46	61	38.6	30.5
54	KBRL 77-1	84	124	85	106	48	36	10	79.5	10.7	37	60	36.6	32.5
55	KBRL 78-2	81	122	91	103	50	34	9	79.5	11.2	50	79	36.1	31.0
56	KBRL 79-2	80	123	81	106	52	34	10	81.3	11.4	45	81	40.1	27.7
57	KBRL 80-3	83	123	80	114	57	33	10	81.0	11.2	44	88	36.7	32.0
58	KBRL 81-1	82	124	80	116	57	31	10	82.3	11.0	40	88	35.6	32.8
59	KBRL 82-2	83	124	81	98	56	36	10	84.0	10.2	45	64	34.5	32.2
60	KBRL 83-3	83	124	80	105	54	36	10	81.0	10.7	44	81	40.1	37.5
C1	*Sonalika*	75	121	88	104	48	40	9	82.7	10.7	50	64	36.4	37.2
C2	*HD 2967*	84	124	89	99	58	37	11	80.2	10.7	60	67	34.7	33.6
	Range	72-90	118-129	74-107	64-120	42-64	31-50	9-13	72.3-84.0	8.8-14.0	34-60	40-88	31.4-43.6	27.7-42.8
	Mean	80	123	88	99	51	39	10	80.8	11.2	46	67	38.4	35.4

Yield Component Screening Nursery

Gyanendra Singh and BS Tyagi

The Indian Institute of Wheat and Barley Research, Karnal constituted and supplied 28th set of Yield Component Screening Nursery (YCSN) having 105 test entries and 04 checks namely; Lok-1 (1000-grain weight), WH-147 (grains/spike), HD 2009 (tillers/meter) and DBW 17 was planted at 25 centres across zones with an objective to evaluate and identify promising lines for yield components traits (tillers per meter, grains per spike and 1000-grain weight). The mean performance of checks (repeated twice) was used to compare test entries across locations. This year data reporting was excellent as dully filled data booklets were received from all 25 centres. Whereas trait specific data from few centres recording unrealistic observations (either very high or very low site mean) was not considered for specific trait so as to make a logical comparison among entries.

The mean values (numerically higher or at par to the best check for particular component trait) were used as the criterion for selecting promising entries. On the basis of superior performance of a particular entry under this nursery for a specific or multiple component trait(s) continuously for three years across locations, promising lines have been identified as genetic resource(s) and are presented (Table 1) for contribution of these entries to NGSN to use as crossing block material by cooperating centres.

Table 1:Promising lines showing consistent performance for three consecutive years (2013-15)

Trait	Promising genetic resources (in order of merit)
Grains / spike (>55)	LBPY-2013-01, LBPY-2013-03, LBPY-2013-05, NIAW 2349
Tillers / meter (>85)	HI 1600, NIAW 2064, RAJ 4393
1000-gr. wt. (>45)	HI 1600, KB-2013-05, LBPY-2013-05, RAJ 4350, RAJ 4394

Similarly, promising entries for multiple or individual component trait(s) based on this year's performance have been identified and are presented (Table 2). The performance (range and mean) of all test entries along with checks is presented in Table 3. Besides, the collaborators made selections from this nursery for use as donor parents in hybridization to improve component trait(s) namely; grain size, grain number and tiller number wherein maximum selections were made for 1000-grain weight followed by number of tillers and grains per spike. As a regular activity, the identified YCSN lines will be supplied in the ensuing National Genetic Stock Nursery (NGSN) for use in their on-going breeding programmes at cooperating centres.

Table 2:Promising lines identified for multiple and individual component trait(s) during 2015-16

Trait(s)	Lines/ genotypes
High tillering, more grains per spike and high gr.Wt.	HI1600, LBPY-2013-05, LBPY-2014-04, LBPY-2014-07, HI 1609, LBPY-2015-01, LBPY-2015-05, UP 2930
High tillering and high gr. wt.	GW-2014-545, Raj 4394, AKAW 4899, RAJ 4472, UP 2929
More grains per spike and high gr. wt.	DWAP 1531, DWAP 1533, GW-2014-544, UP 2931
High tillering	LBPY-2013-02, NIAW 2064, RAJ 4351, RAJ 4393, RAJ 4395, RAJ 4396, GW-2013-478, HI 1608, LBPY-2014-08, RAJ 4444, AKAW 4923, DWAP 1530, DWAP 1534, DWAP 1536, GW-2014-560, GW-2014-562, GW-2014-563, GW-2014-571, LBPY-2015-03, NIAW 3033, RAJ 4478, UP 2928
More grains per spike	LBPY-2013-01, LBPY-2013-03, NIAW 2349, AKAW 4900, GW-2013-489, GW-2013-491, LBPY-2014-10, DWAP 1532, DWAP 1535, DWAP 1537, GW-2014-574, GW-2014-580, KV-2015-02, NIAW 3023, UP 2968, UP 2970, UP 2971
High gr. wt.	RAJ 4350, LBPY-2014-03, NIAW 2844, DWAP 1540, DWAP 1541, GW-2014-547, HI 1610, LBPY-2015-07, KB-2013-05

Table 3: Range and mean of entries for yield components traits during 2015-16

SN	Entry	Tillers/ meter		Grains/spike		1000-gr. wt.	
		Range	Mean	Range	Mean	Range	Mean
1	HI 1600	48-128	92	34-65	56	27-58	46
2	KB 2013-01	45-118	75	32-61	46	35-59	44
3	KB 2013-05	43-112	79	23-68	46	34-60	46
4	LBPY 2013-1	49-120	79	27-86	56	29-52	37
5	LBPY 2013-2	56-110	80	34-67	53	30-50	39
6	LBPY 2013-3	41-108	76	33-78	55	25-48	36
7	LBPY 2013-4	31-126	77	36-74	52	31-50	41
8	LBPY 2013-5	43-125	80	21-72	56	28-59	46
9	NIAW 2349	46-120	77	40-78	56	24-49	37
10	NIAW 2064	52-121	86	25-78	47	34-53	43
11	Raj 4350	30-105	72	31-66	47	30-56	46
12	Raj 4351	40-125	84	21-68	49	28-51	41
13	Raj 4392	45-118	78	27-63	49	28-54	42
14	Raj 4393	33-140	86	37-74	51	29-52	41
15	Raj 4394	46-130	83	27-76	53	27-58	46
16	Raj 4395	48-144	83	20-62	47	25-53	42
17	Raj 4396	34-128	84	17-64	46	28-53	40
18	AKAW 4899	43-132	82	31-82	53	32-60	46
19	AKAW 4900	34-130	79	37-88	59	25-54	38
20	GW 2013-471	31-104	63	29-68	53	32-50	42
21	GW 2013-478	45-124	82	32-68	51	28-50	41
22	GW 2013-482	38-113	67	30-68	50	21-50	38
23	GW 2013-488	41-130	73	32-80	51	25-48	38
24	GW 2013-489	42-101	76	40-72	55	31-57	43
25	GW 2013-491	29-102	57	31-96	58	29-62	43
26	HI 1608	43-145	80	28-65	50	24-60	42
27	LBPY-2014-1	44-105	79	34-72	53	24-52	39
28	LBPY-2014-2	32-126	76	31-68	47	21-51	40
29	LBPY-2014-3	31-117	69	33-66	49	30-58	45
30	LBPY-2014-4	33-135	80	37-78	56	31-58	46
31	LBPY-2014-5	48-156	83	30-80	54	30-48	38
32	LBPY-2014-6	45-145	86	38-80	54	28-52	40
33	LBPY-2014-7	33-114	84	39-78	55	29-58	45
34	LBPY-2014-8	52-136	85	32-74	51	28-50	38
35	LBPY-2014-9	36-126	79	29-76	50	30-56	40
36	LBPY-2014-10	42-125	74	36-80	55	32-53	42
37	LBPY-2014-11	31-107	68	32-70	50	34-54	43
38	LBPY-2014-12	39-124	75	33-72	50	36-57	44
39	NIAW 2809	33-112	73	30-60	47	28-62	43
40	NIAW 2844	39-153	71	29-71	48	35-60	48
41	RAJ 4441	39-114	71	36-78	52	32-61	44
42	RAJ 4442	44-110	74	21-61	46	28-50	41
43	RAJ 4443	40-135	74	24-65	50	27-57	42
44	RAJ 4444	33-150	86	33-80	52	31-46	40
45	RAJ 4445	32-100	67	31-75	50	30-57	41
46	AKAW 4901	63-111	83	39-69	54	25-48	38
47	AKAW 4923	44-112	82	38-78	53	26-51	37
48	DWAP 1530	56-155	91	36-68	52	23-59	36
49	DWAP 1531	36-111	64	31-80	55	32-60	47
50	DWAP 1532	40-117	75	33-80	54	26-48	36
51	DWAP 1533	36-93	60	27-90	58	25-61	45
52	DWAP 1534	38-130	81	33-79	53	23-52	37
53	DWAP 1535	45-115	76	28-75	54	23-58	37
54	DWAP 1536	57-135	80	33-76	50	25-61	38
55	DWAP 1537	30-108	61	19-80	56	27-61	42
56	DWAP 1538	40-118	71	35-81	53	31-58	42

SN	Entry	Tillers/ meter		Grains/spike		1000-gr. wt.	
		Range	Mean	Range	Mean	Range	Mean
57	DWAP 1539	44-105	75	24-62	48	27-61	42
58	DWAP 1540	31-112	67	33-76	51	32-61	45
59	DWAP 1541	47-112	78	31-74	49	34-62	45
60	GW 2014- 544	29-108	55	26-85	56	31-62	46
61	GW 2014-545	40-134	80	21-68	44	22-61	45
62	GW 2014-546	42-130	77	27-68	48	31-58	43
63	GW 2014-547	31-97	59	22-81	51	21-64	47
64	GW 2014-559	40-105	72	24-75	52	28-51	41
65	GW 2014-560	56-111	81	31-73	49	24-50	40
66	GW 2014-562	56-120	85	37-66	50	28-49	37
67	GW 2014-563	54-119	84	19-66	47	32-52	44
68	GW 2014-564	41-98	70	33-64	49	24-55	42
69	GW 2014-571	55-119	83	33-65	51	20-48	34
70	GW 2014-573	42-103	69	33-78	50	23-53	40
71	GW 2014-574	32-99	59	22-86	57	28-62	43
72	GW 2014-578	40-117	73	21-76	50	29-51	41
73	GW 2014-579	43-103	77	30-65	53	24-50	39
74	GW 2014-580	46-111	74	42-80	60	27-57	40
75	GW 2014-581	34-109	77	20-78	49	29-55	39
76	GW- 2014-582	41-120	78	35-72	53	32-64	43
77	HI 1607	43-110	81	25-65	46	27-62	39
78	HI 1609	56-115	84	41-80	56	32-60	45
79	HI 1610	40-110	73	34-65	50	36-60	45
80	LBPY-2015-01	51-125	87	37-94	56	31-58	45
81	LBPY-2015-02	40-104	73	23-64	46	31-54	43
82	LBPY-2015-03	54-120	83	33-70	49	29-47	37
83	LBPY-2015-04	59-144	85	33-80	54	31-45	38
84	LBPY-2015-05	44-124	85	42-79	57	33-54	46
85	LBPY-2015-06	40-110	74	35-66	51	34-52	42
86	LBPY-2015-07	43-97	72	25-61	44	28-60	48
87	LBPY-2015-08	53-103	74	30-71	53	30-51	40
88	KV-2015-01(M_2-415)	43-103	68	36-75	53	29-66	40
89	KV-2015-02(KV)	34-107	77	36-80	57	27-50	38
90	NIAW 2847	32-105	69	29-72	49	26-55	40
91	NIAW 3023	35-110	74	31-80	54	32-52	42
92	NIAW 3033	50-125	83	34-64	49	30-53	44
93	RAJ 4472	53-120	88	34-75	53	29-54	46
94	RAJ 4478	45-109	81	32-65	50	30-56	44
95	RAJ 4479	41-122	76	34-75	53	32-51	42
96	RAJ 4480	35-117	82	24-61	45	28-52	42
97	RAJ 4481	33-103	73	24-65	45	28-50	41
98	UP 2928	39-162	80	36-75	51	31-51	40
99	UP 2929	35-110	80	35-72	52	32-53	46
100	UP 2930	47-109	82	39-70	55	31-52	46
101	UP 2931	49-113	76	34-82	54	32-56	45
102	UP 2968	40-120	65	33-75	56	25-58	41
103	UP 2969	32-94	69	26-74	50	31-61	44
104	UP 2970	48-108	75	36-76	54	25-48	37
105	UP 2971	41-107	78	32-75	54	24-53	42
106	Lok 1 (C)	42-102	70	29-67	48	31-55	44
107	WH 147 (C)	39-115	71	37-73	53	26-53	38
108	HD 2009 (C)	50-117	74	41-65	52	27-50	39
109	DBW 17 (C)	56-116	79	34-63	50	31-47	38

Short Duration Screening Nursery

Ravish Chatrath, Vikas Gupta, Satish Kumar and OP Tuteja

The 29th Short Duration Screening Nursery (SDSN) comprising 60 genotypes was conducted at 22 locations across the country during 2015-16. The aim of the nursery was to identify early maturing genotypes for terminal heat tolerance during grain filling period under late sown conditions. The nursery was conducted in augmented design with 36 test entries and six checks (Sonalika, DBW 71, DBW 14, WR 544, HD 2932 and NIAW 34) which were replicated four times for comparing the performance of the test entries for each block. The nursery was conducted in plots of two rows in 2.5m length spaced 18 cm apart.

The 36 test entries were contributed by 4 wheat breeding centres (Table 1). IIWBR, Karnal contributed maximum 15 entries followed by GAU, Vijapur (11), RAU, Durgapura (08) and PDKV, Akola (2).

Table 1: Contribution of entries for short duration nursery

SN	Centre	Entries
1	GAU, Vijapur	11
2	IIWBR, Karnal	15
3	PDKV, Akola	2
4	RAU, Durgapura	8
	Total	**36**

Data from 20 centres (Karnal, Balachaur, Pantnagar, Jammu, Kanpur, Coochbehar,Faizabad, Ranchi, Patna, Varanasi, Sabour, Shillongoni, Sanosora, Powarkheda, Bilaspur, Jabalpur, Niphad, Pune Dharwad and Dhaulakuan) were pooled zone-wise for analysis and reported here. Data booklet from Anantnag centre was not received while data of Malan was not included due to errors in data.

Data were recorded for days to heading, days to maturity, grain number per spike, 1000-grains weight (g) and yield per plot (g). The data was pooled zone wise for analysis for various traits in order to identify promising lines for specific zone. Performance of promising high yielding, early maturing genotypes for different zones are described here.

Performance of entries for yield

Based on the pooled mean for earliness and yield, the promising genotypes showing better performance over the best check were identified. Zone wise analysis was made and the entries performing better than checks were identified (Table 2).

In NWPZ two test entries RWP 2013-9, RWP 2013-10 performed better than the check varieties for yield. These lines were early maturing and had slightly higher number of grains per spike than the checks. In NEPZ only one genotype GW 2012-475 was high yielding than the checks. IN PZ the test entry RWP 2013-10 was highest yielding and had higher number of grains per spike than the checks. In NHZ, the twot entries RWP 2013-9, RWP 2013-10 were high yielding than the checks.

Table 2:Promising entries during 2nd year of testing in SDSN

SN	Genotype	Yield (g)	Heading days	Maturity days	Grains/ spike	1000 gr. wt.
NWPZ						
1	RWP 2013-10	531	77	118	48	36
2	RWP 2013-9	473	78	118	51	34
Checks						
1	SONALIKA (C)	367	76	119	40	39
2	WR 544 (C)	418	72	119	49	39
3	DBW 71 (C)	429	78	120	45	40
4	DBW 14 (C)	412	76	120	46	38
5	HD 2932 (C)	419	79	119	48	38
6	NIAW 34 (C)	391	78	119	43	36
NEPZ						
1	GW 2012-475	305	66	105	48	35

Checks						
1	SONALIKA (C)	215	66	102	43	37
2	WR 544 (C)	247	63	104	44	37
3	DBW 71 (C)	258	66	106	46	35
4	DBW 14 (C)	254	66	105	47	38
5	HD 2932 (C)	219	69	107	49	36
6	NIAW 34 (C)	240	67	107	47	34
PZ						
1	RWP 2013-10	386	60	96	51	29
Checks						
1	SONALIKA (C)	269	58	94	44	34
2	WR 544 (C)	338	53	92	43	35
3	DBW 71 (C)	365	60	96	50	32
4	DBW 14 (C)	273	57	94	41	35
5	HD 2932 (C)	299	64	99	45	36
6	NIAW 34 (C)	289	61	96	45	33
NHZ						
1	RWP 2013-9	375	107	147	-	-
2	RWP 2013-10	425	104	145	-	-
Checks						
1	SONALIKA (C)	219	108	145	-	-
4	WR 544 (C)	331	107	144	-	-
2	DBW 71 (C)	294	106	143	-	-
3	DBW 14 (C)	294	109	146	-	-
5	HD 2932 (C)	219	107	145	-	-
6	NIAW 34 (C)	319	107	146	-	-

Early maturing genotypes were also identified and analyzed for different traits such as yield, days to heading, days to maturity, number of grains per spike and 1000-grains weight. Entries performing better than the checks were identified for each zone (Table 3). Entries LBP 2014-12, RAJ 4358, RWP 2011-15 & GW 2014-619 for NWPZ; entries DWAP 1408, RWP 2013-10, GW 2014-624, GW 2010-321 & WS 2014-07 for NEPZ; Entries LBP 2014-12, DWAP 1412, GW 2014-619, GW 2010-321 & GW 2012-475 for CZ; entry AKAW 4842 for PZ and entries RWP 2014-18, WS 2014-07 & RWP 2014-19 for NHZ were identified as promising genotypes.

Table 3:Promising early maturing genotypes in different zones during 2015-16

SN	Genotype	Yield		Heading		Maturity		Grains/spike		1000 gr. wt.	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
NWPZ											
1	LBP 2014-12	145-748	517	78-89	84	109-131	120	33-45	37	33-48	39
2	RAJ 4358	165-706	470	75-85	78	108-128	118	43-56	47	28-39	34
3	RWP 2011-15	180-592	464	80-90	84	111-135	121	43-57	49	38-41	39
4	GW 2014-619	180-626	454	70-85	76	109-136	120	45-47	46	40-44	42
Checks											
1	Sonalika(C)	145-508	367	73-82	76	107-135	119	32-47	40	36-41	39
4	WR 544 (C)	186-578	418	62-82	72	109-135	119	42-57	49	38-40	39
2	DBW 71 (C)	195-590	429	74-85	78	110-132	120	32-54	45	39-41	40
3	DBW 14 (C)	190-606	412	71-86	76	109-133	120	32-53	46	34-40	38
5	HD 2932 (C)	186-578	419	72-84	79	107-134	119	39-55	48	36-40	38
6	NIAW 34 (C)	140-585	391	75-85	78	109-132	119	35-53	43	33-39	36
NEPZ											
1	DWAP 1408	109-500	306	62-76	69	98-126	108	51-73	57	30-50	35
2	RWP 2013-10	80-600	306	60-76	68	96-126	107	41-59	49	28-47	34
3	GW 2014-624	161-500	298	61-77	69	95-119	104	24-56	41	31-49	40
4	GW 2010-321	225-434	290	59-76	67	95-120	104	42-67	51	26-47	35
5	WS 2014-07	160-400	278	59-80	68	94-125	107	26-56	44	26-51	36
Checks											
1	Sonalika(C)	80-338	215	55-75	66	86-124	102	31-53	43	31-49	37
2	WR 544 (C)	123-350	247	54-71	63	92-122	104	32-55	44	31-47	37

SN	Genotype	Yield		Heading		Maturity		Grains/spike		1000 gr. wt.	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
3	DBW 71 (C)	146-400	258	60-74	66	96-124	106	38-58	46	31-51	35
4	DBW 14 (C)	149-353	254	56-75	66	93-123	105	28-66	47	31-49	38
5	HD 2932 (C)	66-328	219	61-77	69	97-125	107	35-63	49	27-50	36
6	NIAW 34 (C)	81-436	240	61-76	67	97-124	107	39-52	47	27-47	34
CZ											
1	LBP 2014-12	270-775	528	60-70	66	93-120	113	21-57	41	34-47	41
2	DWAP 1412	250-674	520	54-59	56	97-110	105	31-50	41	42-50	46
3	GW 2014-619	300-694	497	52-69	58	94-110	104	40-45	43	43-50	46
4	GW 2010-321	300-800	494	60-65	62	94-126	113	39-53	46	33-45	40
5	GW 2012-475	240-710	486	54-70	61	95-115	109	39-52	44	39-50	43
Checks											
1	Sonalika(C)	183-650	442	52-64	59	95-120	110	26-50	34	38-52	44
2	WR 544 (C)	268-596	436	48-66	55	87-119	105	31-40	35	38-46	41
3	DBW 71 (C)	255-643	446	57-64	61	92-121	109	35-45	40	39-44	41
4	DBW 14 (C)	213-509	395	55-64	59	93-122	108	28-52	41	38-46	41
5	HD 2932 (C)	195-565	406	59-64	62	95-116	109	31-46	40	40-45	42
6	NIAW 34 (C)	195-650	465	57-62	60	93-115	109	29-46	39	36-51	43
PZ											
1	AKAW 4842	240-689	467	52-63	57	88-104	96	44-60	51	27-33	31
Checks											
1	Sonalika (C)	183-365	269	54-64	58	90-97	94	33-50	44	28-38	34
4	WR 544 (C)	264-482	338	49-59	53	83-96	92	41-46	43	32-39	35
2	DBW 71 (C)	294-405	365	55-67	60	91-98	96	41-58	50	30-33	32
3	DBW 14 (C)	224-347	273	54-63	57	87-101	94	35-50	41	32-37	35
5	HD 2932 (C)	214-389	299	59-69	64	94-102	99	41-51	45	33-37	36
6	NIAW 34 (C)	211-353	289	57-68	61	89-100	96	38-48	45	30-35	33
NHZ (Data of Dhaulakuan only)											
1	RWP 2014-18	500	105	140	-	-					
2	WS 2014-07	475	104	138	-	-					
3	RWP 2014-19	450	109	142	-	-					
Checks											
1	Sonalika (C)	219	108	145	-	-					
2	WR 544 (C)	331	107	144	-	-					
3	DBW 71 (C)	294	106	143	-	-					
4	DBW 14 (C)	294	109	146	-	-					
5	HD 2932 (C)	219	107	145	-	-					
6	NIAW 34 (C)	319	107	146	-	-					

1. NWPZ: Karnal, Balachaur, Jammu and Pantnagar centres. 2. NEPZ: Patna, Sabour, Kanpur, Ranchi, Faizabad, Coochbehar, Shillongani and Varanasi centres. 3. CZ: Jabalpur, Sanosara, Powarkheda and Bilaspur centres. 4. PZ: Niphad, Pune and Dharwad centres. 5. NHZ: Dhaulakuan

Drought Tolerance Screening Nursery

Rinki, Mamrutha HM, BK Meena and Vinod Tiwari

The Drought Tolerance Screening Nursery (DTSN) was conducted to identify wheat genotypes for tolerance to moisture stress throughout the crop period. During the 28th year of this nursery, seeds were supplied to 12 wheat research centers viz. Akola, Bardoli, Dharwad, Hisar, Indore, Kanpur, Karnal, Kharibari, Kota, Pune, Ranchi and Sagar. The nursery had 49 test entries including C306, AKAW3717 and NI5439 as checks. The experiment was laid in 7x7 lattice design. The nursery was sown both under drought and irrigated conditions with two replications. Each genotype was raised on plots with 2 rows of 2.0 meter length with 23cm space between the rows. For drought conditions, the crop was sown with pre-sowing irrigation only. For irrigated conditions recommended package of practice was followed. Data in the prescribed format were received from only 10 centers. Bardoli and Kharibari centers data was incomplete and hence was not included in compilation.

Intensity of stress

The minimum days for 75% heading of the genotypes at respective locations were considered for explaining intensity of stress before and after heading. Karnal received maximum rainfall of 132.3mm, hence no drought stress was observed at Karnal center. During sowing to heading the mean minimum temperature of 7^{0}C was recorded at Hisar and the mean maximum temperature was recorded at Akola and Pune (30.7^{0}C). Kanpur had a highest rainfall of 45.3mm before heading followed by Dharwad (31mm), Pune (22.2mm), Sagar (17mm) and Ranchi (3.2mm). This rain helped in early establishment and better tillering of the genotypes under rain-fed condition. Akola, Hisar, Indore, Karnal has not received any rainfall and Kota centers have received a minimum rainfall (0.6mm) during this period.

The average and range for minimum and maximum temperature before and after heading and the rainfall data is given in Table 1. From heading to physiological maturity the mean minimum temperature of 7.7^{0}C was recorded at Kanpur followed by Hisar (8.9^{0}C), Kota (10.7^{0}C) and Ranchi (10.7^{0}C). The mean maximum temperature of 31.5^{0}C was recorded at Pune, followed by Akola (31.3^{0}C), Dharwad (30.9^{0}C), Sagar (29.9^{0}C) and Indore (29.4^{0}C). Ranchi, Sagar and Hisar received a rainfall of 30.7mm, 28.8mm and 28.7mm respectively. But no rainfall was recorded at Akola, Indore, Pune during this period (Table 1).

Impact of drought and heat stress on different growth and yield parameters

The lowest mean grain yield of 113 gram per meter row length (gm^{-1}) was recorded at Akola, followed by 127gm^{-1} at Dharwad under drought condition. Whereas, for irrigated condition, it was lowest at Kanpur (220gm^{-1}) followed by Dharwad (243gm^{-1}). The low productivity at Akola and Dharwad was because of lack of rainfall during grain filling duration (Annexure 1). Thousand grain weight across the locations ranged from 31 to 47.3g. The lowest mean thousand grain weight (31g) was recorded at Dharwad for drought condition whereas under irrigated condition, Karnal had the lowest mean thousand grain weight of 34.1g. The highest thousand grain weight of 46.3g was recorded at Sagar.

Table 1: Temperature and Rainfall recorded at different centres

SN	Location		Mini temp (^{0}C)	Max temp (^{0}C)	Total Rainfall (mm)	Min temp (^{0}C)	Max temp (^{0}C)	Total Rainfall (mm)
Before heading						During Grain Growth		
1	Akola	Mean	12.7	31.7	0	12.08	31.3	0
		Range	4.6-21.1	25.2-34.2		5-18.4	25.6-36.2	
2	Dharwad	Mean	17.5	30	31	15	30.9	0.4
		Range	12.6-21.5	26.8-31.8		10.9-19.2	26-34.1	
3	Hisar	Mean	7	23.7	0	8.9	23.4	28.7
		Range	1.5-15.2	18-29.4		1.5-18	13.2-33.2	
4	Indore	Mean	16.8	28.5	0	12.5	29.4	0
		Range	6.5-24.0	18.0-32.0		5.0-21.0	20.0-38.0	

5	Kanpur	Mean	13.7	31.5	45.3	7.69	22.8	11
		Range	7.2-20.8	24.2-37.6		0.8-14.2	12.2-29.4	
6	Karnal	Mean	8.97	20.43	0	15.3	29	132.3
		Range	3.4-15.2	9.9-27.2		7.8-23.1	21.2-37.9	
7	Kota	Mean	10.5	27.9	0.6	10.7	28	0.6
		Range	3.8-16.8	22.1-32.5		5.0-17.0	20.6-36.5	
8	Pune	Mean	17	31.7	22.2	12.2	31.5	0
		Range	11.7-22.1	27.1-34		6.5-19.3	26.7-36.5	
9	Ranchi	Mean	9.56	24.5	3.2	11	26.8	30.7
		Range	3-16.5	18.5-30.3		1.0-17.4	18.3-33.3	
10	Sagar	Mean	14.6	28.9	17	14.9	29.9	28.8
		Range	6-20.8	22-33.9		7.2-22	16.1-37.3	

Drought tolerant genotypes

In order to identify the genotypes less sensitive to drought conditions, drought sensitivity index (DSI) was calculated for each location. Genotypes having DSI value less than 0.5 were considered as less sensitive to drought. Location wise drought tolerant genotypes are given in Table 2. By categorising different centres into different zones and by pooling the data the genotypes performing better under different zones are also listed (Table 2). The pooled analysis of data across zones and across centers reveals that RW5* (0.44) showed minimum yield reduction under drought condition across the zones. While identifying drought tolerant genotype Karnal was not included for the identification of drought tolerance genotypes as there was no actual drought condition during crop growth period due to heavy rainfall.

Table 2:Location wise list of drought tolerant genotypes (Drought Susceptibility Index, DSI<0.5)

Location	**Genotypes**
Akola	HI-1619 (0.42)
Dharwad	C-306(C) (0.30), DBW-144 (0.31), DBW-155 (0.02), HI-1620 (0.04), RW-5* (-0.15)
Hisar	None
Indore	DWAP-1526 (0.39), DWAP-1527 (0.28), HI-1619 (-0.16), K-1406 (0.42), MACS-6687 (0.25), RAJ-4455 (-1.84), RAJ-4469 (0.33), RAJ-4488 (0.38), RAJ-4490 (-1.24), RW-5* (0), SATYN-2014-2 (0.01), SATYN-2014-11 (0.25), SATYN-2014-24 (-0.20), UASD-DT2 (-0.16)
Kanpur	C-306(C) (0), DBW-166 (0.37), DBW-180 (0.42), HI-8789 (-7.26), K-1406 (0), K-1417 (0.30), RAJ-4487 (0), RWP-2014-28 (0.37), SATYN-2014-11 (0.25), WH-1198 (0.50)
Kota	AKAW-3717(C) (-0.10), DBW-136 (0.15), HI-8776 (-2.83), HI-8789 (-0.23), HI-8790 (0.17), HI-8792 (0.44), HI-8793 (-0.11), K-1412 (0.50), RAJ-4487 (0.28), RAJ-4489 (0.49), RW-5* (-1.14), RWP-2014-25 (0.42), UASD-DT1 (-1.01), WH-1126 (-0.66)
Pune	None
Ranchi	AKAW-3717(C) (0.43), DWAP-1526 (0.24), HI-1620 (0.49), RWP-2014-28 (0.43), RWP-2014-30 (0.37), WH-1199 (0.18)
Sagar	None
Zone	
NWPZ	AKAW-3717(C) (0.36), HI-8776 (-0.28)
NEPZ	DWAP-1526 (0.39), HI-8776 (-1.51), RWP-2014-28 (0.41)
CZ	DBW-136 (0.40), DBW-166 (0.35), HI-8776 (-1.53), HI-8789 (-1.28), HI-8790 (0.40), HI-8791 (0.50), RAJ-4455 (0.11), RAJ-4490 (0.41), RW-5* (-1.56), RWP-2014-25 (0.22), RWP-2014-29 (0.35)
PZ	None
Across Zones	C-306(C) (0.35), RW-5* (0.44)

Values in the parenthesis indicates DSI values

*RIL of RAJ-4014/WH730

Annexure1: Mean and range for different traits recorded at different locations

SN	Location	Condition		Germination (%)	Days to Heading	Days to Maturity	Plant height (cm)	Productive tillers/m	Grain yield/plot(g)	Test wt.(g)
1	Akola	Drought	Mean	91	58	110	67	54	113	36.6
			Range	85-95	52-64	61-119	31-80	19-96	55-225	21-43
		Irrigated	Mean	92	62	117	86	89	322	42.0
			Range	85-95	56-67	103-123	67-105	48-104	152-475	34-47
2	Dharwad	Drought	Mean	70	56	99	63	44.0	127	31.0
			Range	25-89	41-69	87-108	37-86	27-60	62-221	23-41
		Irrigated	Mean	81	60	105	72	56	243	35.5
			Range	40-96	46-79	81-114	48-94	25-86	69-850	22-46
3	Hisar	Drought	Mean	78	88	129	81	71	256	40.3
			Range	50-95	74-97	123-134	70-102	45-109	130-407	26-46
		Irrigated	Mean	90	92	133	98	104	461	47.0
			Range	65-99	81-104	140-128	79-125	53-147	30-685	40-53
4	Indore	Drought	Mean	59.7	70	118	76	66	253	42.7
			Range	29-92	55-88	114-135	61-112	28-128	107-472	31.8-58.4
		Irrigated	Mean	54.4	65	113	84	69	341.0	46.5
			Range	29-92	58-85	87-130	61-122	32-137	117-550	31.8-58.4
5	Kanpur	Drought	Mean	83	67	116	87	33	146	29.7
			Range	70-85	60-73	108-127	65-116	18-60	100-200	20.4-40
		Irrigated	Mean	85	77	124	96	44.2	220	39.0
			Range	80-90	69-83	117-130	11-132	40-79	43-300	25.2-46
6	Karnal	Drought	Mean	78	89	127	92	32	235	35.5
			Range	40-97	80-94	119-135	76-124	16-57	114-461	19.5-49.0
		Irrigated	Mean	76	92	130	102	45	325	34.1
			Range	18-93	86-96	126-135	75-126	26-94	98-582	24.5-46.5
7	Kota	Drought	Mean	81	71	142	84	60	428	45.2
			Range	80-85	60-95	137-150	57-118	32-110	315-675	37.4-54.6
		Irrigated	Mean	82	74	140	104	108	569	45.0
			Range	49-85	35-98	69-147	70-155	63-190	282-1070	34.6-56
8	Pune	Drought	Mean	79	60	99	60	69	173	34.4
			Range	40-90	48-80	78-118	51-74	40-94	36-286	26.5-44.5
		Irrigated	Mean	72	64	112	85	100	440	38.8
			Range	40-87	49-83	94-126	55-117	45-152	139-757	29.5-49.5
9	Ranchi	Drought	Mean	-	75	113	83	93	294	39.1
			Range	-	69-82	107-121	64-107	43-126	131-462	31.3-58.4
		Irrigated	Mean	-	79	113	98	102	454	41.6
			Range	-	70-87	106-124	80-110	43-143	199-639	32.6-51.1
10	Sagar	Drought	Mean	77	74	128	82	59	347	47.0
			Range	66-84	61-88	119-134	65-125	30-88	125-675	32-60
		Irrigated	Mean	82	72	128	91	70	533	47.3
			Range	18-92	61-85	125-135	66-118	43-81	131-850	33-59

Salinity-Alkalinity Tolerance Screening Nursery

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Salinity and or alkalinity have become a major edaphic problem for wheat cultivation as it significantly affects the overall productivity and production. Over-exploitation of underground water is increasing the problem of soil salinity in irrigated areas. In India about 6.73 million hectares of cropped land is affected by salinity and sodicity. Sodicity constitutes a sizeable area of the stressed fields. Major salt affected areas fall in the plains of UP (1.3 mha.), Gujarat (1.2 mha), West Bengal (0.85 mha, Rajasthan (0.73 mha), Punjab (0.7 mha) and Haryana (0.53 mha). A large portion of salt-affected land in India is cultivated by small and marginal farmers with limited resources to practice soil amelioration package, thereby limiting the crop output. Use of salt tolerant varieties would significantly improve the productivity of wheat in such areas.

With an aim to identify suitable wheat lines that can perform better under saline and alkaline soils the Salinity-Alkalinity Tolerance Screening Nursery was constituted. During the crop season 2015-16 this nursery was proposed at 9 locations in 3 states *viz*., Haryana (CSSRI-Karnal, CSSRI-Nain Bawal, CCSHAU-Hisar, IIWBR-Hisar), Uttar Pradesh (Faizabad, Dilipnagar, Lucknow) and Gujarat (CSSRI-Bharuch). The soil status of different centres is presented in Table-1. The soil of most of the centres was sodic in nature having high pH. The nursery failed at CSSRI Nain due to very high soil EC.

Table 1:Soil status of different centres during 2015-16

SN	Location	Nature of salt stress	pH*	Soil EC	EC_{iw}
1	CSSRI Karnal	Sodic	9.34-9.94	1.55-3.02	-
2	Bawal	Sodic	9.36-9.53	0.17-0.27	-
3	CCSHAU Hisar	Saline	8.19-8.40	1.25	-
4	IIWBR Hisar	Saline	8.14-8.36	1.96-3.68	-
5	CSSRI Nain	Saline	8.23-8.99	5.85-41.85	10.0
6	Faizabad*	Sodic	9.1	-	-
7	CSSRI Lucknow	Sodic	8.92-9.0	0.63	-
8	Dilipnagar	Sodic	9.2-9.4	-	-
9	CSSRI Bharuch	Saline Vertisol	8.1-8.2	7.5-8.1	10.0-11.0

*pH_2: Soil pH was measured in 1:2 soil water suspension

The nursery comprising 55 test entries obtained from different wheat breeding centres of the country was evaluated along with four checks viz., Kharchia 65, KRL19, KRL210 and sensitive checks HD2009 and HD2967 were evaluated in an augmented block design having 5 blocks with plots of 2m length having 3 rows spaced 20cm apart. Each block comprised 16 treatments (11 test entries + five checks interspersed within each block).

The yield data of eight centres CSSRI-Karnal, IWBR Hisar, Bawal, Hisar Faizabad, Dilipnagar, Lucknow and Bharuch were considered for reporting.

On the basis of pooled analysis (Table2), KRL377 was the highest yielding entry followed by WS1505, WS1504, RWP2015-17, KRL370, KRL373, WH1136, WH1135, KRL389, WS1501, KRL383, KRL384, and KRL386. These thirteen entries showed better performance in grain yield as compared to best check KRL210.

However five entries WS1505 (LR(S) 80S, ACI=23.2; LR (N) 40S, ACI=22.2), KRL373 (YR 40S ACI=15.1), WH1315 (YR 60S ACI=15.3), KRL389 (YR 60S ACI=21.9), and KRL383 (YR 60S ACI=28.8), had higher incidence of rust as presented in Table 2. Therefore, eight entries viz., KRL377, WS1504, RWP2015-17, KRL370, WH1136, WS1501, KRL384, and KRL386 might be considered for testing in Salinity –Alkalinity trial to be conducted during 2016-17

Table 2: Pooled yield and rust reactions of promising test entries in SATSN 2015-16

SN	Entry	Yield(g)	Stem rust		Leaf rust (S)		Leaf rust (N)		Stripe rust	
			HS	ACI	HS	ACI	HS	ACI	HS	ACI
1	KRL377	586.2	5S	1.4	5S	1.2	10S	2.0	40S	12.8
2	WS1505	576.9	15S	7.0	80S	23.2	40S	22.2	0	0.0
3	WS1504	550.2	tR	0.1	30S	6.8	10MS	1.6	0	0.0
4	RWP2015-17	537.0	30MS	11	20S	8.2	0	0.0	80S*	11.3
5	KRL370	535.5	10S	2.6	2MS	3.2	0	0.0	20S	5.6
6	KRL373	534.8	5S	1.3	tR	0.1	0	0.0	40S	15.1
7	WH1316	534.4	5S	1.3	20S	7.6	20S	4.8	10S	2.7
8	WH1315	531.6	30MR	7.3	15MS	2.4	0	0.0	60S	15.3
9	KRL389	523.9	5MS	1.6	15MS	4.0	0	0.0	60S	21.9
10	WS1501	523.4	30S	11.6	10MS	3.4	40S*	8	40S	12.5
11	KRL383	520.7	5MS	1.6	tR	0.1	0	0.0	60S	28.8
12	KRL384	519.0	15MR	1.6	20S	5.2	0	0.0	30S	8.8
13	KRL386	518.0	10S	3.1	10S	4.2	0	0.0	40S	7.5

Checks		
SN	**Name**	**Yield**
1	KRL19	459.6
2	KH65	459.2
3	KRL210	516.8
4	HD2009	430.8
5	HD2967	501.5

Promising Accessions for Yield Component in Wheat Germplasm Collections

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During 2015-16, five hundred eighty one indigenous and exotic accessions of wheat comprising 488 accessions of *T. aestivum*, 83 of accessions of *T. durum*, 8 of *T. dicoccum* and one accession each of *T. polonicum* and *T. sphaerococcum* were evaluated and characterized as per DUS testing guideline for 36 characters. The experiment was laid out in augmented design using three checks i.e. Kalyansona, WR 544 and Sonalika.
Each accession was raised in 3 rows of 2.50m length keeping row spacing of 30cm and plants were space planted. Data were recorded on 36 agro-morphological traits and 11 metric traits. In order to identify promising accessions, data on days to heading, days to maturity, plant height, spike length, number of spikelets/ spike, grain no. /spike, 1000 grains weight and yield per plot were used. A wide range of variation was observed for Days to heading (79-132 days), days to maturity (65-136 days), Plant height (65-136 cm), 1000 grains weight (16.43-58.61g), spike length (4.8-17.7 cm), spikelets/spike (14-26), grains per spike (14.4-73.6), grain weight/spike (g) (0.52-3.06) and protein (%) (7.77-14.58).

Days to heading and maturity: Eight accessions of bread wheat flowered in less than 85 days and matured in 130 days. These accessions were CYAN BROOK, E 11254, MEMO-1/ YAN#91/ SILVER-26, MACS 2083, VL 699, VL 867, AKW 770 and BHACHAV-15-5-1-2.

Plant height: Six accessions showed dwarfness and recorded plant height <70cm. These were DURANTI, COOK, LSW 110, CDWR 95101, JAP 46 and VL 504. Accessions namely PI 168486, PI 176202, PI 176203 (RED) (all aestivum) and MADSAUR LOCAL,PI 182114 (S 45), PI 214348 B, BAXI 188 recorded plant height more than 130cm.

Spike length: Six accessions had spike length more than or equal to 13 cm. These included five bread wheat accessions namely E 11017 (17.7 cm), PI 176198 (14.2 cm), PI 176201 (13.2 cm), PI 176202 (13.0 cm), PI 176328 (14.2 cm) and one polonicum accession CMH-76-1330/ TTURA / CMH-74A-370 (17.7 cm).

Spikelets/ spike: Four accessions namely PI 176351, PI 176352, FAWWON (9th)14 and DWR 87had spikelet per spike more than or equal to 24.

Grain number/ spike: Three accessions of bread wheat namely E 11020,PI 176198 and SAWYT (8th) 29 had more than 70 grains per spike.

Grain weight/ spike: Seven accessions of bread wheat (K 5352 (2.87g), EIGN I (97-98) 38(2.84g),PI 322082 (2.59g), EIGN I (99-2K) 15 (2.66 g), EGPYT (2nd) 20 (2.65g), SAWYT (8th) 46 (2.69 g), JAP 42 (2.70 g)) and two accessions of durum (BIJAPUR 422-2 (3.06g), DBPY 2002-4 (2.60 g) had more than 2.5g spike weight.

Thousand gr. wt.: Three accessions of bread wheat (MACS 2083 (55.03 g), PI 180959 (55.21g), K 7201 (58.61 g) and two accessions of durum (BIJAPUR RED (58.13 g), BHALEGAON 3 (55.28g) had 1000 grains weight more than 50g.

Protein: Grain protein was estimated a 10-11% grain moisture content using NMR. The protein content x (100- moisture content)/100 formula was used for calculation of per cent grain protein concentration calibrated. 11 accessions had more than 13% protein content. Some of the accessions having 1000 grains weight more than 40g and protein content more than 13% were CMH-76-1330 / TTURA / CMH-74A-370 (14.2%), PI 168486 (13.9%) and PI 214349 (13.2%).

The accession IC 212176 has only one tiller per plant while durum genotype Banda sharbati was having semi-hard texture and white coloured grains.

The analysis of data revealed significant variability for the trait (Table 1). The promising accessions for yield traits were also identified (Table 2).

Table 1: Variability in germplasm accessions

	Days to heading (50%)	Days to maturity	Plant height (cm)	1000 gr. wt. (g)	Spike length (cm)	Spikelets/ spike	Grains/ spike	Grain wt. /spike (g)	Protein (%)
Mean	93.6	136	107	9.48	38.33	18.6	44.1	1.68	10.44
Range	79-132	126-160	65-136	16.4-58.6	4.8-17.7	14-26	14.4-73.6	0.52-3.06	7.77-14.58
CV%	7.18	3.48	11.8	17.68	16.5	3.48	21.7	25.3	10.89

Table 2: Performance of promising accessions

SN	Genotype	*Sps.*	Days to heading	Days to maturity	Plant height (cm)	Spike length cm)	1000 gr. wt. (g)	Grain texture	Spikelets /spike	Grains/ spike	Grain wt. /spike (g)	Protein (%)
1	E 11020	*T.aes*	97	138	89.6	12.0	34.29	86	22	74	2.52	10.7
2	PI 176206-B	*T.aes*	96	140	127.0	11.7	42.88	71	20	59	2.53	10.3
3	PI 322082	*T.aes*	95	141	113.8	11.8	41.61	74	22	62	2.59	11.3
4	EIGN I (99-2K)15	*T.aes*	91	132	108.0	9.4	46.34	78	18	57	2.66	9.6
5	EIGN I (97-98) 38	*T.aes*	91	128	97.6	10.1	43.92	74	22	61	2.69	9.5
6	2nd EGPYT-20	*T.aes*	93	139	99.4	9.8	45.66	69	20	58	2.65	10.0
7	ISEPTON 162	*T.aes*	96	141	110.4	10.8	36.41	73	20	69	2.51	11.2
8	JAP 41	*T.aes*	89	133	127.6	9.0	47.43	68	20	54	2.58	11.0
9	JAP 42	*T.aes*	88	131	102.8	10.3	38.96	23	18	69	2.70	11.8
10	JAP 53	*T.aes*	93	135	120.2	8.6	45.71	72	18	56	2.56	9.9
11	K 5352	*T.aes*	90	135	126.4	8.6	49.08	54	18	58	2.87	9.0
13	DW 694	*T.aes*	87	133	103.0	10.8	47.91	62	20	53	2.52	10.2
12	BIJAPUR 422-2	*T.dur*	86	139	114.8	7.6	50.80	76	18	60	3.06	10.6
14	DBPY 03-4	*T.dur*	97	137	95.2	6.5	48.35	70	18	53	2.58	9.2
15	DBPY 2002-4	*T.dur*	92	137	86.4	7.0	53.20	80	16	49	2.60	10.6
16	DBPY 03-2	*T.dur*	93	133	94.4	6.5	48.25	81	18	53	2.54	10.0

New Germplasm from International Nurseries and Trials

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The Indian Institute of Wheat and Barley Research, Karnal obtain wheat germplasm from CIMMYT, Mexico in the form of international nurseries and trials in order to enrich the ongoing breeding programmes in our country. The various trials and nurseries were evaluated at various locations and spread across the country. It was provides an opportunity to the co-operators to select desirable lines for utilization in their breeding programmes. During the crop season 2015-16, set of four trials and six nurseries of bread wheat and two nurseries of durum wheat were received from CIMMYT, Mexico. The bread wheat comprising 1259 lines and 191 lines of durum wheat were evaluated at various wheat breeding centres. The details of the material received, replications and test sites for each nursery/trial are summarized and presented in Table- 1.

During 2015-16 CIMMYT yield trials namely Semi-Arid Wheat Yield Trial (SAWYT), Elite Spring Wheat Yield Trial (ESWYT), High Rainfall Wheat Yield Trial (HRWYT), High Temperature Wheat Yield Trial (HTWYT), and International Durum Yield Nursery (IDYN) were received and evaluated at various centres.

One set of each nursery/ trial was planted at IIWBR, Karnal in order to facilitate large number of wheat breeders/pathologist of the country for exercising *in-situ* selection as per their requirement. A Wheat Field Day was organized on March 27th, 2016 at Karnal, wherein wheat breeders/pathologist from various co-operating centres participated. Later on seeds of the selected material were provided to them. Apart from this, duly filled data booklets were received from most of the centres and these served as a feedback reports from centres. Based on yield *per se* under different agro-climatic conditions and yield contributing traits like early heading, maturity period, height, promising lines were identified for various zones as well as across the zones. The lines which recorded grain yield superiority over best check in various CIMMYT germplasm are presented in Table 2.

The data of various yield trials from different centres was compiled and on the basis of the yielding ability of various germplasm lines, the lines showing superiority over the check varieties were identified and the data is presented in Table 2.

The field screening for multiple diseases were also conducted. During the season, most of the entries were showing resistance/ moderate resistance to the rust and spot blotch. However, the lines which recorded resistant reaction to various diseases under field condition were also identified from some of the trials/ nurseries and are presented in Table-3. Promising lines identified from various trials/nurseries for yield *per se*, grain weight, early heading and possessing resistance to rust will be included in Elite International Germplasm Screening Nursery (EIGN) that would be constituted during the forthcoming wheat season for further evaluation and selection by the co-operators.

Table 1: International germplasm received from CIMMYT, Mexico, 2015-16

SN	Trial/Nursery	Entries #	Reps. #	Set #/ Data recd.	Co-operating centres
Bread Wheat					
1	23rd SAWYT	50	Two	17/20	Hisar, Jabalpur, Pantnagar, Powarkheda, Karnal, Bilaspur, Indore, Durgapura, Junagadh, Kanpur, Vijapur, Kota, Pune, Delhi, Dharwad, Varanasi, Ludhiana
2	36th ESWYT	50	Two	13/15	Hisar, Delhi, Indore, Karnal, Sabour, Ludhiana, Varanasi, Pune, Dharwad, Pantnagar, **Gurdaspur**,

SN	Trial/Nursery	Entries #	Reps. #	Set #/ Data recd.	Co-operating centres
					Wellington,Powerkheda
3	23rd HRWYT	50	Two	2/2	Karnal, Coochbehar
4	14th HTWYT	50	Two	18/20	Pune, Hisar, Indore, Pantnagar, **Akola**, Kanpur, Durgapura, Vijapur, Powarkheda, Junagarh, Jabalpur, **Niphad**, Ludhiana, Faizabad, Kota, Dharwad, Delhi, Varanasi, Karnal, Bhagalpur
5	48th IBWSN	300	One	17/18	Hisar, Ranchi, **Delhi**, Karnal, Pantnagar, Powarkheda, Malan, Jaipur, Pune, Faizabad, Kanpur, Vijapur, Niphad**,** Ludhiana, Dharwad Durgapura, Coochbihar, Varanasi
6	33rd SAWSN	285	One	12/14	Ranchi, Jabalpur, Karnal, Bilaspur, Powarkheda, **Delhi,** Durgapura, Junagarh, IARI (Pusa), Bhagalpur, Ludhiana, Hisar, **Niphad**, Sabour
7	10th STEMRRSN	208	One	4/7	Karnal (1+**1**), Ludhiana, Dharwad **Mahabaleshwar, Rahuri,Wellington**
8	26th HRWSN	117	One	2/2	Karnal, Shillongani
9	7th HLBSN	52	One	6/7	Karnal (1+**1**), Sabour, Faizabad, Shillongani, Coochbihar, Varansi
10	17th KBSN	97	One	2/3	Karnal, Ludhiana (1+**1**)
Durum wheat					
11	47th IDSN	145	One	13/14	Pune, Hisar, Jabalpur, Pantnagar, Powarkheda, Indore, Jaipur, Junagarh, Vijapur, **Niphad**, Karnal, Ludhiana, Dharwad, Durgapura
12	47th IDYN	46	Two	13/15	Hisar, Karnal, Pantnagar, Pune, Powarkheda, Indore, Kota, Jaipur, **Akola,** Vijapur, Niphad, Durgapura, Ludhiana, **Niphad**, Dharwad

Centre name with bold indicate that data was not received from these centres

Table 2: Promising lines identified for grain yield in various trial

Trial/ Nursery	Name of the zone/ location	Entry number	Checks used
Bread wheat			
23rd SAWYT	Across the zone (>44 q/ha)	306, 312, 315, 319, 323, 330, 337, 340,	
	NWPZ (>51 q/ha)	314, 318, 321, 323,324, 326, 327, 330, 331,332, 335, 336, 337, 340	HD3086, WH1105, HD2967, DBW88
	NEPZ (>41 q/ha)	304, 306, 310, 329, 311, 314, 315, 319, 323, 325, 326, 329, 340,343	HD2733, K1006
	CZ (>42 q/ha)	304, 306, 312, 313, 315, 318, 320, 322, 330	GW366, GW322, HI1544, MP1201,
	PZ (>42 q/ha)	337, 338, 340, 349, 350	MACS6478, UAS 304
36th ESWYT	Across the zone (>50 q/ha)	104, 106, 107, 112, 115, 117, 118, 121, 128, 131, 133, 136, 142, 144, 182	
	NWPZ (>60 q/ha)	106, 113, 114, 116, 118, 135, 137, 149	HD3086, WH1105, DBW88
	CZ (>50 q/ha)	109, 124, 128, 130, 133, 139, 140, 144, 145, 146, 147, 148,149	HI1544, UAS304, MACS6222, MP1201
	PZ (>50 q/ha)	103, 106, 107, 112, 115, 117, 118, 121, 128, 131, 133, 136, 142, 144	MACS6222, UAS304
14th HTWYT	Across the zone (>44 q/ha)	7, 25, 39, 40	
	NWPZ (>46 q/ha)	7, 10, 13, 18, 21, 25, 26, 28,	HD2967, HD3086,

		32, 33, 35, 36, 39, 40, 42, 46	WH1105, GW366, RAJ4238,HD3059, PBW590,
	NEPZ (>43 q/ha)	8, 10, 11, 21, 25, 27, 34	K1006, HD2733, HD2895, HUW234
	CZ (>55 q/ha)	3, 9, 13, 16, 25, 26, 31, 47	GW366, MP1201, GW322, HI8498, HD2932
	PZ (>53 q/ha)	3, 6, 7, 9, 11, 20, 25, 29, 30, 39, 40	UAS304, MACS 6222, MACS6478, NIAW34
23rd HRWYT	NWPZ (>60q/ha)	205, 206, 207, 218, 223, 225,226, 240, 242, 248	HD2967
Durum Wheat			
47th IDYN	Across the zone (>41 q/ha)	701,705, 706, 717,719,721, 736, 726	
	NWPZ (>41 q/ha)	701,707, 705, 706, 707,717, 719, 721, 745	PDW 291, PDW 314, WHD948, RAJ6560,
	CZ (>50 q/ha)	707, 712, 719,722,726, 729, 734, 736	HI8498, MPO 1215
	PZ (>40 q/ha)	717, 726, 741	MACS3125, UAS 415, NIDW295

Table 3: Lines showing resistance to rusts and leaf blight

Trial / Nursery	Disease	Entry number
Bread Wheat		
23rd SAWYT	Yellow rust (free)	302, 305, 308, 314, 316, 328, 331, 338, 340, 341, 344, 346, 348, 350
	Black rust (free)	321, 322, 324, 326, 327, 328, 335, 337
14th HTWYT	Black rust (free)	18, 19, 21, 32
36th ESWYT	Yellow rust (free)	102, 104, 107, 110, 117, 119, 120, 121, 122, 123, 126, 127, 131, 137, 140, 149, 150
7th HLBSN	Leaf blight (<24)	4, 9, 25, 26, 37
10th STEMRRSN	Stem rust (TR- 10MS)	Majority of the entries had tR type reaction
Durum Wheat		
47th IDYN	Yellow rust (free)	725, 726, 736
47th IDSN	Yellow rust (free)	7024, 7036, 7046, 7052, 7067, 7070, 7074, 7077, 7078, 7085, 7109, 7127, 7147, 7151, 7154, 7156, 7169, 7172, 7175, 7190, 7191
	Brown rust (free)	7110, 7127, 7133, 7150, 7151, 7155, 7157, 7158, 7174, 7175, 7188, 7194, 7212

The promising lines that exhibited numerically higher or at par disease score over the checks used for grain weight were identified for various zones as well as for across the zones of the country (Table- 4).

Table 4: Promising lines identified for 1000-gr. wt.

Nursery name	Zone/location	Entry number
Bread Wheat		
23rd SAWYT	Across the zone (>40g)	317, 318, 321, 324, 325, 326, 337, 338
	NWPZ (>43g)	315, 317, 318, 321, 326, 335, 337, 338
	NEPZ (>40g)	317, 318, 324, 326, 338
	CZ (>42g)	315, 317, 321, 324, 325, 326, 335, 337
	PZ (>42g)	309, 315, 316, 318, 321, 323, 324, 325, 326, 327, 335, 337
36th ESWYT	Across the zone (>40g)	109, 110, 117, 125, 133, 150

	NWPZ (>40g)	109, 110, 113, 116, 117, 119,123, 125, 133, 138, 141, 149, 150
	CZ (>40g)	109, 110, 124, 130, 138, 141, 147
	PZ (>42g)	105, 106, 107, 108, 109, 110, 111, 112, 120, 125, 129, 130, 147
14th HTWYT	Across the zone (>40g)	7, 21, 27, 28, 36
	NWPZ (>40g)	7, 18, 19, 21, 27, 28, 32, 34, 36, 39, 40, 42, 48
	NEPZ (> 40g)	9, 10, 11, 25, 32, 34, 36
	CZ (>43g)	7, 8, 13, 21, 25, 27, 28, 34, 36, 40, 47
	PZ (>41g)	7, 17, 21, 34, 40
23rd HRWYT	Across the centres (>40g)	205, 206, 230, 239, 240, 248
48th IBWSN	Across the zone (>42g)	1029, 1059, 1089, 1090, 1091, 1115, 1116
	NWPZ (>42g)	1028, 1086, 1090, 1091, 1095, 1105, 1107, 1108, 1115, 1116, 1148, 1153, 1205, 1226, 1255, 1258, 1265
	NEPZ (>41g)	1028, 1034, 1048, 1115, 1116, 1123, 1161, 1230, 1249
	CZ (>43g)	1029, 1059, 1089, 1090, 1091, 1273, 1278, 1289
	PZ (>44g)	1029, 1055, 1066, 1089, 1091, 1098, 1115, 1152, 1198, 1225, 1291, 1296
33rd SAWSN	Across the zone (>40g)	3027, 3050, 3051, 3092, 3106, 3116, 3152, 3191, 3205, 3216, 3241, 3268
	NWPZ (>45g)	3087, 3092, 3093, 3099, 3106, 3151, 3279, 3281, 3282
	NEPZ (>42g)	3009, 3060, 3199, 3200, 3205, 3220, 3226, 3241, 3260, 3282
	CZ (>43g)	3002, 3024, 3027, 3050, 3051, 3080, 3091, 3092, 3111, 3116, 3140, 3149, 3191, 3193, 3209, 3210, 3212, 3216, 3218, 3233, 3268
26th HRWSN	Across the zone (>40g)	2006, 2042, 2056
	NWPZ (>41g)	2006, 2042, 2064, 2056
	NEPZ (>45g)	2009, 2017, 2030, 2044, 2058, 2070
10th STEMRRSN	NWPZ (>41g)	6002, 6038, 6041, 6142, 6152, 6155, 6159, 6160, 6173, 6178
7th HLBSN	Across the zone (>39g)	23, 35
	NWPZ (>40g)	2, 3, 8, 13, 14, 15, 23, 35, 45
	NEPZ (>39g)	22, 23, 35
17th KBSN	NWPZ (>40g)	38, 49, 50, 73
Durum Wheat		
47th IDYN	Across the zone (>40g)	737, 734, 707, 744
	NWPZ (>40g)	706, 709, 743, 744, 745
	CZ (>41g)	720, 734, 737, 708, 709, 729, 743, 720, 730, 728, 744
	PZ (>40g)	707, 722, 730
47th IDSN	Across the zone (>44g)	7055, 7070, 7113, 7089, 7082
	NWPZ (>44g)	7055, 7071, 7076, 7080, 7083, 7085, 7088, 7089, 7093, 7095, 7113, 7138
	CZ (>42g)	7055, 7069, 7070, 7079, 7081, 7085, 7089
	PZ (>44g)	7003, 7040, 7047, 7050, 7062, 7069, 7070, 7080, 7082, 7088, 7089, 7093, 7102, 7106, 7111, 7114

National Durum Screening Nursery

BS Tyagi, Arun Gupta, Charan Singh, Vineet Kumar, RK Gupta and Vinod Tiwari

The second National Durum Screening Nursery (NDSN) comprising 91 lines including 53 lines selected from various international durum nurseries, 11 lines from YCSN (2014), 16 lines from YCSN (2015), 7 disease resistance lines contributed by PI (Crop Protection) and 4 from NGSN. These lines along with three checks (HI 8498, PDW 291 and PDW 233) were shared with 13 centres of the NWPZ, PZ and CZ. The NDSN was evaluated in augmented design with two rows plot of 2.5m length with released varieties as checks. The nursery was planted at 13 locations and data were received from all the 13 centres. Genotypes showing promise for early maturity, number of tillers per plant, 1000-grains weight, spike length and grains per spike were identified and the superior entries zone wise and across the zones are presented in Table-1.

Table 1: Trait-wise promising entries from NDSN

Zones	Entry	Checks
Days to maturity		
Across the zone	GW 2015-676, GW-2011-361, GW 2014-565, AKDW 4905, GW 2015-678, GW 2015-679	
NWPZ (<131 days)	46th IDSN 7034, GW 2015-673, GW 2015-681, GW 2015-690	PDW 233
CZ (<115 days)	GW 2015-674, GW 2015-676, GW 2015-679	HI8498
PZ (<111 days)	46th IDYN 742, 46th IDSN-7173, AKDW 4905, GW-2011-361	HI 8498
No. of tillers/ m		
Across the zone	46th IDSN 7175, 46th IDSN 7214, 46th IDSN 7177	
NWPZ (>127)	46th IDSN 7035, 46th IDSN 7040, 46th IDSN-7175, 46th IDSN 7176, 46th IDSN 7177, 46th IDSN 7214	PDW 291
CZ (>103)	46th IDSN-7175, 46th IDSN 7179, GW-2011-361, NIDW 1038	PDW 291
PZ (>116)	46th IDSN 7117, 46th IDSN 7150, 46th IDSN 7214	PDW 233
1000 gr. wt. (g)		
Across the zone	GW 2014-558, GW 2014-550, GW 2015-674, GW 2015-683, GW 2015-673, GW 2015-687, GW 2015-675, GW 2015-677, GW 2015-684, GW 2015-682, GW 2015-676	
NWPZ (>56g)	GW 2014-558, GW 2015-673, GW 2015-683	HI8498
CZ (>54g)	GW 2014-558, GW 2015-677, GW 2015-687, GW 2015-673, GW 2015-674, GW 2015-676, GW 2015-687	HI8498
PZ (>47g)	46th IDSN 7219, GW 2014-550, GW 2014-558, GW 2015-674, GW 2015-678, GW 2015-682, GW 2012-436	HI 8498
Spike length (cm)		
Across the zone	GW 2015-690, GW 2014-558, GW 2015-682, GW 2012-436, GW 2015-675, GW 2015-674	
NWPZ (>9.1)	46th IDSN 7176, GW 2014-558, GW 2015-673, GW 2015-674, GW 2015-675, GW 2015-682, GW 2015-690, GW-2011-36, GW 2012-436	HI8498
CZ (>9.4)	GW 2014-558, GW 2015-675, GW 2015-682, GW 2015-688, GW 2015-690, GW-2011-361, GW 2012-436	PDW 233
PZ (>8.0)	GW 2014-550, GW 2015-690, GW-2011-361	PDW 233
Grains per spike		
Across the zone	46th IDYN 723, 46th IDYN 716, 46th IDSN 7013, 46th IDSN 7035, 46th IDSN-7175	
NWPZ (>66)	46th IDSN 7034, 46th IDSN 7035, 46th IDSN 7104, 46th IDSN-7175, 46th IDSN 7176, 46th IDSN 7177, 46th IDSN 7190	HI 8498
CZ (>63)	46th IDYN 716, 46th IDSN 7013, 46th IDSN 7035, 46th IDSN 7091, 46th IDSN 7127, 46th IDSN-7155	PDW 233
PZ (>51)	46th IDYN 716, 46th IDYN 723, 46th IDYN 725, 46th IDSN 7013, 46th IDSN 7081, 46th IDSN 7117, 46th IDSN 7176, 46th IDSN 7186, 46th IDSN 7214	HI 8498

Across the zone, genotype like GW 2015-676, GW-2011-361, GW 2014-565, AKDW 4905, GW 2015-678, GW 2015-679 earlier than check HI 8498. Lines 46th IDSN-7175, 46th IDSN 7214, 46th IDSN 7177 showed tillers/metre at par with check PDW 291. Some lines namely GW 2014-558, GW 2014-550, GW 2015-674, GW 2015-683, GW 2015-673, GW 2015-687, GW 2015-675, GW 2015-677, GW 2015-684, GW 2015-682, GW 2015-676 and HI 8742 recorded thousand grains weight more than 50g, which were more than best check HI 8498. Lines GW 2015-690, GW 2014-558, GW 2015-682, GW 2012-436, GW 2015-675, GW 2015-674 had spike length more than 8.7cm, whereas lines 46th IDYN 723, 46th IDYN 716, 46th IDSN 7013, 46th IDSN 7035 and 46th IDSN-7175 had grains per spike more than or equal to 60 (Table -2). Regarding yield *per se*, the highest yield per plot (590g) was recorded in lines 46th IDSN 7040 followed by 46th IDYN 723 (528g), 46th IDSN-7175 (522g), 46th IDSN-7173 (515g), 46th IDYN 749 (511g) and HI 8725 (504g). Line 46th IDSN 7040 performed well in both NWPZ and PZ.

Response of lines against black rust, brown rust and yellow rust was also recorded under field conditions. Disease reaction to black rust was recorded at Indore and Vijapur, whereas yellow rust data was recorded at Ludhiana and Hisar centres. The promising genotypes showing resistances under field condition in these locations are listed in Table-3.

Table 2: Promising lines for grain yield in various zones

Entry number in nursery	Original entry numbers	Range	Mean
Across the zone			
21	46th IDSN 7040	360-1300	590
06	46th IDYN 723	190-830.5	528
40	46th IDSN-7175	120-1000	522
38	46th IDSN-7173	185-1250	515
14	46th IDYN 749	220-875	511
66	HI 8725	138-900	504
80a	HI8498	140-930	520
NWPZ			
21	46th IDSN 7040	590-1300	799
14	46th IDYN 749	612-875	793
38	46th IDSN-7173	478-1250	781
08	46th IDYN 726	560-1300	772
10	46th IDYN 739	552-1170	769
40	46th IDSN-7175	540-1000	768
20a	HI8498	681-820	745
CZ			
69	HI 8742	444-736	583
88	GW-2011-361	330-870	562
64	AKDW 4905	350-780	549
50	46th IDSN 7202	350-623	504
71	NIDW 706	420-570	500
85b	PDW 291	340-651	535
PZ			
06	46th IDYN 723	190-831	524
21	46th IDSN 7040	360-667	506
01	46th IDYN 706	394-562	455
16	46th IDSN 7013	270-618	454
11	46th IDYN 742	182-594	413
52	46th IDSN 7217	328-547	410
50a	HI8498	130-630	358

Table 3: Lines showing resistance to diseases in NDSN

Disease	Entry number
Black rust (tMR to 5MS)	46th IDSN 7179, 46th IDSN 7180, 46th IDSN 7188, GW 2014-566, GW 2014-568, HI 8770, HI 8774, GW 2015-675, GW 2015-683, GW 2015-684, GW 2015-690
Yellow rust (tR)	46th IDYN 706, 46th IDYN 723, 46th IDYN 725, 46th IDYN 726, 46th IDYN 736, 46th IDYN 739, 46th IDYN 742, 46th IDYN 748, 46th IDYN 749, 46th IDSN 7012, 46th IDSN 7031, 46th IDSN 7034, 46th IDSN 7035, 46th IDSN 7081, 46th IDSN 7091, 46th IDSN 7116, 46th IDSN 7117, 46th IDSN 7121, 46th IDSN 7151, 46th IDSN-7155, 46th IDSN-7173, 46th IDSN-7174, 46th IDSN-7175, 46th IDSN 7186, 46th IDSN 7188, 46th IDSN 7214, 46th IDSN 7217, GW 2014-550, GW 2014-558, GW 2014-568, HI 8774, HI 8724, HI 8728, HI 8738, GW 2015-673, GW 2015-674, GW 2015-675, GW 2015-676, GW 2015-678 , GW 2015-679, GW 2015-681, GW 2015-682, GW 2015-684, GW 2015-687, GW 2015-690

The feedback reports of NDSN indicate that the nursery is very useful and the wheat researchers across the country are getting desired material and making selections very generously. Majority of centres selected lines for their crossing programme for yield contributing traits. Many lines were selected by scientists for yield *per se* and are being tested directly in trials. Superior lines for 1000-grain weight, tillering capacity and other important yield component traits are also being selected by the breeders. A total of 148 lines were selected by the different centres viz Pune made maximum number of selections followed by Powarkheda, Vijapur and Niphad (Table-4).

Table 4: Centre- wise selection made from NDSN

Centre	Selections #	Traits selected/Utilization
Akola	12	Yield characters
Pune	26	Hybridization, grains/spike, Yield
Hisar	12	Grain Yield, 1000grains weight, tillers/m
Junagarh	15	Earliness, grain yield, spikes/grain
Vijapur	20	Hybridization, genetic resource
Indore	10	Hybridization,
Powerkheda	23	Hybridization
Dharwad	11	Hybridization
Niphad	19	Hybridization, selection,
Total	148	

All the lines of these EIGN 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 at the institute (Table-5).

Table 5: Promising genotypes for processing and nutritional quality parameters

Parameters	Mean	Range	Value	Genotypes
Test wt. (kg/hl)	82.2	71.8-83.7	>83.5	46th IDYN 723, PDW 291, PDW 233, 46th IDSN 7193, 7202, HI 8498, 46th IDSN 7219, GW 2014-566, HI 8773, HI 8774, HI 8725.
Protein content (%)	10.76	8.26-15.87	>13.0	46th IDYN 736, GW 2015-673, 675, 681, 682, 683, 684
Sedimentation value (ml)	38.0	20-48	>45	46th IDYN 706, 710, 46th IDSN 7044, 7176, 7177, 7190, HI 8773, HI 8725
Grain hardness Index	77	53-100	~90	46th IDSN 7013, 46th IDSN 7081, 46th IDSN 7116, 46th IDSN 7127, 46th IDSN-7174, 46th IDSN 7176, 46th IDSN 7188, GW 2014-565, 568
Iron (ppm)	36.0	30.6-46.5	>42.0	46th IDYN 726, 736, GW 2015-673, 674, 683, 684
Zinc (ppm)	35.4	28.3-44.9	>41.0	PDW 233, PDW 291, 46th IDSN 7188, GW 2014-565, HI 8739, GW 2015-673, 674, 675, 682, 684

Quality Component Screening Nursery

R.K. Gupta and D. Mohan

The nursery was conducted at 12 places and 51 test entries were evaluated and compared with three checks to identify new genetic resource for quality improvement. Grain quality analysis was done at Karnal and the parameters involved were grain protein content at 14% grain moisture level, test weight (hectolitre weight), sedimentation volume, grain appearance score and grain hardness index (Table 1). It was successfully conducted at all locations but the field expression was poor at Kanpur. Therefore, Kanpur data was not considered for grain yield and protein yields.

Table 1: Overall quality characteristics at test sites

Locations	Test wt. (kg/hl)	Protein (%)	Protein yield (g/m^2)	Sedimen. value (ml)	Hardness Index	Gr. appearance (score)
Almora	74.2	13.3	49.6	47	56	5.7
New Delhi	79.1	13.7	45.8	47	61	6.3
Karnal	81.0	12.1	57.1	47	59	6.3
Ludhiana	80.4	11.1	40.4	47	56	6.2
Durgapura	74.5	14.5	53.3	47	54	5.6
Pantnagar	80.1	12.0	63.7	46	65	6.4
Kanpur	79.1	12.4	--	47	57	6.1
Pusa	74.7	13.8	36.4	48	59	5.4
Vijapur	79.1	13.2	34.5	46	58	6.6
Junagarh	80.2	14.5	50.2	46	59	6.6
Pune	79.7	13.0	29.6	47	58	6.4
Dharwad	80.0	13.9	40.3	48	63	6.1

Genetic superiority: Statistical analysisrevealed highly significant genotypic differences ($P < 0.001$) in all the traits. To identify promising genotypes, comparison was made against recently identified genetic resources and checks. Genotypes showing superiority for individual quality components are listed in Table 2, whereas overall performance of all test entries is given in Table 3. Detailed information about field conduct of QCSN and quality characteristics of individual test entry is given in the Progress Report of Wheat Quality 2015-16, Vol. IV.

Table 2: Promising genotypes for individual quality trait

Component	Range	Genotypes
Protein content (%)	14.0-14.9	BWL 1664, BWL 1660, BWL 991, GW 2014-596, QLD 46, QLD 11, QLD 78, UAS 462(d)
Protein yield (g/m^2)	50-54	QLD 70, HD 3126, QBP 12-9, QLD 85, QLD 73, QLD 67, QLD 71, HD 3125
Sedimentation value(ml)	59-61	HD 3215, QLD 89,HD 3216, GW 2014-615, UP 2927
Grain hardness index	77-80	PDW 233(d), DBPQ 02(d), GW 2013-503(d), QLD 79, GW 2014-593(d),
	19-25	QLD 84, QLD 49, QLD 67, QBP 12-8, QLD 54, QBP 12-9, QLD 73, QLD 80
Test weight (kg/ml)	81-82	GW 2014-586(d), GW 2014-602(d), GW 2014-593(d), DBPQ 02(d), GW 2013-503(d), QLD 70, GW 2012-454(d)
Grain appearance score out of 10	6.6-6.9	GW 2014-602(d), GW 2013-503(d), GW 2014-586(D), GW 2014-603(d), DBPQ 02(d), QLD 46

Table 3: Overall performance of the test entries

SN	Genotypes	HD (days)	HT (cm)	Yield (g/m^2)	TW (kg/hl)	GHI	SV (ml)	GAS	GPC (%)	PTY (g/m^2)
1	BW-5872 (I)	81	94	390	76.7	71	56	5.9	12.5	49.4
2	QBP-12-8	83	108	392	76.4	21	56	5.8	12.3	48.3
3	QLD-11 (I)	88	96	311	79.5	60	42	5.8	14.1	43.8
4	QLD-46	82	116	312	79.5	48	49	6.6	14.5	45.2

5	QLD-49 (I)	77	96	360	77.8	21	49	5.6	13.7	48.3
6	QLD-54 (I)	74	91	354	77.3	23	38	5.6	13.7	47.8
7	QLD-67	77	93	395	78.5	21	44	5.9	13.4	52.0
8	QBP-12-9 (I)	85	92	432	79.0	23	40	5.7	12.3	53.1
9	QLD-70	86	94	418	80.6	63	54	6.2	13.0	53.8
10	QLD-71	85	91	387	80.3	60	57	6.2	13.3	51.4
11	QLD-73	86	96	400	78.1	23	40	5.7	12.9	52.3
12	QLD-76	86	97	392	78.8	71	57	6.0	12.3	48.5
13	QLD-78	86	95	338	79.8	57	57	6.2	14.0	46.7
14	BWL-991	79	113	315	79.3	56	55	6.4	14.5	45.7
15	BWL-1660	74	106	289	79.7	57	58	6.4	14.7	42.5
16	BWL-1664	75	106	286	78.3	58	57	6.4	14.9	42.2
17	HD 3210	79	94	371	78.3	67	57	6.2	13.4	49.1
18	PHS-708	87	92	307	77.6	64	56	5.8	13.2	39.1
19	GW-2013-498 (D)	83	82	279	79.5	66	30	6.5	13.9	38.8
20	GW-2013-500 (D)	81	87	369	79.1	73	25	6.6	13.8	49.5
21	GW-2013-503 (D)	82	86	360	80.8	77	28	6.9	13.1	47.1
22	DBPQ-02 (D)	88	81	351	81.0	79	33	6.6	13.2	45.9
23	GW-2012-442 (D)	83	82	290	80.2	72	29	6.6	13.9	40.2
24	GW-2012-454 (D)	85	78	280	80.6	75	34	6.3	13.5	37.5
25	UAS 462 (D)	81	106	231	73.9	75	40	5.7	14.1	32.0
26	UAS 463 (D)	82	114	284	72.6	66	37	5.8	13.9	39.0
27	HS 490	83	100	315	74.1	27	44	5.5	12.4	38.4
28	GW 2014-586 (D)	83	86	331	82.0	74	28	6.9	12.9	42.1
29	GW 2014-593 (D)	84	85	332	81.3	77	32	6.7	12.8	42.8
30	GW 2014-602 (D)	82	85	371	81.4	75	30	6.9	13.0	48.3
31	GW 2014-603 (D)	76	79	353	80.2	67	38	6.8	13.5	47.1
32	GW 2014-617 (D)	80	83	307	77.9	73	39	6.5	12.9	39.2
33	UP 2927	80	97	351	77.6	70	59	6.1	13.4	47.2
34	PHS 2014-03	73	112	318	76.3	63	45	6.4	12.6	40.2
35	AKAW 4225 (D)	82	88	349	79.8	76	41	6.5	13.2	45.1
36	GW 2014-568	78	83	277	77.8	61	45	6.4	13.9	38.2
37	GW 2014-596	76	97	297	78.8	61	48	6.3	14.1	41.9
38	GW 2014-615	76	89	370	78.3	70	59	6.2	11.9	43.5
39	HD 3215	82	95	402	77.6	71	61	6.2	12.6	49.7
40	HD 3216	80	97	426	77.5	61	59	6.0	12.7	53.3
41	QLD 79	83	91	382	79.4	77	41	6.3	12.7	48.6
42	QLD 80	90	94	384	76.1	25	58	5.7	13.0	49.4
43	QLD 81	85	98	320	73.7	64	50	5.9	12.5	40.4
44	QLD 82	85	94	398	79.4	26	54	5.6	12.0	47.1
45	QLD 83	85	89	412	78.0	29	49	5.4	12.0	49.2
46	QLD 84	85	89	378	76.4	19	58	5.7	13.2	49.2
47	QLD 85	87	89	415	78.8	71	54	5.9	12.9	52.8
48	QLD 86	92	91	321	77.7	74	55	5.8	12.4	38.8
49	QLD 87	86	92	354	78.4	62	43	5.9	12.7	45.5
50	QLD 88	84	90	396	78.3	73	48	5.9	12.4	49.1
51	QLD 89	83	104	405	79.8	74	59	6.2	12.2	48.7
52	HI 977 (C)	80	92	350	78.2	67	53	6.0	12.5	43.5
53	UP 2672 (C)	80	90	326	78.8	63	57	6.1	13.7	44.5
54	PDW 233(C,D)	89	88	365	80.0	80	40	6.4	12.6	46.1
Overall mean		82	94	375	78.5	60	47	6.1	13.1	49.3
CD (P 0.05)		3	6	63	1.6	5	2	0.3	0.7	8.3
CV (%)		5.07	8.12	21.7	2.48	10.9	6.51	5.23	6.87	21.8

Disease incidence: Rust reactions were reported from seven test sites. Virulence to yellow rust was recorded at Almora, Pantnagar, Ludhiana and Karnal and the entries found susceptible (highest score ≥40S) were QLD 49, UAS 462(d), GW 2014-568(d), GW 2014-596(d), GW 2014-615(d), QLD 80, QLD 84, QLD 87, QLD 88, UP 2672(c) and HI 977(c). Data on brown rust incidence was received from Karnal, Dharwad, Ludhiana, Vijapur and Pune. Entries found susceptible with highest reactions ≥40S were QLD 46, QLD 49, GW 2014-568(d), QLD 81, UP 2672 (c) and HI 977 (c). Black rust was reported from Vijapur only and the entries with score ≥40S were BW 5872, QLD 71, GW 2014-615(d), QLD 81, QLD 82, QLD 84 and HI 977(c).

Utilization: The material tested in QCSN was utilized at nine locations namely Almora, Pantnagar, Ludhiana, Karnal, Durgapura, Vijapur, Junagarh, Dharwad and Pune. 40 entries of this nursery were either retained as genetic resource or recycled in the breeding programme by one or more centres. Most preferred genotypes in the nursery were the QLD entries viz. QLD 70, 71, 80, 82, 83, 84, 85 and 89. Besides QLD numbers, QBP 12-9 and BW 5872 were also preferred by the breeders.

New genetic stocks: New superior genetic resources for quality traits could not be identified during the year 2015-16. Three were three durum lines in the knocking i.e., GW 2012-442, GW 2012-454 and BDPQ 2 but when their three years performance was compared with the durum check PDW 233 and the recently identified genetic resource KLM 1005; there was no additional advantage. In bread wheat, one soft grain entry QLD 67 completed three years of testing. Since two soft grain genotypes were identified during previous year and there are few more in the pipeline, it was thought to identify the new soft types next year.

Evaluation and Utilization of Elite International Germplasm Nurseries

Arun Gupta, Charan Singh, Gyanendra Singh, BS Tyagi, Vinod Tiwari and RK Gupta

The elite international germplasm nursery (EIGN) is constituted every year and shared with cooperating centres with the objective to provide exotic germplasm for utilization in on-going breeding programme. The lines included in EIGN are selected based on superior yield performance and resistance to diseasesduring previous year's evaluation conducted at various locations across the country. EIGN comprised, exotic germplasm received from CIMMYT, Mexico and ICARDA, Syria in the form of International nurseries and trials. A total of 1722 exotic germplasm including 1097 bread wheat lines from CIMMYT and 635 lines from ICARDA were planted and evaluated at various locations in India during 2014-15. TheEIGN was constituted and supplied to 24 centres located across the zones. While selecting materialfor this nursery, it was ensured that material should be diverse, high yielding and disease resistant, so that these can cater to the needs of wheat researcher across the country.

The EIGN consistingof 94 genotypes and four checks (DBW88, K1006, HI1544, and UAS 304) was shared with 24 centres. The genotypes were evaluated in augmented design with two rows plot of 2.5m length with recently released varieties of each zone (NWPZ, NEPZ, CZ and PZ) were used as checks. All the genotypes were also analyzed 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 content at the institute.Data was received from all the locationsexcept Gwalior and the pooled data were analysed to find out the promising genotypes for each trait.

Across the zone, it was found that the entry like 15^{TH} ESBWYT 13 and 13^{th} HTWYT 712 (Table 1) came to heading earlier and at par with check HI 1544 (72 days). The entry number 35^{th} ESWYT 124, 22^{nd} SAWYT 314, 22^{nd}HRWYT 202, 32^{ND} SAWSN 3161, 25^{th} HRWSN 2036, 22^{nd} SAWYT 340, 13^{th} HTWYT 706 and 47^{th} IBWSN 1295showed comparatively higher thousand grains weight (>42g/1000 grains) as compared to the best check variety HI 1544 (41g).

Table 1: Trait-wise promising entries from EIGN 2015-16

Zone	Entry	Check
Days to heading (days)		
Across the zone	15^{TH} ESBWYT 13, 13^{th} HTWYT 712	
NHZ (<105)	15^{TH} ESBWYT 13,13^{th} HTWYT 704,13^{th} HTWYT 712,13^{th} HTWYT 721	DBW 88
NWPZ (<88)	15^{th} SBWON 1, 15^{TH} ESBWYT 13, 13^{th} HTWYT 704,13^{th} HTWYT 711,13^{th} HTWYT 712,13^{th} HTWYT 714,13^{th} HTWYT 716,13^{th} HTWYT 717,13^{th} HTWYT 721,13^{th} HTWYT 737,13^{th} HTWYT 738,22^{nd} SAWYT 314,22^{nd} SAWYT 340	DBW 88
NEPZ (<74)	15^{th} DSBWYT 23,15^{TH} ESBWYT 13,13^{th} HTWYT 704,13^{th} HTWYT 712,13^{th} HTWYT 714,13^{th} HTWYT 721,13^{th} HTWYT 737,13^{th} HTWYT 738,13^{th} HTWYT 747	K1006
CZ (<59)	15^{TH} ESBWYT 13,13^{th} HTWYT 721,13^{th} HTWYT 738,13^{th} HTWYT 747	UAS 304
PZ (<54)	15^{th} SBWON 1,15^{th} SBWON 5,15^{th} SBWON 6, 15^{th} DSBWYT 23,15^{TH} ESBWYT 13,13^{th} HTWYT 712,13^{th} HTWYT 721,13^{th} HTWYT 738	HI 1544
Plant height (cm)		
Across the zone	15^{th} DSBWYT 23, 15^{th} SBWON 6, 13^{th} HTWYT 714, 15^{th} SBWON 1	
NHZ (82<cm)	15^{th} DSBWYT 23,13^{th} HTWYT 717,22^{nd} SAWYT 309,32^{ND} SAWSN 3003	DBW 88
NWPZ (94<cm)	47^{th} IBWSN 1146,47^{th} IBWSN 1182,9^{th} STEMRRSN 164,32^{ND} SAWSN 3003	DBW 88

NEPZ (84<cm)	22nd HRWYT 238,15th SBWON 1,15th SBWON 26,15th DSBWYT 23,13th HTWYT 714,13th HTWYT 716	K1006
CZ (<82cm)	15th SBWON 6,15th DSBWYT 23,15TH ESBWYT 13,13th HTWYT 714,13th HTWYT 737	UAS 304
PZ (69<cm)	15th SBWON 1,15th SBWON 5,15th SBWON 6,15th DSBWYT 21,15th DSBWYT 23	HI 1544
Thousand gr. wt. (g)		
Across the zone	35th ESWYT 124, 22nd SAWYT 314, 22nd HRWYT 202, 32ND SAWSN 3161, 25th HRWSN 2036, 22nd SAWYT 340, 13th HTWYT 706, 47th IBWSN 1295	
NHZ (>49g)	47th IBWSN 1215,47th IBWSN 1295,25th HRWSN 2036,35th ESWYT 148,13th HTWYT 706,22nd SAWYT 320	DBW 88
NWPZ (>44g)	47th IBWSN 1297,25th HRWSN 2001,35th ESWYT 124,22nd SAWYT 323,22nd SAWYT 340,32ND SAWSN 3171	DBW 88
NEPZ (>38g)	22nd HRWYT 241,47th IBWSN 1295,25th HRWSN 2001,35th ESWYT 124,13th HTWYT 721,22nd SAWYT 314,22nd SAWYT 340	K1006
CZ (>46g)	35th ESWYT 124,13th HTWYT 712,22nd SAWYT 314,32ND SAWSN 3161,32ND SAWSN 3171	UAS 304
PZ (>44g)	25th HRWSN 2036,13th HTWYT 706,22nd SAWYT 314,22nd SAWYT 323,22nd SAWYT 350,32ND SAWSN 3161,32ND SAWSN 3171	HI 1544

Regarding yield *per se,* the highest yield per plot (586g) was recorded in entry number 74 followed by 83 (554g), 53 (553g) and 54 (538g). The entry number 74 performed well in all the zones except NHZ, whereas, entry number 33 performed well in NEPZ, PZ and CZ. The entry number 83 performed well in NHZ, NWPZ and NEPZ, while entry number 53 performed well in NHZ, NWPZ and PZ (Table-2).

Table 2: Promising entries for grain yield in various zones

Entry number in Nursery	Original entry numbers	Range	Mean (g)
Across the zone			
74	22nd SAWYT 314	116-1295	586
83	22nd SAWYT 334	250-892	554
53	13th HTWYT 706	218-1375	553
54	13th HTWYT 707	218-1025	538
45	35th ESWYT 124	136-985	535
68	13th HTWYT 745	150-910	535
01	22nd HRWYT 202	131-925	532
33	9th STEMRRSN164	156-859	529
25c	HI 1544 (C)	124-1019	506
NHZ (Almora, Malan)			
60	13th HTWYT 717	360-930	645
56	13th HTWYT 711	260-955	608
83	22nd SAWYT 334	330-835	583
12	47th IBWSN 1112	230-925	578
54	13th HTWYT 707	300-840	570
14	47th IBWSN 1182	280-855	568
53	13th HTWYT 706	280-845	563
21	47th IBWSN 1295	330-785	558
68	13th HTWYT 745	150-910	530
33a	DBW 88 (C)	280-780	530
NWPZ (Pantnagar, Durgapura, Hisar, Karnal, Jammu)			
74	22nd SAWYT 314	400-1295	801
60	13th HTWYT 717	300-1295	777
80	22nd SAWYT 327	420-1090	749
83	22nd SAWYT 334	340-892	701

53	13th HTWYT 706	300-1375	692
06	22ndHRWYT 238	280-815	650
75	22nd SAWYT 315	410-845	650
82a	DBW 88 (C)	440-973	689
NEPZ (Coochbehar, Pusa, Sabour, Faizabad, Shillongani, Ranchi, Kanpur)			
68	13th HTWYT 745	250-800	511
01	22ndHRWYT 202	260-700	510
74	22nd SAWYT 314	220-840	487
77	22nd SAWYT 320	160-800	485
83	22nd SAWYT 334	250-700	482
29	25th HRWSN 2105	265-680	476
45	35th ESWYT 124	165-850	466
64	13th HTWYT 734	200-760	466
73	22nd SAWYT 312	212-660	465
67	13th HTWYT 739	270-650	462
33	9th STEMRRSN164	265-640	460
52	13th HTWYT 704	260-625	456
94d	UAS 304 (C)	265-650	453
CZ (Junagadh, Vijapur, Bilaspur, Jabalpur, Powarkheda, Sanosora)			
01	22ndHRWYT 202	325-925	594
33	9th STEMRRSN 164	156-844	570
74	22nd SAWYT 314	116-878	576
75	22nd SAWYT 315	133-905	574
77	22nd SAWYT 320	310-757	587
93	32ND SAWSN 3171	410-710	580
25c	HI 1544 (C)	375-1019	657
PZ (Niphad, Dharwad, Pune)			
53	13th HTWYT 706	248-904	655
82	22nd SAWYT 333	522-680	601
86	22nd SAWYT 350	514-656	589
80	22nd SAWYT 327	492-740	587
54	13th HTWYT 707	218-913	564
84	22nd SAWYT 335	436-645	564
68	13th HTWYT 745	388-719	562
85	22nd SAWYT 340	490-609	547
33	9th STEMRRSN164	212-719	546
73	22nd SAWYT 312	268-740	546
74	22nd SAWYT 314	346-704	541
94d	**UAS 304 (C)**	406-562	490

Response of lines against yellow rust, black rust, brown rust and leaf blight was also recorded under field conditions. Disease reactions to black rust wererecorded at Vijapur, whereas yellow rust was recorded at Almora, Malan,Hisar, Jammu and Karnal. Leaf blight data from Faizabad, Sabour, Pusaand Coochbehar, whereas brown rust data from Dharwad, Pune and Vijapur was considered for identification of resistant sources. The promising genotypes showing resistances under field condition across the locations are listed in Table 3.

Table 3: Lines showing resistance to diseases in EIGN

Disease	**Entry number**
Yellow rust (tR/tMS)	47th IBWSN 1089, 47th IBWSN 1112, 22nd SAWYT 320, 22nd SAWYT 334, 32ND SAWSN 3011, 32ND SAWSN 3189
Brown rust (0)	22ndHRWYT 241, 47th IBWSN 1215, 47th IBWSN 1222, 47th IBWSN 1290, 25th HRWSN 2017, 25th HRWSN 2024, 25th HRWSN 2104, 25th HRWSN 2105, 9th STEMRRSN 41, 15th SBWON 1, 15th SBWON 6, 15th SBWON 39, 35th ESWYT 132, 35th ESWYT 139, 13th HTWYT 709, 13th HTWYT 716, 13th HTWYT 721, 22nd SAWYT 311, 22nd SAWYT 315, 22nd SAWYT 316, 32ND SAWSN 3011, 32ND SAWSN 3023, 32ND SAWSN 3161

Black rust (tS/tMS/tMR)	47th IBWSN 1182, 47th IBWSN 1185, 47th IBWSN 1215, 25th HRWSN 2126, 15th SBWON 1, 15th SBWON 5, 15th SBWON 6, 15th SBWON 26, 15th SBWON 39, 15th DSBWYT 21, 15th DSBWYT 23, 35th ESWYT 113, 35th ESWYT 139, 15TH ESBWYT 13, 13th HTWYT 714, 22nd SAWYT 315, 22nd SAWYT 331, 22nd SAWYT 340, 32ND SAWSN 3088
Leaf blight (<34)	25th HRWSN 2104, 25th HRWSN 2105, 15th SBWON 1, 15th SBWON 5, 35th ESWYT 139, 22nd SAWYT 315, 32ND SAWSN 3023

The feedback report of EIGN indicates that breeders across the country selected the genotypes from this nursery for various purposes. A total of 320 selections were made by the cooperating centres during 2015-16 (Table-4).

Table 4: Centre-wise selections made from EIGN

Centre	Selections #	Traits selected
Almora	22	Direct introduction
Junagarh	10	Earliness, tillers/m, spike length
Vijapur	9	Hybridization, germplasm enrichment
Faizabad	18	Hybridization, germplasm enrichment, direct introduction
Sabour	26	1000-grains wt., yield attributing traits
Malan	12	1000-grains weight, agronomic base
Durgapura	6	Hybridization
Bilaspur	31	Yield, 1000-grains weight
Pantnagar	30	Hybridization
Jabalpur	15	Hybridization
Powarkheda	21	Hybridization, further selection
Shillongani	8	Hybridization
Sanosora	4	Hybridization
Niphad	41	Hybridization, further evaluation
Hisar	17	Hybridization, further selection
Pune	22	Earliness, yield
Dharwad	22	Hybridization
Karnal	6	Further selection
Total	**320**	

During the year (2015-16), 109 lines including checks of EIGN were grown at IIWBR Research Farm, Karnal. All the lines 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. Range of variation and promising genotypes identified in EIGN for processing and nutritional quality is given in Table 5.

Table 5: Promising EIGN genotypes for processing and nutritional quality parameters

Parameters	Mean	Range	Value	Genotypes
Test wt. (kg/hl)	80.5	77.0-83.6	>83.0	22nd HRWYT 214, 231, 238, 250, 13th HTWYT 734, 22nd SAWYT 320, 32nd SAWSN 3189.
Protein Content (%)	11.17	9.18-14.13	>13.0	9th STEMRRSN 41, 164, 35th ESWYT 113, 32nd SAWSN 3161.
Sedimen. value (ml)	52	30-63	~60	22nd HRWYT 238, 239, 47th IBWSN 1089, 1182, 9th STEMRRSN 164, 15th SBWON 39, 22nd SAWYT 311, 315, 327, 331
Grain Hardness Index	62	18-81	>75	9th STEMRRSN104,15th SBWON 39, 35th ESWYT 143, 13th HTWYT 733, 22nd SAWYT 327, 32nd SAWSN 3088
			<45	22nd HRWYT 202, 47th IBWSN 1295, 25th HRWSN 2001,2126, 35th ESWYT 132, 13th HTWYT 719, 22nd SAWYT 309, 350.
Iron(ppm)	36.5	30.4-43.3	>42.0	35th ESWYT 113, 32nd SAWSN 3011.
Zinc(ppm)	34.5	26.7-43.0	>41.0	22nd HRWYT 241, 9th STEMRRSN 41

Table 6: Evaluation of Processing & Nutritional Quality Parameters of National Wheat Nurseries (EIGN) for year 2015-16

SN	Entry	Processing Quality					Nutritional Quality	
		Test wt.(kghl)	Protein (%)	Moisture (%)	Sed. Value (ml)	Grain Hardn-ess	Iron (ppm)	Zinc (ppm)
1	22nd HRWYT 202	81.8	11.87	9.03	44	30	40.2	35.1
2	22nd HRWYT 209	82.3	9.86	8.57	58	56	33.5	31.7
3	22nd HRWYT 214	82.6	10.55	9.06	57	61	36.0	30.7
4	22nd HRWYT 222	81.3	10.02	8.88	55	59	32.3	31.4
5	22nd HRWYT 231	83.0	11.43	8.87	43	54	34.0	35.2
6	22nd HRWYT 238	82.7	10.65	8.40	59	65	30.6	29.4
7	22nd HRWYT 239	80.0	12.04	8.79	63	65	39.7	33.6
7A	**DBW88 (C)**	82.5	11.65	10.50	56	68	37.9	30.7
8	22nd HRWYT 241	80.6	11.95	9.48	52	57	37.7	42.2
9	22nd HRWYT 250	83.4	11.49	8.66	55	50	40.7	32.8
10	47th IBWSN 1027	80.5	11.13	8.96	56	68	35.4	33.4
11	47th IBWSN 1089	78.4	11.49	8.74	59	68	36.3	36.3
12	47th IBWSN 1112	80.6	11.53	8.98	43	55	40.5	39.5
13	47th IBWSN 1146	79.0	11.31	8.98	50	67	32.8	32.6
14	47th IBWSN 1182	80.6	10.37	8.85	60	46	35.2	28.4
14B	**K1006 (C)**	82.2	9.85	9.09	35	75	36.8	33.0
15	47th IBWSN 1185	80.6	10.15	9.31	42	61	35.0	30.9
16	47th IBWSN 1215	81.8	10.08	8.76	42	60	38.3	33.5
17	47th IBWSN 1222	80.1	10.64	8.79	55	56	34.8	29.7
18	47th IBWSN 1223	78.3	10.42	8.82	51	58	32.1	34.4
18C	**HI 1544 (C)**	78.1	11.45	9.20	45	75	38.8	38.7
19	47th IBWSN 1219	81.6	10.24	8.75	53	66	32.0	30.3
19D	**UAS 304 (C)**	81.3	10.78	8.86	45	74	38.8	35.1
20	47th IBWSN 1290	82.5	11.48	8.89	58	54	39.2	37.7
21	47th IBWSN 1295	80.8	11.83	9.03	50	32	40.0	35.0
22	47th IBWSN 1297	81.2	9.88	9.16	44	47	34.0	32.8
22B	**K1006 (C)**	81.4	10.35	9.25	35	78	43.3	35.8
23	25th HRWSN 2001	81.6	11.50	8.84	43	44	38.9	35.6
24	25th HRWSN 2010	80.8	10.87	8.86	48	47	36.6	31.9
25	25th HRWSN 2017	81.4	10.93	9.13	53	67	34.7	35.2
25C	**HI 1544 (C)**	78.4	11.23	9.17	46	79	40.2	34.9
26	25th HRWSN 2024	80.0	12.12	8.58	53	59	40.0	33.4
27	25th HRWSN 2036	81.6	10.67	8.92	45	62	35.8	39.5
28	25th HRWSN 2104	81.0	10.71	8.89	50	62	31.6	34.0
28D	**UAS 304 (C)**	77.6	12.29	9.30	45	76	42.6	34.4
29	25th HRWSN 2105	81.3	11.05	8.88	53	59	35.3	29.7
30	25th HRWSN 2126	78.4	11.68	8.45	43	38	35.6	35.5
31	9th STEMRRSN 41	77.1	14.13	9.15	50	74	40.1	43.0
32	9th STEMRRSN 104	80.0	12.49	8.89	55	76	40.1	34.4
33	9th STEMRRSN 164	77.5	13.13	9.08	61	73	36.4	32.3
33A	**DBW88 (C)**	80.3	12.48	9.25	59	70	36.9	33.5
34	15th SBWON 1	78.3	11.50	8.80	49	70	37.1	35.8
35	15th SBWON 5	77.5	11.33	8.64	47	69	39.0	33.6
36	15th SBWON 6	78.0	11.18	8.93	47	60	36.9	26.7
37	15th SBWON 26	79.7	10.96	9.01	53	73	36.3	30.3
38	15th SBWON 39	82.0	11.10	9.22	59	81	32.7	34.6
39	15th SBWON 117	-	-	-	-	-	-	-
40	15th DSBWYT 21	78.5	11.44	8.63	45	67	34.8	34.3
41	15th DSBWYT 22	79.7	11.32	8.81	54	64	37.7	37.4
42	15th DSBWYT 23	77.0	12.10	8.89	47	71	39.2	29.7
43	35th ESWYT 113	79.4	13.58	8.87	55	66	43.0	35.8

SN	Entry	Processing Quality					Nutritional Quality	
		Test wt.(kghl)	Protein (%)	Moisture (%)	Sed. Value (ml)	Grain Hardn-ess	Iron (ppm)	Zinc (ppm)
43C	**HI 1544 (C)**	78.4	12.31	8.98	50	71	37.3	34.4
44	35th ESWYT 123	81.6	11.47	8.96	50	63	38.7	38.7
45	35th ESWYT 124	77.8	12.46	8.80	58	64	38.9	31.6
46	35th ESWYT 131	79.0	11.44	8.98	53	71	34.6	32.5
46D	**UAS 304 (C)**	81.5	11.05	9.00	40	62	35.6	35.9
47	35th ESWYT 132	80.3	9.44	8.69	55	44	31.8	30.7
48	35th ESWYT 139	82.4	10.00	8.85	53	54	31.1	30.1
49	35th ESWYT 143	81.5	10.61	9.36	55	78	35.8	33.1
49B	**K1006 (C)**	81.6	10.71	9.11	36	74	40.6	39.3
50	35th ESWYT 148	81.7	10.67	9.23	55	54	36.0	33.7
51	15th ESWYT 13	78.4	11.08	9.86	46	67	31.6	31.6
52	13th HTWYT 704	79.5	11.60	8.84	56	57	34.6	35.0
53	13th HTWYT 706	79.4	11.90	9.32	53	55	41.8	34.2
53A	**DBW88 (C)**	78.4	13.43	9.44	55	70	37.6	30.9
54	13th HTWYT 707	78.6	11.59	9.63	51	68	38.4	34.2
55	13th HTWYT 709	82.0	11.60	9.39	58	65	37.5	38.9
56	13th HTWYT 711	80.9	10.19	8.96	58	51	34.6	36.7
57	13th HTWYT 712	81.8	9.18	8.60	54	51	30.5	32.2
58	13th HTWYT 714	80.0	10.05	8.80	30	65	32.6	34.5
59	13th HTWYT 716	82.3	10.78	8.91	55	56	39.7	38.0
60	13th HTWYT 717	81.0	10.44	9.11	48	68	35.1	37.6
61	13th HTWYT 719	80.3	12.16	8.70	48	18	34.6	34.8
62	13th HTWYT 721	79.7	11.86	9.00	58	58	38.8	34.9
63	13th HTWYT 733	80.6	11.50	8.99	56	78	33.1	37.5
63B	**K1006 (C)**	79.2	12.03	9.17	35	77	42.5	40.5
64	13th HTWYT 734	82.7	9.96	8.84	56	66	34.4	32.6
65	13th HTWYT 737	81.0	10.60	10.06	53	61	32.3	33.2
66	13th HTWYT 738	81.6	10.97	8.66	58	59	36.4	31.7
67	13th HTWYT 739	80.5	10.53	8.91	55	53	33.2	38.1
67D	**UAS 304 (C)**	80.0	12.08	9.22	44	58	37.8	39.8
68	13th HTWYT 745	79.4	12.32	9.13	45	64	37.9	37.4
69	13th HTWYT 747	82.4	10.95	8.61	55	63	34.5	34.8
70	22nd SAWYT 302	80.3	10.86	9.34	56	72	36.9	33.0
71	22nd SAWYT 309	78.7	10.75	8.80	53	40	37.1	36.6
71A	**DBW88 (C)**	81.0	11.47	9.58	54	74	36.7	42.2
72	22nd SAWYT 311	82.0	11.43	9.14	59	56	34.3	39.7
73	22nd SAWYT 312	78.5	10.98	8.88	54	55	33.8	31.9
74	22nd SAWYT 314	81.5	10.10	9.11	54	51	33.9	34.9
75	22nd SAWYT 315	81.4	10.07	9.12	59	56	33.9	34.4
75C	**HI 1544 (C)**	82.0	9.74	9.00	47	76	34.7	32.1
76	22nd SAWYT 316	81.7	10.92	9.16	55	68	38.6	37.9
77	22nd SAWYT 320	83.6	9.47	8.87	52	64	34.8	35.0
78	22nd SAWYT 321	81.8	10.62	9.56	56	61	37.7	34.4
79	22nd SAWYT 323	81.3	11.86	8.94	58	56	35.4	33.1
80	22nd SAWYT 327	80.2	11.79	8.88	60	79	36.2	30.9
81	22nd SAWYT 331	80.2	11.52	9.43	59	73	30.4	32.5
82	22nd SAWYT 333	82.4	10.24	8.68	52	54	36.2	32.0
82A	**DBW88 (C)**	83.2	10.89	9.26	59	66	34.9	30.8
83	22nd SAWYT 334	81.3	10.78	9.00	55	52	35.5	34.5
84	22nd SAWYT 335	81.8	10.32	8.79	56	71	33.4	35.1
84B	**K1006 (C)**	82.5	9.99	9.31	36	69	36.6	41.2
85	22nd SAWYT 340	81.4	10.16	8.74	58	53	35.4	33.8
86	22nd SAWYT 350	81.7	10.04	8.29	54	35	33.5	33.4
87	32ndSAWSN 3003	80.0	9.85	8.52	51	53	32.1	30.8
88	32nd SAWSN 3011	79.5	11.51	8.90	56	58	42.4	31.2

SN	Entry	Processing Quality					Nutritional Quality	
		Test wt.(kghl)	Protein (%)	Moisture (%)	Sed. Value (ml)	Grain Hardn-ess	Iron (ppm)	Zinc (ppm)
89	32nd SAWSN 3021	79.5	12.62	9.23	58	66	39.5	38.7
90	32ndSAWSN 3023	77.6	12.66	8.88	49	72	40.9	35.1
90C	**HI 1544 (C)**	79.4	12.92	9.18	58	59	41.1	35.1
91	32ndSAWSN 3088	81.0	12.88	6.69	55	78	39.1	34.0
92	32nd SAWSN 3161	77.4	13.31	9.37	54	70	37.8	36.1
93	32nd SAWSN 3171	81.8	10.23	8.82	50	61	35.3	31.9
94	32ndSAWSN 3189	82.7	10.11	8.63	50	68	36.9	39.5
94D	**UAS 304 (C)**	81.5	10.42	8.79	43	60	38.8	41.2
	Mean	80.5	11.17	8.98	52	62	36.5	34.5
	Minimum	77.0	9.18	6.69	30	18	30.4	26.7
	Maximum	83.6	14.13	10.50	63	81	43.3	43.0

PART B

EFFORTS IN CREATING NEW GENETIC VARIABILITY

Spring x Winter Wheat Hybridization

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The winter wheats possess huge variability for traits of economic importance along with resistance/tolerance against various biotic and abiotic stresses. Utilizing the variability present in winter wheat gene pool for enhancing the productivity of spring wheat along with resistance to various biotic and abiotic stresses is a novel approach. During the crop season 2015-16 the material generated in the programme was provided to six centres in four major wheat growing zones (NHZ, 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 were CSKHPKV Malan, GBPUA&T-Pantnagar, NDUAT-Faizabad, BAU-Sabour, JNKV-ZARC-Powarkheda and SDAU- Vijapur

Sharing of segregating material

The Spring x Winter wheat Segregating Stock Nursery (SWSSN) comprising 41 crosses from F_2 generation was shared with six cooperating centres, namely CSKHPKV Malan, GBPUA&T-Pantnagar, NDUAT-Faizabad, BAU-Sabour, JNKV-ZARC-Powarkheda and SDAU- Vijapur. The segregating material was subjected to natural biotic and abiotic stresses at different centres located in major wheat zones. There was occurrence of yellow rust and powdery mildew and early season moisture stress at Malan, terminal heat at Pantnagar; leaf blight and sodicity at Faizabad; leaf blight and late heat at Sabour; early heat at Vijapur; early heat, stem rust and leaf rust at Powarkheda

The utilization report from cooperating centres showed that the percent utilization of the spring x winter crosses varied from 27% (Faizabad) to 100% (Malan). The maximum number of 949 single plants was selected at Malan followed by Powarkheda (170) and Shimla (150) as shown in Table-1.

Table 1: Utilization report from cooperating centres

Name of the centre	Crosses Selected #	Utilization %	Plants selected	Characteristics for which utilized
CSKHPKV, Malan	41	100	949	Resistance to yellow rust and powdery mildew and yield components
GBPUAT, Pantnagar	22	54	41	Yield components and disease resistance
NDUAT-Faizabad	11	27	66	Yield components, disease resistance, morphological and seed characteristics
BAU-Sabour	28	68	58	Yield components, leaf blight resistance and seed characteristics.
JNKV-ZARC-Powarkheda	17	42	170	Yield components, Disease resistance morphological traits and seed characteristics
SDAU-Vijapur	19	37	46	Yield components, disease resistance and morphological traits

The majority selections across the cooperating centres were done in the crosses with pedigreeES85-19/V-763-254/3/RSK/NAC//CTK/VEE/HS1507,BRAEWOOD/HS507,6043/4*NAC//PASTOR/3/BABAX/VL907,BU/PVN//MILAN/3/TX96V2427/DBW60,VL404/JO7-47//YR10/5*DATALINE,KS98/HW220.5.1(ARLIN/YUMA)/KS01HW162(TGO/BTYSIB)/VL2005.The utilization of SWSSN at the cooperating centres was very encouraging and it reflected the usefulness of winter wheats in spring wheat improvement.

Promising cross-combinations

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, 449 F_2 crosses, and families in filial generations numbering 1193 F_3, 139 F_4, 79 F_5, 20 F_6, 35 F_7 and 17 F_8 families were evaluated in field and plants were selected on the basis of maturity, plant type, rust resistance (yellow and brown) and grain characteristics. Some of the promising cross-combinations in advance generations along with their characteristics and rust reactions are given in Table-2 and promising lines having high yield and desirable plant type with rust resistance are being tested in IIWBR Station Trial as presented in Table-3. In this year 100 F_2 crosses were planted at Seed and Research Farm Hisar and desirable plants were selected. During the crop season about 4867 breeding lines have been shown at IIWBR-RS, Dalang Maidan for generation advancement and recording the disease reaction.

Table2: Promising cross-combinations in F_6/F_7 generations

SN	Cross Combination	Characteristics
1	F81.513/Milan-2//HW3067	High tillering, medium late maturity, long spikes, resistant to leaf rust and stripe rust
2	EC479379/K0711	High tillering, dwarf plant type, medium maturity and bold grains with good grain appearance, resistant to stripe rust
3	EC609395/PBW639	High tillering, medium late maturity and longer spikes with good grain appearance resistant to leaf rust and stripe rust
4	EC609399/WH1125	High tillering, strong stem and bold grains, resistant to stripe rust
5	EC609395/PBW550	High tillering, early medium maturity and longer spikes
6	EC609410/PBW 658	High tillering, medium maturity with good grain appearance
7	EC609403/PBW639	High tillering, medium late maturity and longer spikes with good grain appearance

Table 3: Promising cross-combinations in yield trials (IIWBR Station Trial)

SN	Cross Combination	Characteristics
1	WR1206/F81.513//Milan-1/3/PBW509	Resistance to stem rust (ACI=0.6) and leaf rust south (ACI= 9.6), early, bold grains (44g)
2	UP2556//ID13.1/MLT/3/ESWYT70	Resistance to leaf rust (ACI=0.0) and yellow rust (ACI= 0.6) and high tillering
3	F81.513/Milan-2//HW3067	Resistance to leaf rust (ACI=2.0), yellow rust (ACI=5.0), early maturing and high thousand grains weight (52g)
4	EC429377/DBW16	High tillering, early maturing and resistance to leaf rust (ACI=0.1)

Performance of entries in Nation Trials

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 Salinity/Alkalinity trial. The comparative performance of the entries in different NIVTs with best check is presented in Table 4.

Table 4: Performance of entries in NIVTs

Entry	Yield (q/ha) and rank	
	NWPZ	NEPZ
DBW160 (NIVT-1A)	51.9 (9)	45.1 (15)
	Best check: WH1105 = 51.6 (7)	K0307= 46.3 (5)
DBW166 (NIVT-1B)	55.4 (1)	46.3 (33)
	Best check: WH 1105 = 51.07(10)	HD 2733 = 47.1 (9)
	CZ	**PZ**
DBW 180 NIVT-5A-RF	42.1 (1)	22.6 (8)
	Best check: MP3288 = 40.1 (5)	NI 5439 = 22.0 (10)
DBW 180 NIVT-5A-RI	42.2 (3)	26.8 (25)
	Best check: MP 3288 = 41.7 (4)	MP3288 = 30.5 (6)

Entries under test in National trial

During 2015-16 season, eleven entries from the project were contributed to national trials, viz., DBW 188 and DBW 190 in NIVT-1A, DBW 196 and DBW 197 in NIVT-1B, DBW 200 and DBW 201 in NIVT-2, DBW 204 in NIVT-3A and DBW 211 in NIVT-5A and DBW 214, DBW 215 and DBW 216 in Salinity/Alkalinity trial for multi-location evaluation.

New spring x winter wheat crosses

During the 2015-16 season, 65 winter wheats were planted on 23rd Oct., 2015 under natural photoperiod condition so as to synchronize with the spring wheat lines (planted in January 2016) during late March and first week of April for making hybridizations. A total of 445 spring x winter wheat crosses were made during the crop season at Karnal which included 351 three-way crosses and 94 single crosses. At VPKAS Almora a total of 93 crosses were successfully attempted during rabi2015-16.

Segregating Stock Nursery

Ravish Chatrath, Vikas Gupta, Satish Kumar and OP Tuteja

The 19th Segregating Stock Nursery (SSN) was constituted with the objective to share promising segregating material with upcoming wheat breeding centres of AICW&BIP to enable them to evaluate and select superior plants as per the breeding objectives and cultural conditions prevailing under agro-climatic conditions. The nursery consisted of 83 segregating populations (F_2/F_3) that including material from rice-wheat programme (30), warmer area programme (25), leaf blight programme (18) and durum wheat programme (10) of IIWBR, Karnal. The nursery was supplied to 18 wheat breeding centres namely Jammu, Coochbehar, Faizabad, Ranchi, Sabour Shillongani, Bilaspur, Gwalior, Sanosora, Sagar, Udaipur, Kota, Jabalpur, Dhaulakuan, Malan, Khudwani, Parbhani, and Akola,. Data and utilization report from three centres namely Khudwani, Ranchi and Kota was not received. The utilization report indicated that the nursery could achieve 47.2% utilization across the centres (Table 1). The maximum utilization was observed for the material developed under leaf blight programme (53.7%), followed by Rice-Wheat programme (51.3%), warmer area programme (44.2%), and durum programme (30.6%)

Table 1: Utilization pattern of segregating populations in 19th SSN

Programme	Segregating Populations	Frequency of Utilization	Utilization %	Plants Selected
Rice-Wheat	30	231	51.3	2119 (43.6%)
Warmer area	25	166	44.3	1280 (26.3%)
Leaf Blight	18	145	53.7	1106 (22.8%)
Durum	10	46	30.7	345 (7.1%)
Total	**83**	**588**	**47.2**	**4850**

Almost all the segregating populations were utilized by one or the other centre and total of 4850plants were selected. The report indicated that maximum number of plants was selected from rice-wheat (2119) followed by warmer area (1280), Leaf Blight (1106) and durum wheat (345) programmes.During the selection of segregating plants or populations, the co-operators have given maximum emphasis to yield components (588) followed by morphological traits (288), disease resistance (276), seed traits (225) and physiological parameters (132).The details are given in Table 2.

Table 2: Selection of segregating populations in 19th SSN

Programme	Frequency of Utilization				
	Yield Components	Disease Resistance	Morphological Traits	Physiological Traits	Seed Traits
Rice-Wheat	231 (28.09%)	110 (25.9%)	110 (22.38%)	51 (26.22%)	82 (31.33%)
Warmer area	166 (35.51%)	77 (35%)	85 (33.83%)	39 (42.62%)	63 (39.05%)
Leaf Blight	145 (32.15%)	62 (35.45%)	65 (37.31%)	30 (27.86%)	54 (24.46%)
Durum	46 (4.24%)	27 (3.63%)	28 (6.46%)	12 (3.27%)	26 (5.15%)
Total	**588**	**276**	**288**	**132**	**225**

The centre wise utilization pattern of segregating populations (Table 3) indicated that the Sabour centre has utilized maximum number of segregating populations followed by Sanosora,, Parbhani, Dhaulakuan, Malan, Bilaspur, Jabalpur, Udaipur, Coochbehar, Sagar, Gwalior, Shillongoni, Jammu, Faizabad and Akola. The upcoming and voluntary centres under AICW&BIP network showed a good response towards this nursery that indicated its importance in strengthening the breeding programme at these centres. The maximum selections were made by Jabalpur, Parbhani, Malan, Sagar, Coochbehar, Sabour, Bilaspur, Sanosora, Dhaulakuan, Jammu, Udaipur, Faizabad, Gwalior, Shillongoni and Akola centres. (Table3). Main traits for selecting the lines were different yield components, disease resistance, morphology, physiological traits and seed traits.

Table 3: Centre-wise utilization of segregating stocks in 19th SSN

SN	Centre	Segregating Stocks Utilized	Plants Selected	F_2 Utilization (%)	Programme wise utilization			
					Rice-Wheat	Warmer Area	Leaf Blight	Durum
1	Sabour	73	336	87.95	28	21	16	8
2	Sanosora	72	185	86.74	28	22	16	6
3	Parbhani	66	800	79.51	25	21	14	6
4	Dhaulakuan	52	17	62.65	20	18	14	0
5	Malan	51	792	61.44	24	9	13	5
6	Bilaspur	40	248	48.19	19	11	7	3
7	Jabalpur	40	1000	48.19	19	13	7	1
8	Udaipur	40	129	48.19	9	11	14	6
9	Coochbehar	38	350	45.78	18	7	13	0
10	Sagar	29	492	34.93	10	7	9	3
11	Gwalior	26	60	31.32	10	7	6	3
12	Shillongoni	24	44	28.91	4	8	7	5
13	Jammu	23	138	27.71	12	6	5	0
14	Faizabad	11	82	13.25	4	3	4	0
15	Akola	3	24	3.61	1	2	0	0
Total		**588**	**4850**	**47.22**	**231**	**166**	**145**	**46**

Diversification of Wheat Germplasm for Biotic and Abiotic Stress Tolerance and Enriching Cooperating Centres

BS Tyagi, Sindhu Sareen, Gyanendra Singh, Arun Gupta and MS Saharan

Pre-breeding is an alternative term used for 'genetic enhancement', and in recent times it has become an essential, planned part of all plant breeding activities. Pre-breeding refers to the transfer or introgression of gene or gene combinations from non-adapted sources into breeding materials. Present day varieties constitute a narrow genetic base in the context of the wide spectrum germplasm available. Use of wild spp., hexaploid synthetics, adapted cultivar, exotic germplasm and land races of crop are required for making a beginning of a pre-breeding programme. Fortunately wheat family provides untapped reservoir of genetic variation for biotic as well as abiotic traits. In this regard sources with unknown genes have been crossed with promising and agronomic base genotypes to introgress the desired traits. Accessions of 20 wild species including *T. boeoticum, 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 the chlorophyll fluorescence and chlorophyll content in ninety six accessions of wild species were analysed which will be the indicator of photosynthetic rate and its input use efficiency.

Chlorophyll fluorescence and content in ninety six accessions of wild species

- Accessions of *Aegilops juvenelis, Ae.squarosa, Ae. columnaris, Ae. urartu, Ae. compactum, Ae. ovata, Ae. carthlicum, Ae. longissima, Ae. spelta, Ae. triuncialis, Ae. triasistata, Ae. peregrina*and *Ae. polonicum*had high fluorescence value at heading.
- Accessions of *Aegilops ventricose, Ae. triuncialis, Ae. sphaerococcum, Ae. carthlicum, Ae. polinicum*and *Ae. ovata*had high chlorophyll content index at heading.
- Accessions of *Aegilops squarrosa, Ae. vavilovii, Ae. sphaerococcum, Ae. umbellulate, Ae. juvenelis, Ae. peregrine, Ae. carthlicum, Ae. timopheevii, Ae. dicoccoides, Ae. ventricose, Ae. geniculata*and *Triticum dicoccum* had 4.0 to 6.0^{0}C cooler canopy

Evaluation of synthetic wheats for heat tolerance

Thirty synthetic wheat lines were evaluated for drought tolerance under field during the crop season 2015-16. Earlier during 2013-14 and 2014-15, seventy-eight synthetic lines were evaluated for heat tolerance and thirty synthetic lines were selected. Based on heat susceptibility index for 1000 grain weight, seventeen of these were found to be tolerant to heat stress and thirteen as heat susceptible. Field sowing was done under timely irrigated and timely rain-fed conditions. The temperature and rainfall data was recorded throughout crop season. The mean maximum and minimum temperatures were slightly lower under irrigated conditions. The post heading average maximum and minimum temperatures under irrigated field conditions were higher by 2.9^{o}C and 2.2^{o}C than the temperatures under rain-fed field conditions. Both the conditions experienced similar rainfall of about 132.0mm rainfall in 4 days; 95.0 mm in one single day. The irrigated fields were irrigated as per package of practice, whereas under rain-fed conditions, only pre-sowing irrigation was given. .

Agronomical, morphological and physiological parameters were used for screening. The susceptibility index for all traits was calculated to identify the tolerant and susceptible lines. Accordingly, synthetic lines SYN 164, SYN 225, SYN 199, SYN 284, SYN 278, SYN 283, SYN 285 and SYN 267 were tolerant for grain filling duration; SYN 214, SYN 304, SYN 302, SYN 249, SYN273, SYN 260, SYN 271 and SYN 259 for grain number/ spike; SYN 193, SYN287, SYN 249, SYN 306, SYN 225, SYN 164, SYN 257, SYN 259, SYN 203, SYN 280, SYN 199 and SYN 169 for 1000 grain weight and SYN 214, SYN 304, SYN 302, SYN 273, SYN 260, SYN 271, SYN 262, SYN 245, SYN 249 and SYN 284 for grain weight/spike (Table). Similarly, synthetic lines SYN 292 , SYN 302, SYN 251, SYN 273 and SYN 203 were susceptible for grain filling duration, SYN 279, SYN 287, SYN 306, SYN 270 and SYN 164 for grain weight/spike, SYN 270, SYN 251, SYN 164, SYN 285 and SYN 278 for grain number/spike and SYN 267, SYN 251, SYN 262, SYN 285 and SYN 284 for 1000 grain weight.

Table 1: Tolerant and susceptible synthetic wheat lines identified for various traits

Trait	Tolerant lines	Susceptible lines
GFD	SYN 164, SYN 225, DHTW 60(c), HTW 11(C)	SYN 292, SYN 302, SYN 251, SYN 273, SYN 203
GWS	SYN 214, SYN 304, SYN 302, SYN 273, HTW 11(C)	SYN 279, SYN 287, SYN 306, SYN 270, SYN 164
GNS	SYN 214, SYN 304, SYN 302, HTW 11(C)	SYN 270, SYN 251, SYN 164, SYN 285, SYN 278
TGW	SYN 193, SYN 287, SYN 249, SYN 306, SYN 225, SYN 164, SYN 257, DHTW 60 (C), SYN 259, HTW 11 (C)	SYN 267, SYN 251, SYN 262, SYN 285, SYN 284
GFR	SYN 164, SYN 193, SYN 225, SYN 306, DHTW 60 (C), HTW 11(C)	SYN 285, SYN 302, SYN 203, SYN 251, SYN 273
CHL	HTW 11 (C), SYN 260, SYN 169, SYN 193, SYN 284, SYN 245, DHTW 60 (C)	SYN 257,SYN 302
CFL	SYN 259, SYN 306, DHTW 60 (C)	SYN 280, SYN 260, SYN 203, SYN 270, SYN 283

GFD= Grain filling duration, GWS=Grain weight/spike, GNS=Grain number/spike, TGW=1000 grain weight, GFR=Grain filling rate, CHL=Chlorophyll content, CFL=Chlorophyll fluorescence

Synthetic line 249 was tolerant for all traits under rain-fed conditions while SYN 270 was susceptible for all traits. Similarly synthetic line 259 was tolerant for all traits except productive tillers and line 251 was susceptible. SYN 169 was also tolerant except grain weight/spike and lines 164 and 199 were susceptible for grain weight and grain number/spike. Drought susceptible index for various traits is given in Table 1.

Table 2: Drought susceptible index for various traits in synthetic lines

Synthetic ID	HSITGW*	TGW	GFD	GWS	GNS	GFR	PTL
SYN 193	4.36	-3.4	0.4	3.3	1.4	-2.1	1.0
SYN 287	-4.13	-3.3	1.9	3.6	1.1	0.2	1.1
SYN 249	-0.21	-2.8	0.7	-0.5	-1.7	-0.6	0.8
SYN 306	-0.36	-1.9	0.7	3.8	1.8	-1.4	1.2
SYN 225	2.02	-1.6	-1.7	3.5	1.6	-1.5	0.9
SYN 164	-1.19	-1.3	-3.5	5.9	3.6	-2.3	0.5
SYN 257	-0.23	-1.3	1.0	3.4	1.6	0.2	0.8
SYN 259	-0.60	-0.9	0.7	0.7	0.1	0.0	1.2
SYN 203	-1.38	-0.5	5.2	2.3	1.4	4.8	0.9
SYN 280	3.98	-0.4	0.4	2.8	1.7	0.1	1.4
SYN 199	-1.00	-0.3	-1.2	3.2	1.9	-0.8	0.8
SYN 169	-3.71	-0.3	0.8	1.1	0.6	0.4	0.7
SYN 279	-1.27	0.4	1.9	3.5	2.5	1.9	1.0
SYN 292	-0.11	0.7	3.0	2.0	1.7	2.2	0.6
SYN 278	-0.88	0.9	-0.5	6.7	4.8	0.9	1.5
SYN 271	-1.02	0.9	1.5	-2.2	-0.9	1.5	1.0
SYN 260	-0.94	1.0	2.5	-2.4	-1.1	2.4	1.0
SYN 283	3.82	1.1	-0.4	1.1	1.2	0.0	0.7
SYN 304	-0.31	1.5	0.9	-10.6	-6.0	1.4	0.5
SYN 270	-2.16	2.2	1.6	4.4	3.2	2.5	1.2
SYN 302	2.09	2.4	3.3	-10.1	-5.1	3.9	1.3
SYN 214	2.82	2.5	1.5	-14.1	-8.6	2.3	0.6
SYN 181	3.53	2.6	0.9	0.3	1.3	1.9	1.1
SYN 245	-0.17	2.9	0.6	-1.2	0.7	1.8	0.9
SYN 273	-0.54	3.7	3.6	-4.7	-1.4	5.4	1.1

SYN 267	2.86	4.0	0.0	0.9	2.3	0.0	1.2
SYN 251	3.85	4.1	3.3	2.6	3.3	5.4	0.8
SYN 262	-1.84	4.2	0.4	-1.4	1.0	2.6	1.3
SYN 285	-2.68	5.5	0.0	2.2	3.6	3.0	1.0
SYN 284	-0.69	6.3	-0.9	-0.5	2.5	2.9	1.0
DHTW 60(C)		-1.17	-1.75	-1.56	-1.84	-1.37	1.23
HTW 11 (C)		-0.7	-1.5	-3.2	-2.6	-1.1	1.1

*HSITGW=Heat susceptibility index pooled over years (2013-14 & 2014-15)
TGW=1000 grain weight, GFD= Grain filling duration, GNS=Grain number/spike, GWS=Grain weight/spike, GFR=Grain filling rate, PTL=Productive tillers

Based on heat susceptible and drought susceptible index for 1000 grain weight, SYN 287, SYN 249, SYN 306, SYN 164, SYN 257, SYN 259, SYN 203, SYN 199, SYN 169 were tolerant to both stresses and lines SYN 283, SYN 214, SYN 181, SYN 267, SYN 251 were susceptible to both the stresses (Fig. 1)

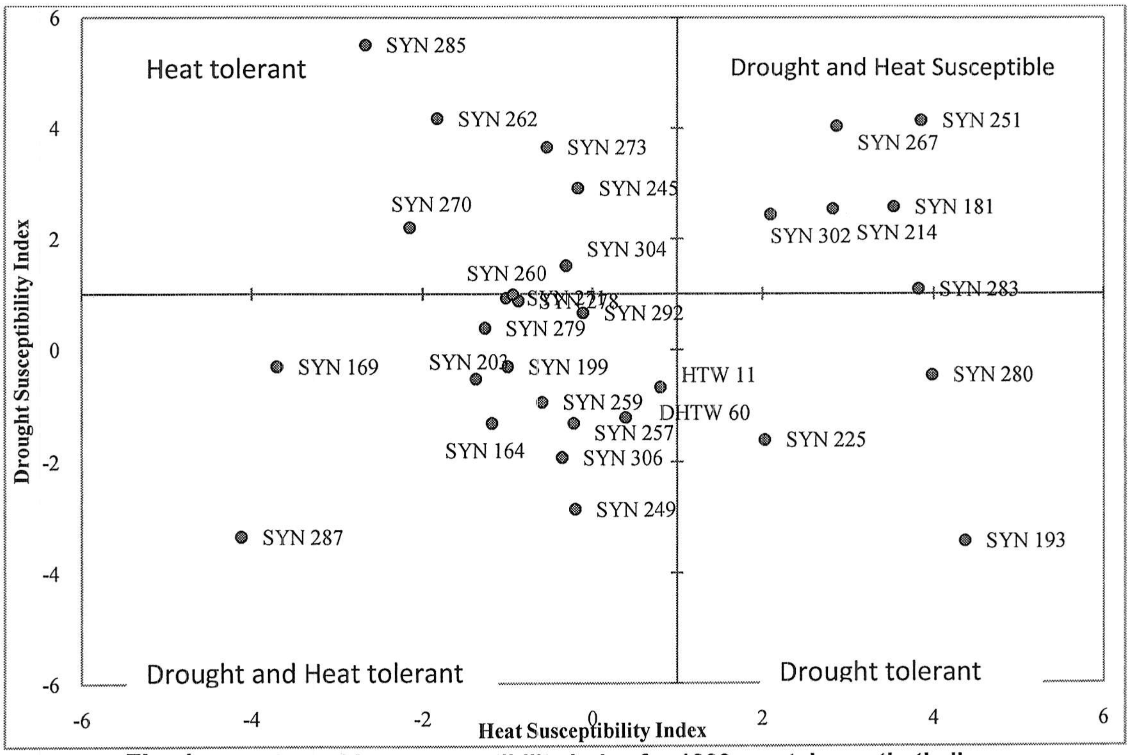

Fig. 1:Drought and heat susceptibility index for 1000 gr.wt. in synthetic lines

Wide crossing program

The promising accessions out of diploid, tetraploid and hexaploid species were identified and used to introgress genes into released high yielding varieties / genotypes. These accessions were selected for introgressing traits like high biomass, biotic and abiotic stress tolerance. The accessions were crossed and back crossed with agronomic base genotypes particularly highly promising lines. The *Polonicum* is known for high thousand grain weight and dicoccum & dicoccoides are good for quality parameters. Besides, F2s and BC2s 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 and early heat.

Crosses attempted using wild species

Compactum/PBW 550/PBW 550	*Ae. kotschyi (3774)/*DBW 107	*Ae. peregrina (PI604169)/*HS 277//DBW 71
Compactum/PBW 550/DPW 621-50	*Ae. kotschyi (402242)/*IC 532653/ HD 2967	*Ae. peregrina (PI604169)/*IC 118737 (HALBERD)
*Ae. tauschii (3759)/*NIAW 34	*Ae. tauschii (9787)/*IC-118737 (Halberd)	*Polonicum/Urartu* 83/HD 2967/HD 2967
*Ae. tauschii (3758)/*SUN STAR//HD 3086	*T dicoccum(103)/* HD 2932	PDW 291/Ventricosa/HI 8498
*Ae. kotschyi (3774)/*DBW 107//HD 2967	*T. dicoccoides (4821)/* DBW 88	*Polonicum/Urartu* 83/HD 2967/HD 2967
*Ae. tauschii (9803)/*HS 277// DBW 71	*T. dicoccoides (7132)/*HD-2967	*T. urartu 78/STT 68/*HD 3117

Developing head scab resistance in bread and durum wheats genotypes

The most of the Indian varieties particularly of North West region are very susceptible to head scab disease. Many a times when temperature has been high with humid environment the disease appeared and it spreads quickly damaging the crop upto 60 percent. When a set of 100 released varieties including durum and bread wheats, was evaluated for head scab tolerance, no one showed promise. Therefore in a view to develop Head Scab (*Fusarium blight)* resistant genotypes in wheat, a back cross program at IIWBR Karnal was taken up involving the resistant stocks Sumai # 3 and Frontana. These stock ware facultative winter wheats and therefore were crossed with Indian promising varieties in order develop stocks of spring types. The crosses available are Sumai 3/DBW 16, Sumai 3/ PBW 502, Sumai 3/ PDW 274, Sumai 3/ PDW 291, Frontana/ DBW 16, PBW 502/ Frontana and Sumai 3/ Frontana. The material generated is in advance stage and it was evaluated under contained artificial conditions of polyhouse at IIWBR, Karnal. The disease incidence of some selected lines which were showing tolerance was compared to the checks as below:

Table 3: Selected lines showing high degree of tolerance to Head Scab under artificial polyhouse conditions at IIWBR

Bread wheat		% Av. spikelet infection	Durum wheat		% Av. spikelet infection
HSRBW-1	Sumai#3/PBW 502	3	HSRDW-1	Sumai#3/PDW 274	6
HSRBW-2	Sumai#3/HD 2967	2	HSRDW-2	Sumai#3/PDW 291	3
HSRBW-3	Sumai#3/DPW 621-50	4			
HSRBW-4	Frontana/Sumai#3	1	HSRDW-3	Frontana/PDW 233	6
HSRBW-5	Frontana/PBW 502	5	HSRDW-4	Frontana/HI 8498	6
Sumai 3	Donor Parent	4	PDW 274	Recipient Parent	90
Frontana	Donor parent	5	PDW 233	Recipient Parent	80
PBW 502	Recipient Parent	68	PDW 291	Recipient Parent	75
HD 2967	Recipient Parent	65	HI 8498	Recipient Parent	75
DPW 621-50	Recipient Parent	67			

Quality traits in some selected genotypes:
About 150 genotypes developed at IIWBR under pre-breeding program and also some direct selections were analysed for quality traits. This included *triticales*, bread wheat lines and the tetraploid genotypes. The parameters like test weight, protein, grain hardness andsedimentation value were analysed and some selected lines are given in table below.

Quality traits in selected lines

Pedigree	**Hect. wt**	**Protein % (14%mb)**	**Grain hardness index**	**Sed. value (cc)**
ITYN 846 (Triticale)	69.4	8.5	23	3.5
ITYN 848 (Triticale)	70.8	9.9	22	5.8
ITYN 850 (Triticale)	72.7	9.2	28	4.5
PBSel-12-01	75.0	14.9	64	9.0
PBSel-12-02	76.5	12.4	85	7.0
PBSel 67	82.6	9.5	84	7.0
PBSel 70	74.8	14.6	73	13.5
PBSel 80	74.6	13.3	73	10.0
PBSel 81	75.6	12.0	80	10.5
PBSel 2061	82.1	8.3	67	7.1

Some triticales were found very soft (around 25 hardness index) with low sedimentation and this trait is good for biscuit making quality. Three lines PBSel-12-01, PBSel 70 and PBSel 80 were having more than 14 per cent protein content. In some genotypes namely PBSel 67 and PBSel 2061, very high test was observed. These selected lines are being shared with cooperating centers for further use in pre-breeding programmes.

Genetic studies and development of rust resistant wheat stocks

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Screening of segregating wheat lines and advancement

More than 600 wheat lines were screened using virulent pathotypes of the three rusts. During the season twelve segregating population were evaluated and advanced. In the off-season nursery, 1585 lines of segregating material were planted for generation advancement. Besides this, studies on resistance pattern were performed and gene postulations based on multi-pathotypes response data were done. More than forty parents were identified for genetic studies and gene pyramiding.

Genetics and breeding for rust resistance in wheat

Based on the screening at seedling resistance and adult plant evaluation 48 wheat genotypes were selected and used in the crossing programme during 2015-16. A total of 57 crosses and five back crosses were attempted during the period. Some of the F_1's generated are being utilized in the doubled haploid production of wheat to reduce the time and space taken in making recombinant inbred lines/advanced breeding lines.

Evaluation and selection of elite material from winter spring hybridization

During crop season 2015-16winter-spring segregating nurseries received from Karnal during 2012-13, 2013-14 and 2014-15 were utilized for identification of resistant segregants for the three rusts and yield attributing characters to identify wheat lines performing better in Northern Hill Zone. Among the three nurseries, lines were selected based on screening at seedling stage and field evaluation. Ninety-three lines were selected for further breeding. CIMMYT 9th SSRN nursery was used to select rust resistant wheat material for the advancement and use in the crossing programme. Introgression wheat lines from wild relatives, Watkins selections and European winter wheat line were also used for breeding wheat for Northern Hill Zone.

Marker assisted selection and validation of rust resistance gene

Forty varieties of wheat released between 2010-2014 were used for identification for rust resistance genes *Lr24/Sr24, Lr19/Sr25, Yr15, Yr17, Yr18/Lr34, Yr9/Lr26/Sr3, Sr28* and *Lr68* through known gene molecular markers and successfully validated. Marker assisted selection was done in the segregating population of breeding programme to select the plants for presence of *Yr15, Sr26, Sr32, Sr43* and *Lr24/Sr24* rust resistance genes and the plants which were confirmed to carry resistance genes were selected and harvested. Figure 1 shows presence of *Lr24/Sr24* gene in seven varieties namely HD3090, HI1563, HW5216, MP3288, NIAW1415, Raj4229 and Raj 4238 with the help of dominant marker Sr24#50.

Development of rust resistant genetic stocks with diverse resistance genes

Six wheat rust resistant genetic stocks (FLW10, FLW16, FLW18, FLW21, FLW22 and FWW2) developed by ICAR-IIWBR Regional Station, Shimla were screened during 2015-16 for seedling resistance test against virulent pathotypes of black, brown and yellow rusts.

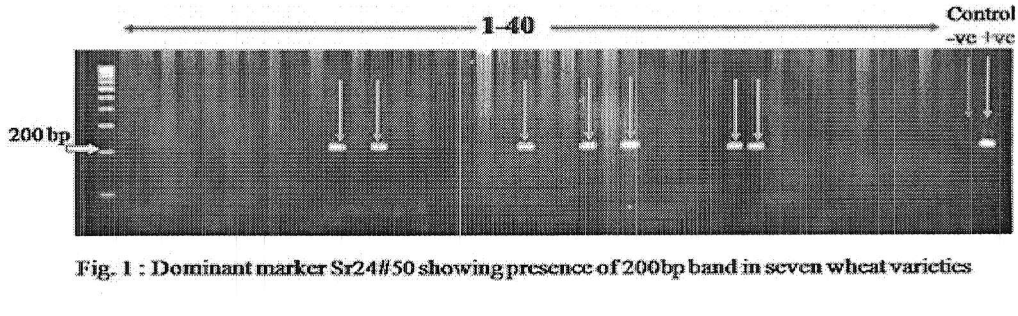

Fig. 1 : Dominant marker Sr24#50 showing presence of 200bp band in seven wheat varieties

The seedling response of these stocks is depicted in (Table1). Adult plant evaluation of these genotypes were conducted for three years 2013-14, 2014-15 and 2015-16 under polyhouse conditions at Flowerdale, Shimla using a mixture of pathotypes separately for the three rusts(Table2). All these stocks were found to be resistant to virulent pathotypes of wheat rusts and showed superiority in morpho-agronomic characters (Table3). All these genetic stocks are in the pipeline for registration with National Bureau of Plant Genetic Resources (NBPGR, New Delhi) and will serve as the 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), confers complete resistance to yellow and black rusts in India. At the same time it would increase the diversity of yellow rust resistance in India. When tested It was found to be resistant to virulent pathotypes of black (11, 40A, 40-1, 117-1 and 117-6) and yellow (78S84, 46S103, 46S119, 47S102 and 110S119) rusts. FLW16 carries *Lr*26, *Sr*31, *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*. *Lr*39 is known to provide complete resistance against brown rust pathotypes in India. Its yield is slightly less than PBW343. FLW18 would be very useful in developing brown and black rust resistant wheat varieties.

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. Since FLW21 has rust resistance from diverse sources, its incorporation would add to more variability in wheat material.

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. Its use in wheat breeding programme would add to the diversity and durability of rust resistance in Indian wheat.

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 85cm with test weight of 40.6g. FWW2 matures in 118 days and its per meter row yield is slightly less than PBW343.

Development of Ug99 rust resistant genetic stocks

Three rust resistant genetic stocks, namely FLW31, FLW32 and FLW33 carrying *Sr43, Sr26* and *Sr32,* respectively were developed. These three genotypes also showed good resistance against Ug99 and its variants when evaluated in Kenya during 2013. These provide complete resistance against black rust pathotypes of Indian sub-continent (Table 4&5).

FLW31 is derived from the cross between HI1500 and exotic line KS10-2 C83.4(*Sr43*). This genotype is completely resistant to black (based on two genes) and brown rusts. It showed resistance against Ug99 pathotypes of black rust when tested in Kenya. FLW31 carries *Sr24/ Lr24* and *Sr43*. This genotype has an average plant height of 105 cm and matures in 155 days under Shimla conditions. Its grains are reddish-amber coloured, semi hard and thousand grain weight is 41.6 g. Coleoptile anthocyanin is absent, whereas plant growth habit is semi-erect. Anthocyanin colouration of auricles is absent. Plants of FLW31 have moderate waxiness on leaf sheath and peduncle, however wax is absent on flag leaf and glumes. The ear shape is parallel with dense spikelets. The awns are of medium length with white colour.

FLW32 has been developed from cross Raj3765/Eagle. Eagle is a source of *Sr26* derived translocation on chromosome 6A from an alien segment from *Agropyron elongatum. Sr26* is known to confer long term black rust resistance in Australia. Two backcrosses followed by pedigree selection for resistance and yield attributes were done to develop this stock. The developed stock provides complete resistance against stem rust pathotypes and adult plant resistance against yellow and brown rusts. It also showed resistance against Ug99 and its variants when tested in Kenya in 2013. FLW 32 carries *Lr10, Lr13, Sr2,* and *Sr26*. This genotype has an average plant height of 99cm and takes 152 days to mature under Shimla conditions. The grains of FLW32 are amber, semi hard and on an average weigh 42.1g per 1000 grains. Coleoptile anthocyanin is absent whereas plant growth habit is semi-erect. Plants show moderate waxiness on leaf sheath, peduncle and glumes. The earheads are parallel with medium dense spikelets and medium length awns.

FLW33 has been derivative of cross between HI1500 and donor line C77.19(*Sr32*) though pedigree selection method. It is completely resistant to black and brown rusts and partially resistant to yellow rust of wheat. Its yield is slightly less than HI1500. Average plant height is 93cm and maturity duration is 145 days under Shimla conditions. FLW33 possesses rust resistance genes *Sr24/Lr24* and *Sr32.*

Table1: Seedling resistance test data of six genetic stocks under artificial controlled conditions

Genetic Stock	Brown rust								Black rust						Yellow rust					
	12-5	77A	77-2	77-5	77-7	77-8	77-10	104-2	11	21-1	40A	40-1	117-1	117-6	47S102	46S102	46S103	46S119	78S84	110S119
FLW10	0;	0;	0;	3^+	3^+	0;	3+	3^+	2-	0;	2^-	2^-	2^-	2^-	0;	0;	0;	0;	0;	0;
FLW16	0;	0;	0;	3^+	3^+	3^+	3+	3^+	2-	2^-	2^-	2^-	2^-	2^-	0;	0;	0;	0;	0;	0;
FLW18	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	2^-	2^-	2^-	2^-	0;	0;	0;	;2	3+	3+
FLW21	;	;1	;	;1	;1	;1	;1	;1	2-	2^-	2^-	2^-	2^-	2^-	0;	0;	0;	0;	0;	0;
FLW22	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	2^-	2^-	2^-	2^-	0;	0;	0;	0;	0;	0;
FWW2	0;	0;	0;	0;	0;	0;	0;	0;	0;	0;	2^-	2^-	2^-	2^-	0;	0;	0;	3^+	;	3+

1) Seedling response

R	Resistance	$;^-$;1 ;2, 2^-	Resistance
MR	Moderate Resistance	3^+	Susceptible
S	Susceptible		
0	Free from rust/No rust response		
0;	Immune		

2) Race designation

12-5	19R45	**11**	79G31
77A	109R31	**21-1**	24G5
77-2	109R31-1	**40A**	62G29
77-5	121R63-1	**40-1**	62G29-1
77-7	121R127	**117-1**	166G2
77-8	253R31	**117-6**	37G19
77-10	377R60-1		
104-2	21R55		

Table2: Adult Plant Resistance data of six genetic stocks under polyhouse condition at Shimla during 2013-14, 2014-15 and 2015-16

Genetic Stock	Brown rust						Black rust						Yellow rust					
	2013-14		2014-15		2015-16		2013-14		2014-15		2015-16		2013-14		2014-15		2015-16	
	APR score	AUD PC	APR score	AUD PC	APR score	AUD PC	APR score	AUD PC	APR score	AUD PC	APR score	AUD PC	APR score	AUD PC	APR score	AUD PC	APR score	AUD PC
FLW10	20S	150	30MS	60	20S	150	10MR	5	15MR	7	10MR	10	R	0	R	0	R	0
FLW16	20S	150	30MS	60	30MS	60	15MR	7	15MR	7	20MR	10	R	0	R	0	R	0
FLW18	R	0	R	0	R	0	10MR	5	10MR	5	10MR	5	10MR	5	10MS	20	10MS	20
FLW21	R	0	R	0	R	0	10MR	5	10MR	5	10MR	5	R	0	R	0	R	0
FLW22	R	0	R	0	R	0	10MR	5	10MR	5	15MR	7	R	0	R	0	R	0
FWW2	R	0	R	0	R	0	5MR	2	5MR	2	10MR	5	20S	150	30MS	60	30MS	60

Table 3: Specific and morpho-agronomic characters of genetic stocks

Genetic Stock	**Pedigree**	**Specific character**	**Genes for rust resistance**	**Days to maturity**	**Plant height (cm)**	**1000 gr. wt (g)**	**Yield/M row (g)**	**Grain colour**
FLW10	WH542/Moro (*Yr*10)	Resistant to black and yellow rusts	*Lr*26(M), *Sr*31, *Yr*9+*Yr*10*	118	75	39.7	98	Amber
FLW16	UP2338/*Triticum spelta album* (*Yr*5)	Resistant to black and yellow rusts	*Lr*26 (M), *Sr*31, *Yr*9+*Yr*5*	120	78	38.1	93	Amber
FLW18	PBW343/*Lr*39 (KS92WGRC15)	Resistant to black and brown rusts	*Lr*26 (M)+*Lr*39*, *Sr*31, *Yr*9+*Yr*27	125	89	38	98	Amber
FLW21	UP2338/Centurk//UP2338/*Yr*15	Resistant to brown, black and yellow rusts	*Lr*24+*Lr*26(M), *Sr*24+*Sr*31, *Yr*9+ *Yr*15*	122	91	37.3	118	Non-amber
FLW22	WH542/*Lr*28//WH542/China84-40022	Resistant to brown black and yellow rusts	*Lr*28+*Lr*26(M), *Sr*31, *Yr*9+ *Yr* China84*	118	90	38.4	116	Amber
FWW2	PBW343/PH137	Resistant to black and brown rusts	*Lr*19+*Lr*26 (M), *Sr*31, *Yr*9**	118	85	40.6	138	Amber

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

Table 4: Resistance test (2013-16) of three Ug99 resistant lines against rusts

Genetic Stock	Black rust				Brown rust		Yellow rust	
	Kenya 2013	Shimla 2013-14	Shimla 2014-15	Shimla 2015-16	Shimla 2014-15	Shimla 2015-16	Shimla 2014-15	Shimla 2015-16
FLW31	R	R	R	R	R	R	30MS	40MS
FLW32	R	R	R	R	20MR-MS	20MS	20MR-MS	40MS
FLW33	R	R	R	R	R	R	30MS	50MS

Table 5: Seedling resistance test (2015-16) of three Ug99 resistant lines with virulent pathotypes of brown, black and yellow rusts

Genetic Stock	Black Rust					Brown rust				Yellow rust			
	40A	40-1	117-1	117-6	Pgt mix	12-5	77-5	104-2	Ptr mix	78S84	46S103	46S119	Pst mix
FLW31	0;	0;	0;	0;	0;	;1	;1	;1	;1	3+	3+	3+	3+
FLW32	0;	0;	;	;	;	;12	3+	;12	3+	3+	3c	3c	3+
FLW33	0;	0;	0;	0;	;	;1	;1	;1	;1	3+	3+	3+	3+

PART C

MOLECULAR APPROACH FOR GERMPLASM EVALUATION

Application of Molecular Markers in Wheat and Barley Improvement

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Molecular markers are being used for identification of genomic regions associated with biotic and abiotic traits in wheat and β-glucan content in barleyat ICAR- Indian Institute of Wheat and Barley Research, Karnal. PCR based markers are also used to identify photoperiod sensitivity and glutenin alleles.

Mapping of effective adult plant stripe rust resistance in Cappelle- Desprez / PBW343 derived recombinant inbred line population

A population of recombinant inbred lines (RILs) developed to study resistance against stripe rust from a cross between Cappelle-Desprez (resistant) and PBW343 (susceptible) was utilized for map construction and QTL analysis with 1,012 polymorphic (DArT and SSR) markers. Screenings for stripe rust disease were carried out in field condition for two consecutive crop seasons. Susceptible parent (PBW343) achieved a significant level of disease i.e., 100 percent in both the years. Resistance in Capelle-Desprez was found stable and response to the rust in it ranged from 0-1.5 percent over the years. The estimated broad- sense heritability (h^2) of stripe rust relative area under the disease progress curve (rAUDPC) in the mapping population was 0.82. The rAUDPCdata showed continuous distributions, indicating that trait was controlled multigenically. Genomic region identified on chromosome 2D, was located within the short arm, with flanking markers (*Xgwm484-Xcfd73*) (Fig.1), explaining phenotypic variation (PVE) range from 13.9-31.8%. The genomic region identified on chromosome 5B was found with the effect of maximum contribution with flanking DArT markers (1376633|F|0-1207571|F|0) (Fig.2), explaining phenotypic variation (PVE) range from 24-27.0%. This can therefore be utilized for marker assisted selection in developing much needed stripe rust resistant lines for the Northern Wheat belt of India.

Mapping QTLs associated with grain filling duration and grain number under terminal heat stress in bread wheat (*Triticum aestivum* L.)

Terminal heat stress in particular is a primary constraint to global wheat production, particularly in the tropical and subtropical regions of South Asia, including large portions of India. Although, there is considerable variation among genotypes in response to heat stress, relatively little is known about the critical genes or quantitative trait loci (QTLs) controlling heat tolerance due to its quantitative nature. To identify QTL for heat tolerance, a RIL population of K 7903 (heat tolerant) and RAJ 4014 (heat sensitive) wheat genotypes was investigated under timely and late sown conditions. Heat susceptibility index (HSI) of GFD, grain number per spike (GN) and GFD under late sown condition (LGFD) were used as phenotypic data for QTL identification. Stable QTLs associated with HSIGFD, HSIGN and LGFD were identified. These QTLs were located on chromosomes 1B, 2B and 5A. The LOD value ranged from 2.9 to 5.0 and the corresponding phenotyping variation explained were 12.0 to 22%. QTL for HSIGFD were co-localized with QTL for LGFD on chromosome 5A (Fig.3). These genomic regions could be exploited for molecular wheat breeding programs targeting heat tolerance.

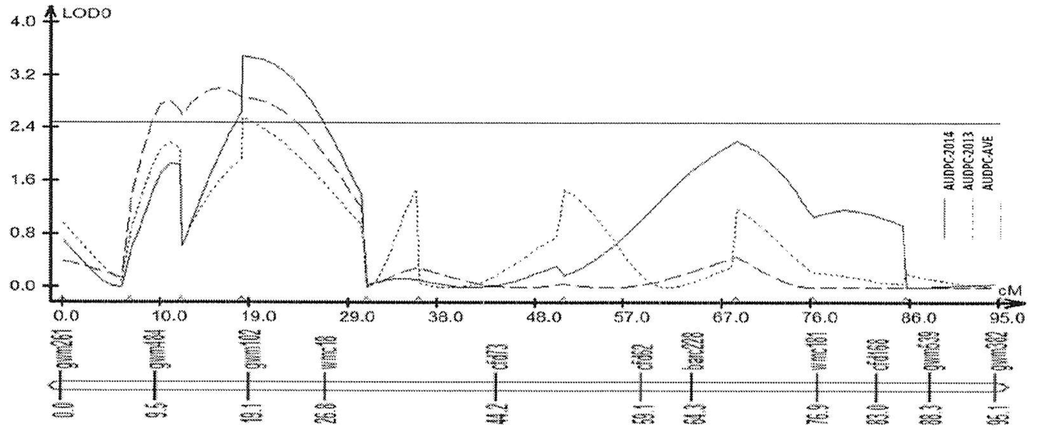

Fig 1: Composite interval mapping of stripe rust severity at adult plant stage in the Cappelle-Desprez/PBW343 mapping population detecting QTL on chromosome 2D

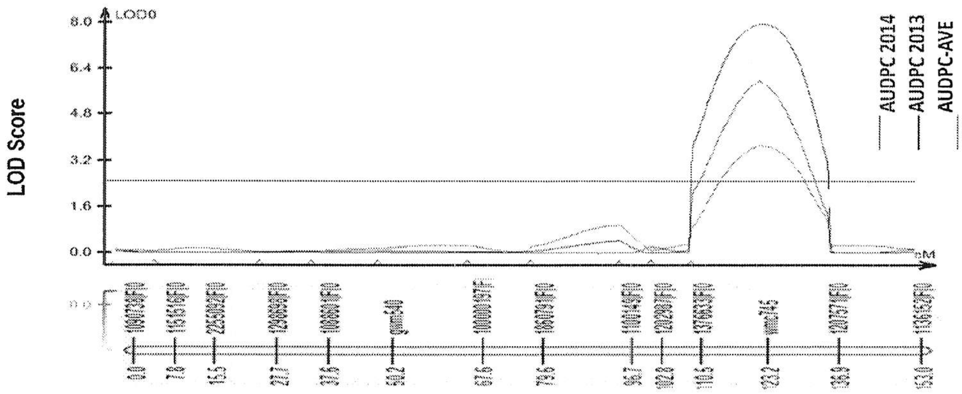

Fig 2: Composite interval mapping of QTL on chromosome 5B

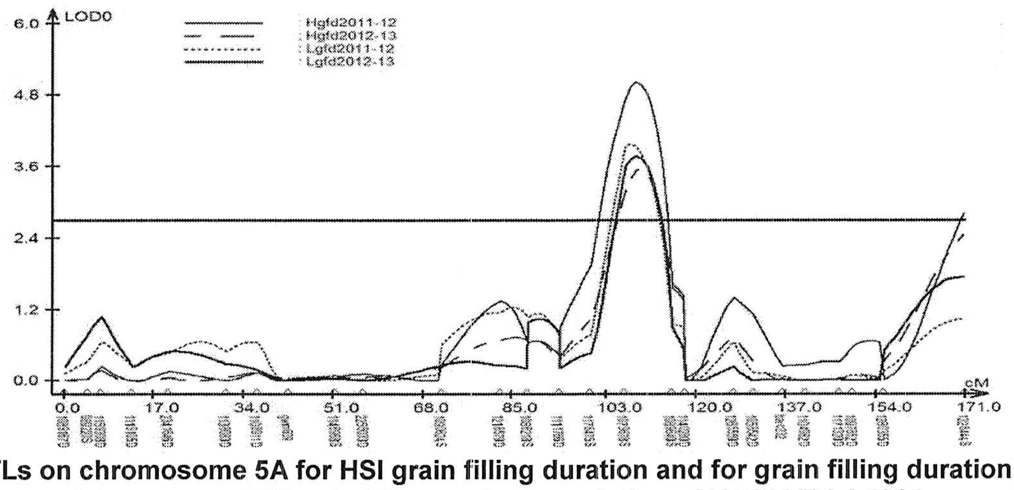

Fig 3: QTLs on chromosome 5A for HSI grain filling duration and for grain filling duration under late sown condition in RIL mapping population of K 7903/RAJ 4014

Allelic variation at photoperiod sensitive locus in winter wheat genotypes

Winter wheat has ample variability for traits of economic importance that can be utilized for improvement of spring wheat. The ability of wheat crop to regulate flowering time is a key factor for its global adaptability under very diverse agro-climatic conditions. The flowering time in wheat is a complex character, which exhibits a continuous variation and mainly controlled by vernalization (*Vrn*) and photoperiod (*Ppd*) response, and earliness per se (*Eps*) genes. The *Vrn* gene system accounts for about 70–75 %, the *Ppd* gene system for about 20–25 % and earliness per se for about 5 % of the genetic variability in the flowering time of bread wheat. A photoperiod insensitive genotype immediately switches to reproductive growth when temperature increases in the spring, whereas a photoperiod sensitive genotype remains in vegetative phase until the day length increases and satisfies its photoperiod requirement. Photoperiod response in wheat is genetically controlled by allelic variation at the *Ppd-A1*, *Ppd-B1* and *Ppd-D1* loci located on short arm of homologous group 2 chromosomes. Photoperiodism in wheat is mainly controlled by the *Ppd-D1* locus located on chromosome 2D which greatly influences flowering time by the separation of genotypes into photoperiod sensitive and insensitive ones and accelerates flowering by several days. Sixty-two winter wheat genotypes were screened for allelic variation at *Ppd-D1* locus. The photoperiod insensitive allele (*Ppd-D1a*) was detected in 28 genotypes, whereas, 34 genotypes were found to possess photoperiod sensitive allele (*Ppd-D1b*) (Fig.4). Winter wheat genotypes 14[th]IWWYT-SA-9907, IC 528917, IC 529002, IC 529170, IC 529862, IC 530010, IC 530154, MV Emese, EC 609405, TURKEY (97-98)-9, TURKEY (97-98)-22, TURKEY (97-98)-24 and TURKEY (97-98)-25 have *Ppd-D1a* allele and genotypes IC 528971, IC 528979, IC 529019, IC 529178 and TURKEY (97-98)-3 have *Ppd-D1a* allele. The winter wheat genotypes having *Ppd-D1a* allele are better adapted to the environment and easy to use for transferring the traits of economic importance to the spring wheat. However, both photoperiod sensitive and insensitive winter wheats are being utilized for improving the spring wheats in terms of tillering ability, yellow rust and nutritional traits. Some genotypes were crossed with spring cultivars or lines during 2015-16 and 103 crosses were attempted.

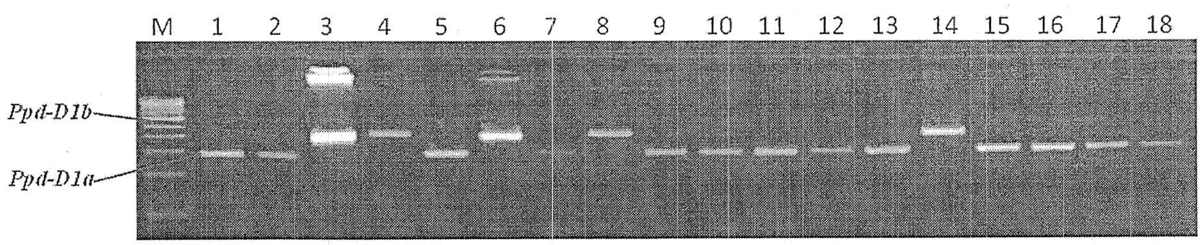

Fig 4: PCR amplification to detect *Ppd-D1a* and *Ppd-D1b* alleles. 1- 14[th]IWWYT-SA-9907, 2- IC 528917, 3- IC 528971, 4- IC 528979, 5- IC 529002, 6- IC 529019, 7- IC 529170, 8- IC 529178, 9- IC 529862, 10- IC 530010, 11- IC 530154, 12-MV Emese, 13-EC 609405, 14-TURKEY (97-98)-3, 15-TURKEY (97-98)-9, 16-TURKEY (97-98)-22, 17-TURKEY (97-98)-24, 18- TURKEY (97-98)-25.

Assessment of HMW and LMW glutenin alleles in elite wheat germplasm lines using allele specific PCR based markers

During the year 2014-2015, on the basis of biochemical analysis 16 and 31 promising genotypes from NGSN (National Genetic Screening Nursery) and EIGN-I (Elite International Germplasm Nursery) respectively were selected to identify allelic variations encoded by high molecular weight glutenin (HMW-G) and low molecular weight glutenin (LMW-G). HMW and LMW subunits are the major determinants of the visco-elastic properties of dough. To date, large number of functional markers related to LMW and HMW glutenins have been developed using sequence information from selected genotypes available at public databases (NCBI) and used to identify LMW and HMW glutenin alleles. For LMW, at *Glu-A3* locus, *GluA3-1*allele was found in 56.0% of genotypes (Fig.5), *GluA3-2* in 75%, *GluA3ac* in 68.0%, *GluA3d* in 50.0% and *GluA3g* in 87.5% of NGSN entries. Since, bread making quality is the major thrust of wheat quality improvement studies, efforts have been made to identify the proportion of HMW-GS that are known to be associated with good bread making quality. Concerning the *Glu-1A* locus for HMW, *Ax2** allele was found in 68.0% genotypes of NGSN while only 7% of genotypes of EIGN-I contained this allele. At *Glu-B1* locus, the primer for *By8* allele amplified in 51.0%, *By9* in 50.0% and Bx7/17 in 83.8% genotypes of EIGN-I. Wheat varieties containing allelic compositions *Dx5* paired with *Dy10* at the *Glu-D1* locus will form stronger dough than those containing *Dx2* paired with *Dy12*. 87.5% genotypes of the NGSN showed an allele of *Dx5* (Fig.6). The frequencies of other alleles were diverse in different nurseries. The composition and quantity of HMW-GS and LMW-GS plays an important role in determining the end-use quality of wheat products. Taking into account the significance of these alleles, this variation can be used for production of desirable varieties. In addition, it was observed that PCR based markers are capable of allelic identification in the respective genetic locus.

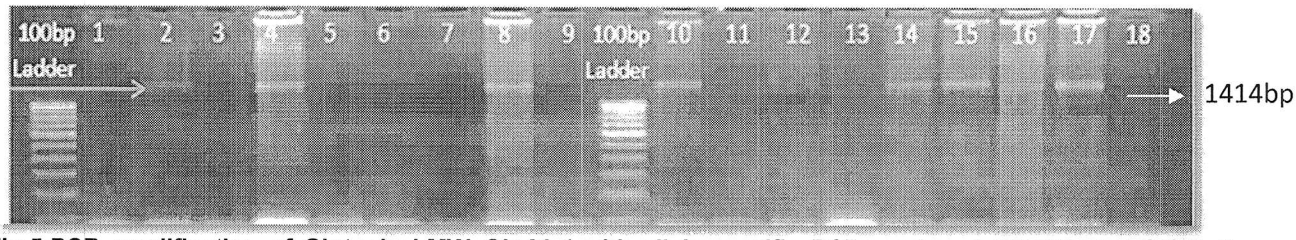

Fig.5:PCR amplification of Glutenin LMW *GluA3-1* with allele-specific PCR marker. 1-DBW58, 2- LOK62, 3-PHS1108, 4- HPW 355, 5- LBPY 2010-11, 6- LOK65, 7- LOK BOLD,8- LBPY 2010-24, 9- Raj 4388, 10- 20th HRWYT 219, 11- 45th IBWSN 1122, 12- 23rd HRWSN 2002, 13- 22nd ISEPTON 6219, 14- 20th SAWYT 315, 15- 20th SAWYT 337, 16- 30th SAWSN 3005, 17- 30th SAWSN 3029, 18- 30th SAWSN 3071.

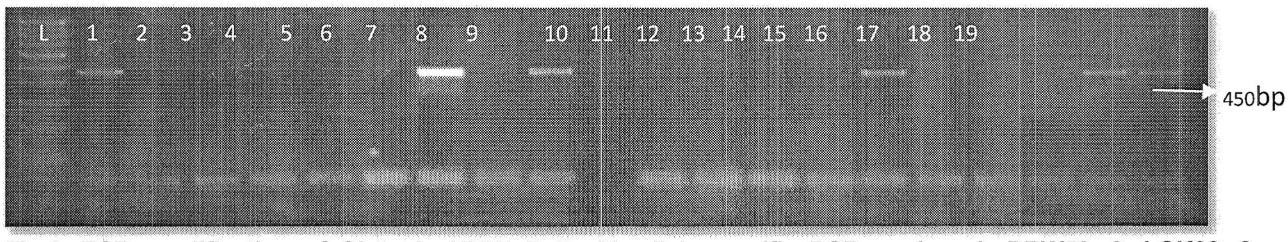

Fig.6: PCR amplification of Glutenin HMW *Dx5* with allele-specific PCR marker. 1- DBW58, 2- LOK62, 3-PHS1108, 4- HPW 355, 5- LBPY 2010-11, 6- LOK65, 7- LOK BOLD, 8- LBPY 2010-24, 9- Raj 4388, 10- 20th HRWYT 219, 11- 45th IBWSN 1122, 12- 23rd HRWSN 2002, 13- 22nd ISEPTON 6219, 14- 20th SAWYT 315, 15- 20th SAWYT 337, 16- 30th SAWSN 3005, 17- 30th SAWSN 3029, 18- 30th SAWSN 3071, 19- DBW39.

β-glucan content regulating genomic region in barley genotype Jagriti

Beta glucans are considered valuable for human health and nutrition, but for malt, high levels of β-glucans are unfavorable. In order to determine the correlation between β-glucan content and genomic region which regulate the quantitative trait, multiple regression analysis was used to study β-glucan trait in barley genotype Jagriti. Two genotypes, DWR30 having high β glucan (7.5%) and Jagriti with low β glucan (3.0%) content were crossed to develop recombinant inbred population ($F_{2\text{-}3}$). Biochemical evaluation of RILs for β glucan concentration ranged from 3.9% to 6.5% as shown in figure 1. Most of segregating lines contained intermediate level of β glucancontent ranging from 4.0 to 5.0% followed by 5.0 to 6.0% and then 6.0 to 7.0% categories therefore, showing continuous variation for quantitative trait in segregating population. These RILs were grouped for low (3.0 to 4.5%) and high level (4.6 to 7.5%) β glucancontent categories for multiple regression analysis. The RIL population demonstrated a near normal distribution with few transgressive segregates having either higher or lower β glucan concentration than the parents. A set of five STS/SSR markers which have been reported closely linked for β -glucan and malt quality traits were selected to characterize the genomic regions influencing β -glucan content in barley. Amplification profiles of contrasting parental lines were used to compare the RILs segregating for β -glucan trait as of high and low β -glucan content category. Data collected by biochemical analysis and molecular data generated from amplified bands were subjected to multiple regression analysis for β -glucan trait using SAS statistics version 9.1.3. Means for each STS marker were separated by the least significant difference (LSD) at *P* ≤ 0.05 and *P* ≤ 0.01. A significant correlation was observed between the β glucan trait and molecular marker associated with this quantitative trait. During multiple regression analysis molecular markers, Brz was found to be closely linked with β glucan trait with R^2 value of 0.62. Marker Brz was previously mapped on chromosome 7H of barley genome. This is the genomic region on 7H chromosome of barley which is responsible for regulation of β- glucan quantitative trait. This result shows that polymorphic genomic regions identified by molecular marker in this narrow gene pool tend to be associated with malting quality QTLs of trait.

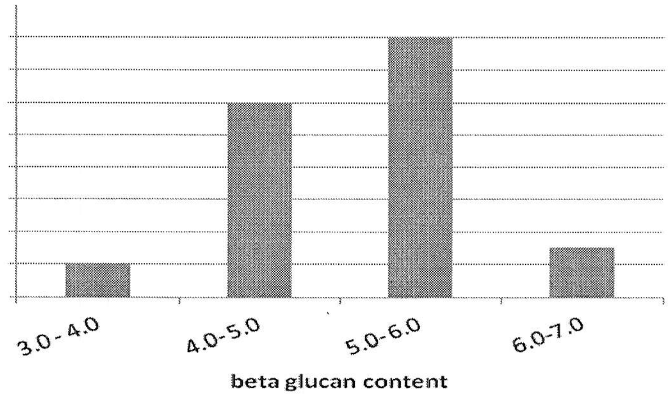

Fig 1: Frequency distribution graph showing β- glucan range distributed in recombinant inbred lines of DWR30/Jagriti

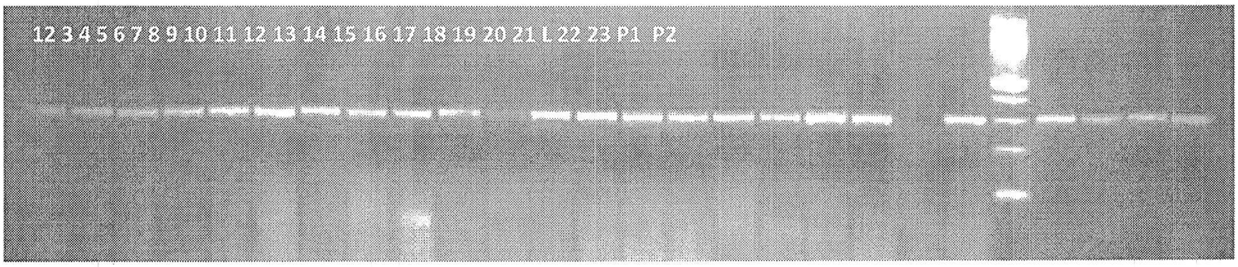

Fig 2: Amplified PCR product obtained with STS marker Brz in recombinant inbred lines (RILs) and parental lines of cross DWR30/ Jagriti. Lane 1-23 RILs: P1: DWR30, P2: Jagriti