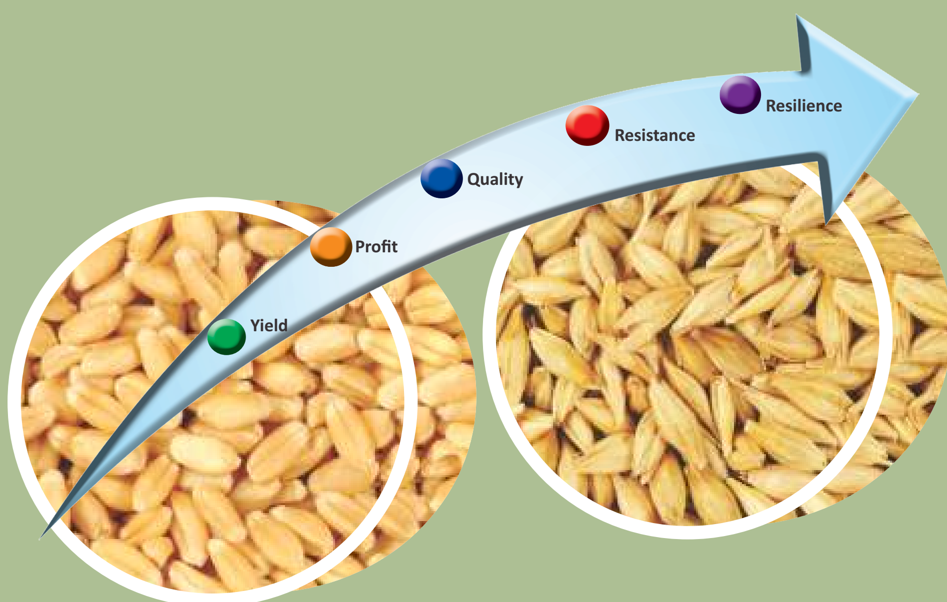
प्रगति प्रतिवेदन
PROGRESS REPORT
2015-16

अखिल भारतीय समन्वित गेहूँ एवं जौ सुधार परियोजना
ALL INDIA COORDINATED WHEAT & BARLEY IMPROVEMENT PROJECT



निदेशक रिपोर्ट
DIRECTOR'S REPORT

भा.कृ.अनु.प. – भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल
ICAR - Indian Institute of Wheat and Barley Research, Karnal

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All India Coordinated Wheat & Barley Improvement Project

DIRECTOR'S REPORT 2015-16

G P Singh
Director

भा.कृ.अनु.प. – भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल
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It is my proud privilege to express our sincere gratitude, on behalf of the entire wheat fraternity, to Dr. T. Mohapatra, Secretary DARE & Director General, Indian Council of Agricultural Research (ICAR), New Delhi for continuous guidance, encouragement and support to the national wheat and barley improvement programme. I am also thankful to Dr. S. Ayyappan, Former Secretary, DARE & Director General, ICAR for continuous support and guidance. I take this opportunity to extend my heartiest thanks and deep sense of gratitude to Dr. J. S. Sandhu, Deputy Director General (Crop Science), ICAR, New Delhi for his valuable support and guidance in successfully implementing the programme during 2015-16 leading to significant achievements. The regular and timely support rendered by Dr. I. S. Solanki, Assistant Director General (FFC), ICAR and his team is also gratefully acknowledged.

I am also highly indebted to my predecessors Dr. (Mrs.) Indu Sharma and Dr. R.K. Gupta for their untiring leadership as Director and Director (Acting), respectively at IIWBR Karnal during the year 2015-16.

The concerted and untiring efforts of the scientific and field staff at different cooperating centres across zones for successfully conducting the coordinating trials are duly acknowledged. The cooperation, support and leadership of the Vice-chancellors and Director (Research) of the State Agriculture Universities for facilitating and successful implementation of the envisaged programme need special mention. I consider it as my profound duty to acknowledge and congratulate all wheat and barley workers for successfully executing the programme and making contributions towards improving wheat and barley productivity and production in the country.

I greatly appreciate to each one of the large number of voluntary centers for their support in wider evaluation of the nurseries and trials.

The notable valued contribution and very sincere efforts made by all the Principal Investigators, team of scientists and technical staff of various disciplines along with other staff members of administration and accounts in planning, execution and monitoring of the programme in various ways deserve great appreciation.

(G P Singh)
Director

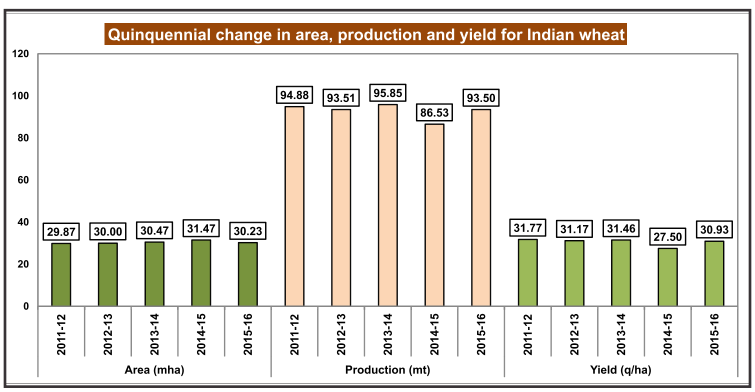
Place: Karnal
Date: August, 2016

DIRECTOR'S REPORT 2015-16

Globally, wheat and barley altogether cultivated in around 270 million hectares (mha) and occupy the first and fourth position respectively among the cereals. In India, these crops covered about 31mha (Wheat: 30.23 mha and Barley: 0.59 mha) during the recent past 2015-16 *Rabi* season and accounts for about 38 per cent of the country's total foodgrains production as per the recent 4th Advance Estimates from the Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare (MoA&FW), India.

Wheat production had set an all-time highest 95.85 million tonnes (mt) in 2013-14. Due to unfavourable weather the subsequent year's production had witnessed a major quantum fall of 9.32 mt registering 86.53 mt. However, it has revived in the recent past 2015-16 *Rabi* season with an estimated production of 93.50 mt (4th Advance Estimate). The positive growth in production (8.06%) is attributed to the increased yield by 12.47 per cent despite a fall in the crop acreage by 3.94 per cent.

Scenario for Wheat in India



In spite of increase in the support price by Rs. 75 per quintal in comparison to the previous year and announced as Rs.1525 per quintal of wheat, the current year acreage has reduced by 1.24 mha. The average productivity of the country has increased by 343 kg/ha which is a major reason for the increased current year 93.50 mt production against the acreage decline.

However, there are regional disparities in all the three variables in comparison to the previous year final estimates (2014-15). Lack of sufficient

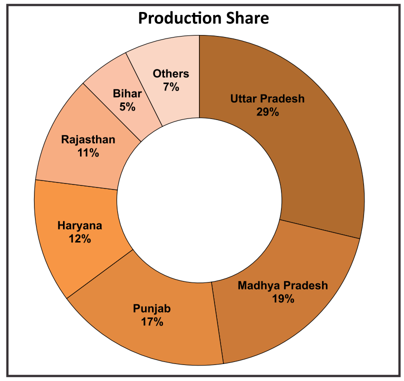
Quantum change in area, production and yield of wheat

State/ Country	2014-15 (Final Estimates)*			2015-16 (Third Estimates)**			Quantum Change in		
	Area (000'ha)	Production (000't)	Yield (kg/ha)	Area (000'ha)	Production (000't)	Yield (kg/ha)	Area (000'ha)	Production (000't)	Yield (kg/ha)
Asom	24	29	1216	30	35	1167	6	6	-49
Bihar	2154	3987	1851	2156	4753	2205	2	766	354
Chhattisgarh	98	135	1388	108	137	1270	10	2	-118
Gujarat	1112	3059	2751	851	2484	2919	-261	-575	168
Haryana	2601	10354	3981	2576	11352	4407	-25	998	426
Himachal Pradesh	330	646	1957	345	679	1968	15	33	11
Jammu & Kashmir	321	314	979	321	497	1550	0	183	571
Jharkhand	171	330	1931	161	274	1701	-10	-56	-230
Karnataka	198	261	1318	171	173	1012	-27	-88	-306
Madhya Pradesh	6002	17104	2850	5911	17689	2993	-91	585	143
Maharashtra	1067	1308	1226	629	758	1205	-438	-550	-21
Odisha	0.40	0.66	1650	0.48	0.55	1146	0.08	-0.11	-504
Punjab	3505	15050	4294	3499	16081	4596	-6	1031	302
Rajasthan	3318	9824	2961	3109	9871	3175	-209	47	214
Telengana	6	7	1167	5	5	1000	-1	-2	-167
Uttar Pradesh	9846	22417	2277	9645	26874	2786	-201	4457	509
Uttarakhand	348	654	1881	342	761	2225	-6	107	344
West Bengal	335	939	2807	340	960	2825	5	21	18
Others	29	106	3598	28	116	4109	-1	10	511
INDIA	31466	86527	2750	30228	93501	3093	-1238	6974	343

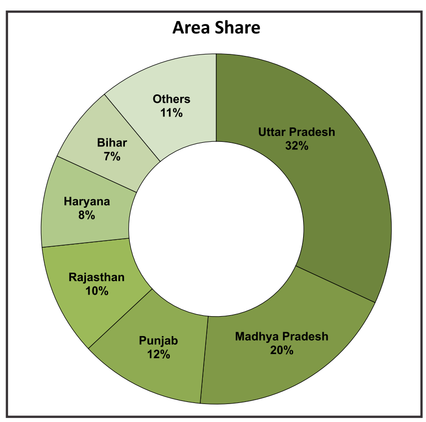
* and ** indicate the final and third advance estimates respectively from the DES, MoA&FW, India.

soil moisture for germination owing to warm temperature prevailed in Gujarat, Madhya Pradesh and Rajasthan coupled with late harvesting of rice and/or sugarcane varieties in pockets of Uttar Pradesh, Haryana and Punjab led to the fall in wheat area sown.

Perusal of state wise production indicated that Uttar Pradesh tops the list with 26.87 mt, followed by Madhya Pradesh (17.69 mt), Punjab (16.08 mt), Haryana (11.35 mt), Rajasthan (9.87 mt) and Bihar (4.75 mt). These top six states together contributed about 93 per cent of the total production. Barring Gujarat and Maharashtra, the rest of the major producers showed an increase in production in comparison to 2014-15. Production in these two states has declined by 1.13 mt owing to the fall in yield levels and acreage in the case of Maharashtra and decline in the crop acreage in Gujarat during 2015-16. The increase in wheat production was maximum in the case of Uttar Pradesh (4.46 mt), followed by Punjab (1.03 mt) and Haryana (1 mt).



Wheat acreage during 2015-16 has declined by 1.24 mha with regional differences in terms of magnitude. The highest decline was noticed in Maharashtra (0.44 mha), followed by Gujarat (0.26 ha), Rajasthan (0.21 mha) and Uttar Pradesh (0.20 mha). Yet, Uttar Pradesh occupies more area under wheat (9.65 mha), followed by Madhya Pradesh (5.91 mha), Punjab (3.50 mha), Rajasthan (3.11 mha), Haryana (2.58 mha) and Bihar (2.16 mha). All these states together cover about 89 per cent of the total area and produce 93 per cent of the total wheat. Among states, Himachal Pradesh, Chhattisgarh, Asom and West Bengal registered an increase in the crop acreage during 2015-16 in comparison to 2014-15 and the highest increase was noticed in Himachal Pradesh (15,000 ha). The percentage decline in acreage was highest in the case of Maharashtra, followed by Gujarat and Telengana. States like Jharkhand, Karnataka, Maharashtra and Telengana have registered a decline in both area and yield which had a significant reduction in the national output relative to their previous year's production.

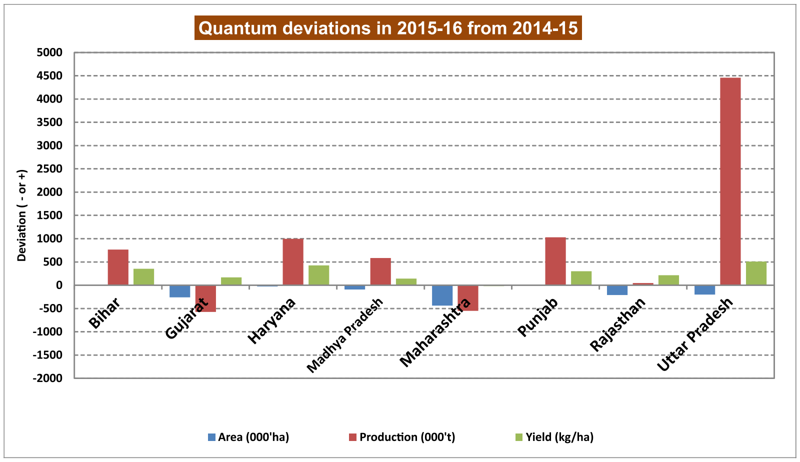


Area Contribution of yield and/or area to wheat production (2015-16)

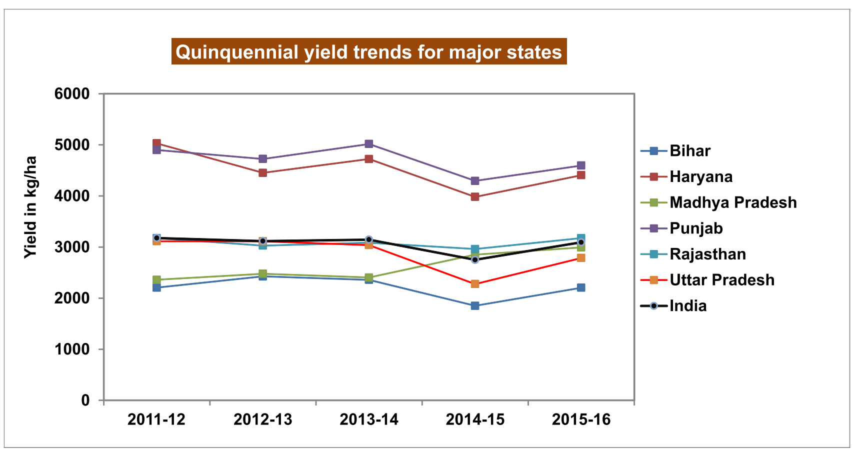
State/Country	Change in production in 2015-16* over 2014-15		% contribution by	
	Quantity (in '000 tonnes)	Deviation (in %)	Area	Yield
Asom	6	21.65	25.00	-4.06
Bihar	766	19.22	0.08	19.12
Chhattisgarh	2	1.55	10.41	-8.51
Gujarat	-575	-18.80	-23.47	6.10
Haryana	998	9.64	-0.96	10.70
Himachal Pradesh	33	5.05	4.57	0.56
Jammu & Kashmir	183	58.25	-0.01	58.31
Jharkhand	-56	-17.05	-5.86	-11.91
Karnataka	-88	-33.72	-13.64	-23.24
Madhya Pradesh	585	3.42	-1.52	5.00
Maharashtra	-550	-42.05	-41.05	-1.71
Odisha	-0.11	-16.67	20.00	-30.56
Punjab	1031	6.85	-0.17	7.03
Rajasthan	47	0.48	-6.31	7.23
Telengana	-2	-28.57	-16.67	-14.31
Uttar Pradesh	4457	19.88	-2.04	22.37
Uttarakhand	107	16.33	-1.66	18.30
West Bengal	21	2.21	1.56	0.63
Others	10	9.85	-2.28	14.20
INDIA	6974	8.06	-3.94	12.48

*Note: * indicate the fourth advance estimates from the DES, MoA&FW, India.*

Analysis on contribution of yield and/or area to the current year's wheat production indicated that the average productivity increase by 12.47 per cent (343 kg/ha) in 2015-16 has been the major reason for enhanced country's production by producing an additional 6.97 mt of wheat. State wise estimates showed that barring Gujarat and Maharashtra, the rest



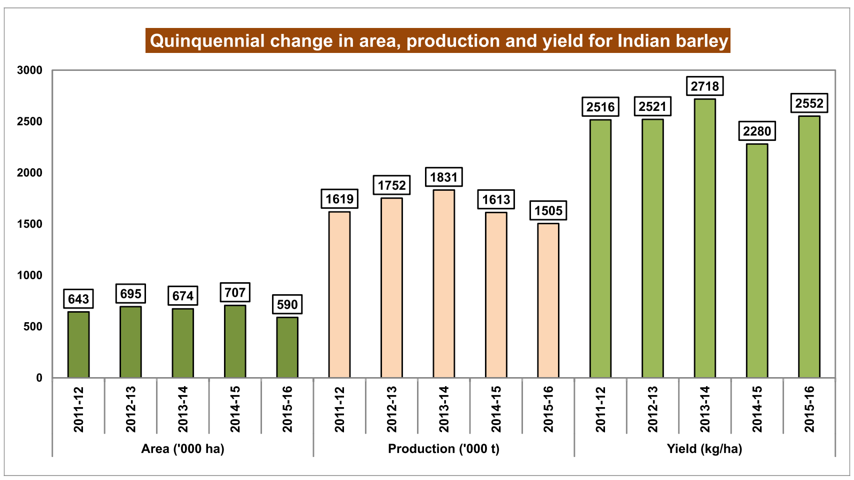
registered a significant increase in wheat production. With the exception of minor wheat growing regions, in the rest of the states like Bihar, Gujarat, Haryana, Madhya Pradesh, Punjab, Rajasthan and Uttar Pradesh the average yield levels have increased relative to 2014-15. Even then in Gujarat, the production has declined owing to the acreage fall by 23 per cent (- 0.26 mha). Yield levels varied across regions and it ranged from 4596 kg/ha in Punjab to 1000 kg/ha in Telengana. The increase in yield during 2015-16 was highest in Jammu & Kashmir (+ 571 kg/ha) and the fall was highest in Odisha (- 504 kg/ha).

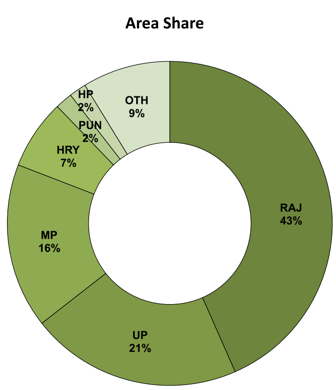


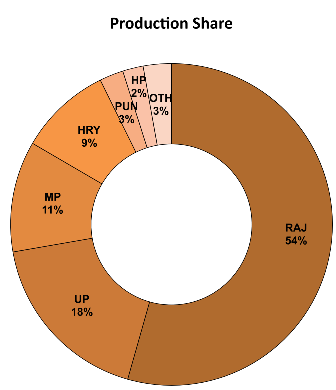
Scenario for Barley in India

Barley, the nutri-rich and competing cereal for wheat experienced a reverse kind of scenario. The current year production of barley witnessed a quantum fall of 0.11 mt registering 1.51 mt which is attributed to decline in the crop area by 16.55 per cent despite an increase the average productivity by 11.93 per cent (4th Advance Estimates from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India). The overall reduction in area has been estimated at 1.17 lakh hectares despite the increase in the support price by Rs.75 per quintal in comparison to the previous year and announced as Rs.1225 per quintal of barley. Since the *Rabi* season (2015-16) has encountered weather anomalies and fraught with uncertainites similar to 2014-15, the yield and consequently production in both the years reduced significanlty in comparion to 2013-14. Area decline is a serious concern for barley researchers since the choice of farmers shifts to remunerative crops like mustard and pulses.

Perusal of state wise estimates indicate that Rajasthan tops the list in barley production (0.82 mt), followed by Uttar Pradesh (0.27 mt) and Madhya





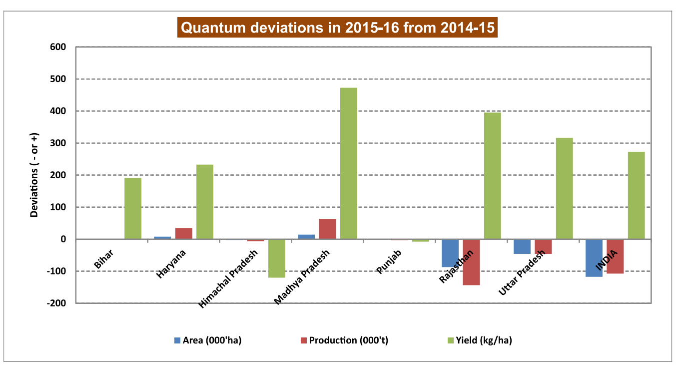


Quantum change in area, production and yield of barley

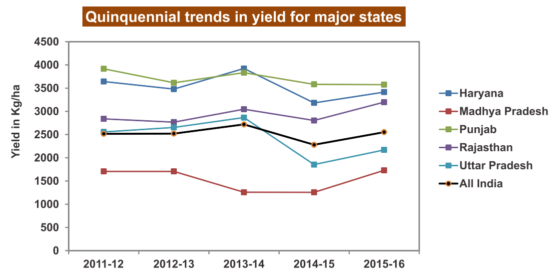
State/ Country	2014-15 (Final Estimates)*			2015-16 (Third Estimates)**			Quantum Change in		
	Area (000'ha)	Production (000't)	Yield (kg/ha)	Area (000'ha)	Production (000't)	Yield (kg/ha)	Area (000'ha)	Production (000't)	Yield (kg/ha)
Bihar	12	13	1109	11	14	1300	-1	1	191
Chhattisgarh	2	3	1304	2	1	500	0	-2	-804
Haryana	33	105	3182	41	140	3415	8	35	233
Himachal Pradesh	22	38	1739	19	31	1619	-2	-7	-120
Jammu & Kashmir	7	4	602	7	4	642	0	0	40
Madhya Pradesh	83	104	1257	97	168	1730	14	64	473
Punjab	11	39	3582	10	36	3574	-1	-3	-8
Rajasthan	343	962	2803	256	819	3198	-87	-144	395
Uttar Pradesh	170	315	1853	124	269	2169	-46	-46	316
Uttarakhand	21	25	1149	19	18	947	-2	-7	-202
West Bengal	2	3	1500	3	4	1400	1	1	-100
Others	1	1	1139	1	1	1466	0	0	327
INDIA	707	1613	2280	590	1505	2552	-117	-108	272

* and ** indicates the final and fourth advance estimates respectively from the DES, MoA&FW, India.

Pradesh (0.17 mt). These three states altogether accounted for 83 per cent of total national barley production. Rajasthan had the maximum area under barley (0.26 mha) during 2015-16 and contributed a share of 43 per cent to the total area under the crop in India, a plausible reason for its high share in production as well (54 %). In the 2015-16 *Rabi* season, the average crop productivity in barley was highest in the case of Punjab (3574 kg/ha) followed by Haryana (3415 kg/ha), Rajasthan (3198 kg/ha) and Uttar



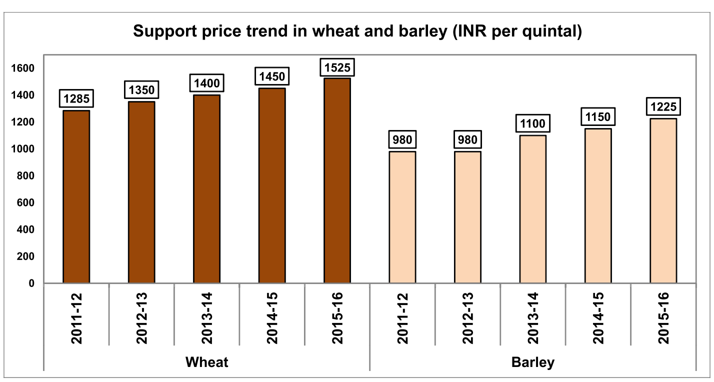
Pradesh (2169 kg/ha). These states with their consistent higher yield coupled with high area under barley cultivation helped to produce 1.51 mt.



Despite the increase in national average productivity level during 2015-16 in comparison to the previous year, a wide range of yield reduction was observed as well across states. The decline was highest in Chhattisgarh (-804 kg/ha), followed by Uttarakhand (-202 kg/ha), Himachal Pradesh (-120 kg/ha) and West Bengal (-100 kg/ha). However, some states like Bihar, Haryana, Jammu & Kashmir, Madhya Pradesh, Rajasthan and Uttar Pradesh have registered a higher yield in 2015-16 in comparison to 2014-15. The maximum positive growth in yield was noticed in Madhya Pradesh (+37.63 %), followed by Bihar (+17.22 %) and Uttar Pradesh (+17.07 %). In terms of quantum change, it was highest in the case of Madhya Pradesh (+473 kg/ha), followed by Rajasthan (+395 kg/ha) and Uttar Pradesh (+316 kg/ha). It is also interesting to note that Haryana and Madhya Pradesh have showed an increase in all the three variables *viz.,* area, production and yield.

Price Scenario for Wheat and Barley

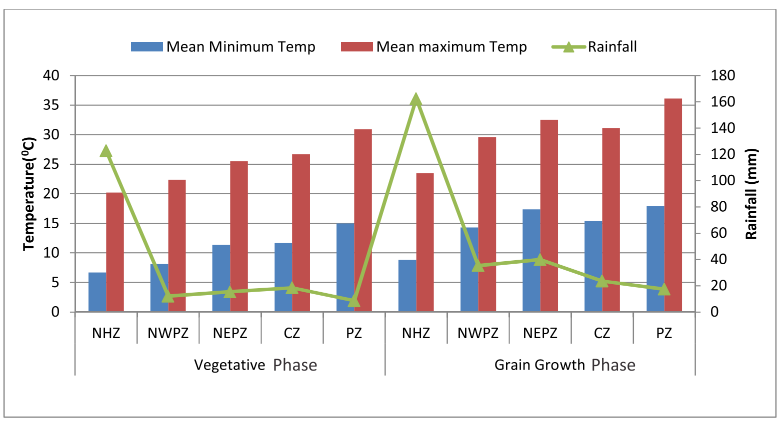
Perusal of the support price (in nominal terms) over years indicates a continuous increase for both wheat and barley. However, in 2015-16, the magnitude of change in the support prices over 2014-15 had a negative impact on both the crops acreage as they declined marginally due to other external factors. It is also clear from the quinquennial data that the support price difference between wheat and barley hover around Rs. 300 per quintal.



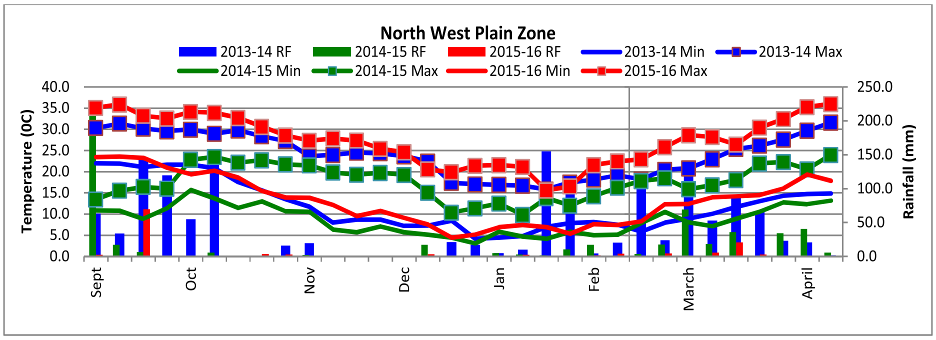
Weather Report 2015-16

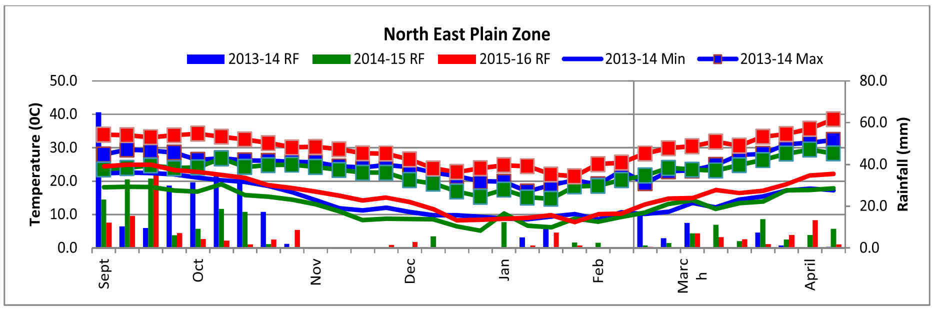
Meterological data was provided by 69 centres covering Northern Hills Zone (NHZ : 7), North Western Plains Zone (NWPZ : 15), North Eastern Plains Zone (NEPZ : 22), Central Zone (CZ : 13) and Peninsular zone (PZ : 12). The mean minimum temperature and mean maximum temperature were 14.3^{0}C and 29.6^{0}C in NWPZ and 17.4^{0}C and 32.5^{0}C in NEPZ during grain filling period. The mean maximum temperatures were below 30^{0}C in NHZ, above 30^{0}C in PZ, NEPZ and CZ and near 30^{0}C in NWPZ. The mean minimum temperature was highest (17.9^{0}C) in PZ followed by 17.4^{0}C in NEPZ and was below 15^{0}C in NHZ and NWPZ during grain growth. Compared to weather data collected during the crop season 2014-15, during grain growth phase the mean maximum and minimum temperatures were higher in all the zones. The mean maximum temperature was higher by 10.0^{0}C (NWPZ), 8.1^{0}C (PZ), 7.0^{0}C (NEPZ) and 2.7^{0}C (CZ) and mean minimum by 4.2^{0}C (NWPZ), 3.0^{0}C (NEPZ), 2.7^{0}C (PZ) and 1.8^{0}C (CZ).

All the zones received rainfall during the crop season. Maximum rainfall of 285 mm was recorded in NHZ. WhereasNWPZ, NEPZ and CZ received 40–50 mm rainfall and PZ received 26 mm rainfall during the crop duration (November–mid April). Compared to previous crop season, NHZ received more rainfall. All the zones experienced more rainfall during grain growth period. In CZ and PZ, most of the locations had heavy spell of rainfall in September i.e. before wheat sowing.



Compared with data collected during the previous four crop seasons, the mean minimum and maximum temperatures during 2015-16 were higher in all the zones except mean maximum temperature in CZ during 2011-12 and NHZ during 2012-13. The mean minimum temperature was higher by 0.1^{0}C in NEPZ to 2.2^{0}C in PZ than that of 2011-12, 0.7^{0}C in NHZ to 3.1^{0}C in PZ (2012-13), 0.9^{0}C in CZ to 1.8^{0}C in NEPZ (2013-14) and 1.4^{0}C in CZ & NHZ to 3.2^{0}C in NWPZ (2014-15). Similarly, mean maximum temperature was higher than that of 2011-12 by 2.1^{0}C in NWPZ to 5.4^{0}C in NEPZ, 0.3^{0}C in CZ to 5.4^{0}C in PZ (2012-13), 0.8^{0}C in CZ to 6.1^{0}C in PZ (2013-14), 1.8^{0}C in CZ to 8.2^{0}C in NWPZ (2014-15).





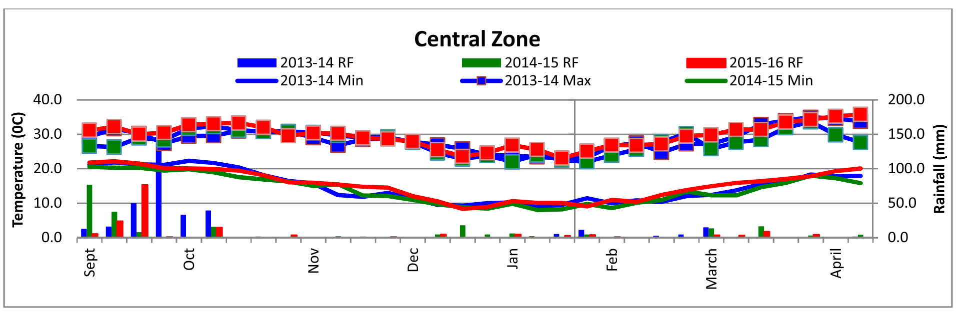
In NWPZ, the weekly average minimum temperature was higher than two preceding crop seasons except two weeks before grain growth. During vegetative phase, the temperature was higher during November but afterwards it remained below 10^{0}C. During grain growth also the temperature was higher than those in previous four crop seasons. The mean minimum temperature was above 15^{0}C from 13th week in contrast to 2014-15 and 2013-14 where it occurred after 15th week. Mean maximum temperature of 30^{0}C was recorded from 12th week; 4 weeks earlier than 2014-15, 3 weeks than 2013-14, 2 weeks than 2012-13 and 1 week earlier than 2011-12. A spate of rainfall was recorded from the zone during early March and for rest of the period there was no or scanty rainfall.

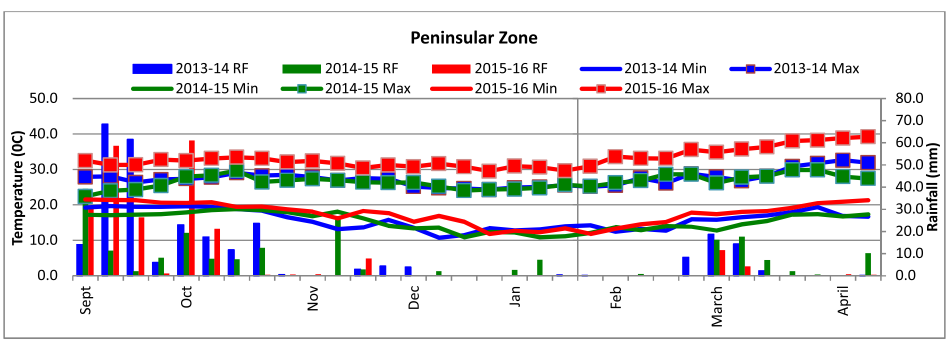
In NEPZ also the mean minimum temperature above 15^{0}C was earlier by three and two weeks compared to 2014-15 and 2013-14 crop seasons respectively. In this zone the minimum temperature was above 10^{0}C upto

50^{th} week; higher than those of preceding three crop seasons, but lower than those during 2011-12. The mean maximum temperature was recorded above 30^{0}C from 9^{th} week. The mean maximum temperature was higher throught out the crop season than preceding four seasons. From mid February onwards the zone received rainfall almost every week.

In central zone, the average maximum 30^{0}C temperature was recorded from 10^{th} week compared to 12^{th} week in 2014-15 and 11^{th} week in 2013-14. Compared to previous year, maximum temperature was slightly lower during 7^{th} and 8^{th} week (February) and higher for rest of the period. The zone received rainfall throughout the crop season.

In PZ, if compared with previous four sesons, mean minimum temperature during 4^{th} week (January end) was lowest while. 5^{th} week onwards it was higher. The mean maximum temperature was higher than the four preceding crop seasons throughout the crop season. The mean minimum temperature of 15^{0}C was recorded throughout crop season except for the period 52^{nd} week to 6^{th} week (7 weeks); during 2014-15 it remained less than 15^{0}C for 15 weeks (48^{th} to 10^{th} week). Mean maximum temperature of 30^{0}C was recorded throughout the crop season. The zone received scanty or no rainfall during the crop season except 47^{th} and 9^{th} week. The rainfall was lesser than 2014-15 and 2013-14.





MAJOR RESEARCH ACHIEVEMENTS

Crop Improvement

Development and release of new wheat varieties for different zones

The Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) recommended the release of four wheat varieties, namely Raj 4238, UAS 347, HS 562, and HD 4728 (durum), during the year 2015-16.

Wheat varieties released by CVRC during 2015-16

SN	Variety name and parentage	Area	Developed by	Production Condition	Grain yield (q/ha)	
					Average	Potential
1.	**UAS 347** *(TOB/ERA/TOB/CNO67/#/PLO/7/VEE#5/5/KAUZ/6/FRET2)/ DWR162)*	PZ	UAS, Dharwad	Rainfed, Timely sown	18.4	24.6
2.	**HS 562** *(OASIS/SKAUZ//4*BCN/3/2* PASTOR)*	NHZ	IARI RS, Shimla	Rainfed/ irrigated, Timely sown	36.0 (RF) 52.7 (IR)	58.8 (RF) 62.2 (IR)
3.	**HD 4728** *(Pusa Malwi)* (Durum) *(ALTAR84/STINT//SILVER453/SOMAI 3.1/4/GREEN14/YAV10/AUK*	CZ	IARI, N. Delhi	Irrigated, Timely sown	54.2	75.1
4.	**Raj 4238** *(HW2021/RAJ3765)*	CZ	SKNAU, Durgapura	Irrigated, Late sown	45.5	62.8

State released varieties

During the year 2015-16, notification of seven wheat varieties namely PBW 658, MPO 1255 (durum), HD 3117, HDCSW 18, GW 451, NIAW 1994 and MP 3382 under different production conditions prevailing in the named states were recommended for notification by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC).

Wheat varieties released by SVRC during 2015-16

SN	Variety name and parentage	Area	Developed by	Prod. condition	Grain yield (q/ha)	
					Av.	Pot.
1	**PBW 658** *(CS/Th.sc//3*PVN/3MIRLO /BUC/4/MILAN/5/TILHI)*	Punjab	PAU, Ludhiana	Irrigated, Late sown	46.7	60.7
2	**MPO 1255** *(MPO (JW) 1255* (Durum) *(ALTAR84/STINT//SILVER45)*	M.P.	JNKVV, Powarkheda	Rainfed/ Restricted irrigation	21.3 (RF), 33.8 (RI)	34.5 (RF), 47.3 (RI)

3	**MP 3382** *(JW 3382) (CHOIX/STAR/3/HE1/3*CNO79 //2*SERI/4/GW273)*	MP	JNKVV, Jabalpur	Irrigated, Timely sown	59.2	79.4
4	**HD 3117** *(HD2733/HD2824//DW1278)*	National CapitalRegion	IARI, N. Delhi	CA under late sown	47.9	50.1
5	**HDCSW 18** *(PBW 343/CL1538)*	NCR	IARI, N. Delhi	CA under early sown	63.0	73.0
6	**GW 451** *(GW324/5/CROC_1/AE.SQUA RROSA(205)//JUP/JY/3/SKAUZ/ 4/ KAUZ/6/GW339)*	Gujarat	SDAU, Vijapur	Irrigated, Timely sown	53.9	66.0
7	**NIAW 1994** *(Phule Samadhan) (NIAW34/PBW435)*	Maha.	MPKV, Niphad	Irrigated, Timely sown	46.1 (TS), 44.2 (LS)	62.0 (TS), 57.9 (LS)

Registration of new genetic stocks

In all, twenty genetic stocks of wheat were found suitable for registration by the Plant Germplasm Registration Committee, based on the traits like gluten content, heat tolerance and disease resistance to rusts, blight and Karnal bunt during the year 2015-16. The genetic resources unit of the IIWBR, Karnal multiplies the seeds of these registered genetic stocks and supplies to breeders across the country for use in wheat improvement.

Genetic stocks registered during 2015-16

SN	Name	Registration number	National ID number	Trait
1	WH 1127	INGR 15020	IC0610417	High gluten index (86%)
2	IC 536140	INGR 15022	IC 0536140	Resistance to rust conferred by 3 minor APR genes viz., *Lr34/Sr57/Yr18/Pm38*; *Lr46/Sr? /Yr29//Pm39* & *Lr67/Sr55/Yr46/Pm 46*
3	EC 573562	INGR 15023	EC573562	
4	DHTW 60	INGR 15021	IC036761A	Heat tolerance
5	KBRL 77-1	INGR 15039	IC0616061	Resistance to Karnal bunt
6	KBRL 81-1	INGR 15043	IC0616065	Resistance to Karnal bunt and high 1000-grain weight
7	KBRL 78-2	INGR 15040	IC0616062	
8	KBRL83-3	INGR 15045	IC0616067	Resistance to Karnal bunt and high number of tillers/m
9	KBRL 79-2	INGR 15041	IC0616063	
10	KBRL 82-2	INGR 15044	IC0616066	Resistance to Karnal bunt and high number of grains per spike
11	KBRL 80-3	INGR 15042	IC0616064	
12	LBRIL102	INGR 15060	IC0611477	Resistance to leaf blight
13	LBRIL 189	INGR 16013	IC0611476	Resistance to leaf blight
14	PAU 16062	INGR 15051	IC0616577	Resistance to all the test pathotypes of leaf and stripe rusts and carrying *Lr57* and *Yr40* genes transferred from *Ae. geniculata*
15	PAU 16055	INGR 15046	IC0616571	

16	PAU 16057	INGR 15047	IC0616573	Resistance to all pathotypes of leaf and strip rusts. Carrying leaf and strip rust resistance genes *LrU* and *YrU* transferred from *Ae. umbellulata* (accession 3732) and from *Ae. peregrina* (accession 3519)
17	PAU 16058	INGR 15048	IC0616574	Resistance to leaf and strip rusts. Carrying leaf and stripe rust resistant genes transferred from *Ae. peregrina* (PAU accession 3519).
18	PAU 16059	INGR 15049	IC0617118	Leaf and stripe rust resistance (APR) genes transferred from Wild 'A' genome species T. *monococcum* into wheat cv. WL 711.
19	PAU 16060	INGR 15050	IC0616575	Resistance to all the test pathotypes of leaf and stripe rusts and carrying resistance genes transferred from *Ae. caudata*
20	PBW 703	INGR 15052	IC0616578	Resistance to leaf rust and stripe rust (resistant version of PBW 343)

Registration of varieties with the PPV&FRA

During this year 19 registration proposals were submitted to PPV&FRA, New Delhi for seeking protection under PPV&FRA, 2001. It included six proposals (HS 3059, HD 3090, DBW 107, DBW 110, MACS 6478 and DBW 93) under the new variety category, 12 proposals (HI 8737, HPW 349, HI 8713, GW 11, GW 1255, HW 1095, HW 1098, HW 5216, HS 542, HS 507, HD 2932 and HD 3118) under extant variety category, and one proposal (KBRL 77-1 Karnal bunt resistance in the back ground of PBW 343) under EDV category.

Coordinated Yield Trials - Summary of Results

Conduction of coordinated trials

The wheat coordinated varietal evaluation programme is undertaken with the cooperation of 33 funded and 108 voluntary centres spread across six wheat growing zones in the country. During the crop season 2015-16, a total of 26 series of trials comprising AVTs, NIVTs, IVTs and Special trials were laid out in different zones under four major production conditions *viz.* timely sown irrigated, late sown irrigated, timely sown restricted irrigation and timely sown rainfed condition.

This year altogether 395 test entries were evaluated along with 66 check varieties in different trials. A total of 456 trial sets were supplied to 141 centres out of which 436 trials were actually conducted but the data on 337 trials were found qualifying for reporting based on set norms. In all, 36 trials were rejected by the monitoring teams in various zones while the trials failed at 8 centres. The rest of the trials were not considered for reporting due to low site mean (31), late sowing (9), high coefficient of variation (5), HCV or low site mean (6) and other anomalies like unrealistic yield (3) and early sowing & unrealistic yield (1).

The conduction of trials was 100% in North Western Plains Zone and Central Zone. In North Eastern Plains Zone trial conduction was 99.1%, while it was 89.7% in Peninsular Zone. In Southern Hills Zone and North Hills Zone trial conduction was 85.7% and 83.3%, respectively. The overall conduction of trials during the crop season was 95.6 percent.

Percent success in trial conduction and reporting during 2015-16

Zone	% conduction of proposed trials	% reporting of conducted trials
NHZ	83.3	65
NWPZ	100	90.5
NEPZ	99.1	71.2
CZ	100	79.1
PZ	89.6	72.1
SHZ	85.7	50
Total	**95.6**	**77.3**

Varieties in final year of testing

There were 10 varieties in the final year of evaluation in various AVTs and Special trials in different zones during the year under report. Out of these five genotypes were under MABB and Special-WB trial evaluation while three were under rainfed / restricted irrigated testing.

Varieties in final year of testing during 2015-16

SN	Trial	Final year entries
Northern Eastern Plains Zone		
(i)	AVT-RF-TS-TAS	HD 3171, K 1317
Central Zone		
(i)	AVT-IR-TS-TAD	HI 8759 (d)
Peninsular Zone		
(i)	AVT-IR-TS-TAD	MACS 3949 (d)
(ii)	AVT-RI-TS-TAD	HI 1605
Special Trial		
(i)	MABB-IR-LS-NWPZ	PBW 723
(ii)	MABB-IR-LS-CZ/PZ	HD 3209
(iii)	SPL-WB	WB 2, HPBW 01, HPBW 02

Promising varieties in Advanced Varietal Trials

The revised criteria for promotion of varieties based on significant superiority of genotypes over the best check of the trials was implemented and 55 genotypes were evaluated in AVTs conducted in different zones during this crop season. This year only 7 genotypes were identified to be superior on the basis of their yield performance with respect to the best check varieties of the trials and their response to the incidence of rusts. The entries found promising were one each under irrigated timely sown and late sown condition; two entries were under restricted irrigation condition and three under rainfed condition. While, among the 33 genotypes tested in 7 special trials conducted for specific requirements, only one genotype for very late condition (January sown) was found promising.

Most promising Varieties in AVTs and Special trials, 2015-16

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Restricted irrigation	Timely sown, Rainfed
NHZ	-	-	-	-
NWPZ	-	DBW 173	DBW 179	-
NEPZ	-	-	HI 1612	-
CZ	-	-	-	-
PZ	DBW168	-	-	UAS 375, MACS 4028(d), HI 8777(d)
Special trials				
SPL-VLS	PBW 757			

Promising varieties in NIVTs and IVTs

In seven NIVTs, 277 new entries were evaluated, and 27 entries were found promising on the basis of high yielding ability and disease resistance. Ten entries were observed to be promising for timely sown irrigated condition, two for late sown irrigated condition and 15 for restricted irrigation condition. Under different conditions at the zonal level, 18 entries showed promise in NWPZ, five in NEPZ, and four in CZ.

In NHZ under IVTs, altogether 38 new entries were tested in rainfed and irrigated conditions and restricted irrigation condition in SHZ. Only one entry in SHZ was found performing significantly superior to the checks.

Promising entries in NIVTs and IVTs, 2015-16

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Restricted irrigation
NIVTs			
NWPZ	DBW 189, WH1202, BRW 3773, UP 2942, HP 1963, DBW 196, PBW 750, HD 3226	PBW 752, HI 1617	HD 3237, HI 1620, HI 1619, CG 1023, PBW 758, MP 1318, HS 611, MACS 6677
NEPZ		-	HI 1620, HS 611, UAS 384
CZ	-	-	BRW 3775, UAS 385, UAS 462(d), HI 8791(d)
SHZ	-	-	UAS 387

Monitoring of coordinated trials and nurseries

This year three teams in each zone consisting five scientists of multidisciplinary scientists, were constituted to monitor almost all the trial conducting centres in the six zones. Monitoring of coordinated trials and nurseries was carried out during February to April, 2016 for examining the conduction of trials and performance of test genotypes in each of the six wheat growing zones. The total number of centres monitored was 111 out of 141 centres where trials were conducted during this crop season. As many as 36 trials were rejected by the monitoring teams in different zones. The comments of the members of the zonal teams on the genetic purity of test genotypes would be taken into account for promotion, retention or dropping of a particular test entry during the group meeting at the ensuing workshop.

The monitoring teams recommended the rejection of the trials based on poor conduction, faulty layout, poor plant stand, sowing beyond the recommended dates, etc. The monitoring teams observed variation, segregation for different traits in some of the test genotypes. The entries recommended for dropping from further testing by different monitoring teams in various trials are as below.

Entries dropped from further testing

Trial	Entries dropped for further testing
NIVT-1A	N-1A-123 (K 1503), N-1A-125 (UP 2937), N-1A-133 (HD 3221), N-1A-148 (DBW 190)
NIVT-1B	N-1B-210 (JKW 225)- red grains, N-1B-223 (UBW-8)- light red grains, N-1B-211 (NW 6093), N-1B-204 (DBW 199), N-1B-225 (K 1505)
NIVT-2	N-2-322 (WH 1208), N-2-321 (HD 3231)
NIVT-3A	N-3A-401 (PBW 754), N-3A-408 (K 1514)
NIVT-3B	N-3B-519 (RVW 4241)
NIVT-5A	N-5A-721 (PBW 758), N-5A-715 (MP 3466), N-5A-735 (MP 1317)

New crosses made by AICW&BIP and ICAR centres during 2015-16

The strength of the breeding programme at major and small centres across the zones can be gauged from the crosses produced at the centres. Among the major centres in NWPZ, PAU Ludhiana had the biggest crossing programme followed by Pantnagar, Durgapura and Hisar. Sabour, Kanpur, Faizabad, Varanasi and Coochbehar made a major contribution in NEPZ. In CZ, Vijapur, Jabalpur, Powarkheda followed by Junagadh, Sagar and Bilaspur made a strong attempt for increasing the crossing programme. Similarly in PZ, Dharwad, Niphad and Pune made good number of crosses. The coordinated centres involved in wheat improvement made a total of 7139 crosses during this season as per the priorities and requirements of zone.

Among the ICAR institutes involved in wheat improvement, centres of IARI and IIWBR, Karnal were major contributors to the total crossing programme in the country accounting 5303 crosses. The total crosses made during the crop year 2015-16 numbered 12442.

Evaluation of National and International Nurseries/Trials

National Nurseries

Eight national nurseries and two segregating stock nurseries were constituted at IIWBR and supplied to different cooperating centres located across the various zones for evaluation and utilization as per their requirement during the crop season 2015-16.

The Salient features observed in various national nurseries are as below:

Nurseries shared with cooperators

SN	Nurseries	Genotypes + Checks #	Cooperating centres #
National Nurseries			
1	National Genetic Stock Nursery (NGSN)	60 + 2	30
2	Yield Components Screening Nursery (YCSN)	105 + 4	25
3	Salinity-Alkalinity Tolerance Screening Nursery (SATSN)	55 + 4	9
4	Short Duration Screening Nursery (SDSN)	36 + 6	22
5	Drought Tolerance Screening Nursery (DTSN)	46 + 3	12
6	Quality Component Screening Nursery (QCSN)	51 + 3	12
7	Elite International Germplasm Nursery (EIGN)	94 + 4	24
8	National Durum Screening Nursery (NDSN)	91 + 3	13
Segregating stock nurseries			
1	Segregating Stock Nursery (SSN)	83 F_2 & F_3	18
2	Spring x Winterwheat Segregating Stock Nursery (SWSN)	41 F_2	6

(1) ***National Genetic Stock Nursery (NGSN):*** It comprises elite lines, confirmed genetic stocks for yield traits, disease resistance and quality traits and was supplied to breeding centres as a suggested crossing block. During 2015-16, 60 lines were provided to 30 centres. On the basis of utilization report received from 24 locations, it was found that 26% genotypes in the NGSN were either directly used for selection or utilized in hybridization as parents.

Promising lines identified for yield component and quality traits in NGSN during 2015-16

Characteristics	Criteria	Promising Genotypes
Yield components		
Tillers/m	>115	HW 4013, MACS 5031 (dic.), HW 1099 (dic.), DDK 1044 (dic.), KBRL 81-1
Grains /spike	>60	JS 6-1, HW 1900, GW2010-288
1000-gr weight (g)	>45	PHSL 5, LBPY 11-9, RAJ 4304, PHS 1106, LBPY 11-2, GW2010-288, GW 2011-362, PHSL 10
Spike length (cm)	>11	JS 6-1, PHSL 5, GW 2010-288, UP 2847, GW 2011-346, PHSL 10, NW 5013, PHS 1106, LBPY 11-2, HPW 381
Processing and nutritional quality		
Test weight (kg/hl)	>83.0	KBRL 82-2, HUW 668, DBW 71, PBW 660, JAUW 598
Protein content (%)	>12.5	DBW 93, K 1006, HW 4013, PHSL 11, GW 2011-362, DBW 107 and PHSL 10
Sedimentation value (ml)	>55	UP 2872, VL 3001, HD 3098, DBW 88, DBW 90, NW 5054
Grain hardness index	>80 <45	KBRL 80-3, KBRL 81-1, KBRL 79-2, KBRL 83-3 HPW 381
Iron (ppm)	>42.0	GW2010-288, PHS 1106, K 1006, PBW 660, DBW 90
Zinc (ppm)	>41.0	RAJ 4250, K 1006, DBW 93, LBPY 11-9, PBW 660, HD 3095

dic-dicoccum

(2) ***Yield Component Screening Nursery*:** The 28th Yield Component Screening Nursery (YCSN) consisting of 105 genotypes was supplied to 25 centres. On the basis of superior performance for specific traits to three major yield components (tillers per meter row, grains per spike and 1000-grains weight) continuously for three years across locations, the trait specific entries were identified as promising genetic resources.

Promising genetic resources in YCSN

Trait	Promising genetic resources
Grains/spike (>55)	LBPY-2013-01, LBPY-2013-03, LBPY-2013-05, NIAW2349
Tillers/meter (>85)	HI1600, NIAW2064, RAJ4393
1000-grains weight (>45g)	HI1600, KB-2013-05, LBPY-2013-05, RAJ4350, RAJ4394

(3) ***Short Duration Screening Nursery*:** The 29th Short Duration Screening Nursery comprising 36 entries and 6 checks was conducted at 22 locations. Early maturing genotypes tolerant to high temperature during grain filling period under late sown conditions were identified. The genotype RWP 2013-10 was found superior to check during 3 years of testing in NWPZ, PZ and NHZ. The entries showing consistently superior performance as compared to checks are listed here.

Promising lines (grain yield per plot) identified from SDSN on the basis of two years of testing

Zone	Germplasm line	Best check
NWPZ	RWP 2013-10 (531g), RWP 2013-9 (473g)	DBW 71 (C) (429g)
NEPZ	GW 2012-475 (305g)	DBW 71 (C) (258g)
PZ	RWP 2013-10 (386g),	DBW 71 (C) (365g)
NHZ	RWP 2013-10 (425g), RWP 2013-9 (375g)	WR 544 (C) (331g)

(4) ***Drought Tolerance Screening Nursery (DTSN)*:** The 28th DTSN having 46 entries and three checks (C 306, AKAW 3717 and NI 5439) was supplied to 12 wheat research centres. Drought sensitivity index (DSI) was calculated for each centre. Genotypes having DSI value less than 0.5 were considered as less sensitive to drought. The pooled analysis of data across zones as well as across centres revealed that RW 5 (0.44) showed minimum yield reduction under drought condition across the zones.

List of drought tolerant genotypes

Zone	Genotypes
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 indicate DSI values

(5) ***Salinity-Alkalinity Tolerance Screening Nursery*:** The nursery comprising 55 test entries and 4 checks viz., Kharchia 65, HD 2009, KRL 19, KRL 210 and HD 2009 was evaluated at nine locations in four states under augmented design. Eight entries were identified as higher yielding along with resistance to all the three rusts (stem, leaf and yellow rust). These genotypes would be tested in special trial for salinity/alkalinity conditions.

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

S.N.	Entry	Plot Yield(g)	Stem rust	Leaf rust	Stripe rust
1	KRL 377	586.2	5S (1.4)	10S (2.0)	40S (12.8)
2	WS 1504	550.2	tR (0.1)	10MS (1.6)	0 (0.0)
3	RWP 2015-17	537.0	30MS (11)	0 (0.0)	80S* (11.3)
4	KRL 370	535.5	10S (2.6)	0 (0.0)	20S (5.6)
5	WH 1316	534.4	5S (1.3)	20S (4.8)	10S (2.7)
6	WS 1501	523.4	30S (11.6)	40S* (8.0)	40S (12.5)
7	KRL 384	519.0	15MR (1.6)	0 (0.0)	30S (8.8)
8	KRL 386	518.0	10S (3.1)	0 (0.0)	40S (7.5)
Best check	KRL 210	516.8			

***(6) Quality Component Screening Nursery*:** The QCSN comprising 51 test entries and three checks was planted at 12 locatios to identify new genetic resources for improvement of quality parameters.

Promising genotypes for individual quality parameters during 2015-16

Trait	Range	Genotypes
Protein content (%)	14.0-14.9	BWL1664, BWL 1660, BWL 991, GW 2014-596, QLD 46, QLD11, QLD78, UAS462(d)
Protein yield (g/m2)	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
High grain hardness index	77-80	PDW 233(d), DBPQ 02(d), GW 2013-503(d), QLD 79, GW 2014-593(d),
Low grain hardness index	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	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 (max.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

Values in the parenthesis indicates DSI and DTI values

***(7) Elite International Germplasm Nursery*:** The promising lines from the international germplasm nurseries and trials which are evaluated in India every year are utilized for constituting the Elite International Germplasm Nursery (EIGN) for bread wheat. The nursery comprising 94 entries was supplied to 24 centres. A total of 320 selections were made by different cooperating centres for further utilization.

Trait-wise promising entries from EIGN during 2015-16

Trait	Original entry numbers
Plant height <85cm)	15th DSBWYT 23, 15th SBWON 6, 13th HTWYT 714, 15th SBWON 1
Heading days <72d)	15TH ESBWYT 13, 13th HTWYT 712
1000-grains weight (>42g)	35th ESWYT 124, 22nd SAWYT 314, 22nd HRWYT 202, 32nd SAWSN 3161, 25th HRWSN 2036, 22nd SAWYT 340, 13th HTWYT706, 47th IBWSN1295
Grain yield/plot (>550g)	22nd SAWYT 314, 22nd SAWYT 334, 13th HTWYT 706, 13th HTWYT 707, 35th ESWYT 124, 13th HTWYT 745, 22nd HRWYT202, 9th STEMRRSN164
Yl rust (tR/tMS)	47th IBWSN 1089, 47th IBWSN 1112, 22nd SAWYT 320, 22nd SAWYT 334, 32nd SAWSN 3011, 32nd SAWSN 3189
Brown rust (0)	22nd HRWYT 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 ESWYT139, 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 (tR/tMS)	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

(8) ***National Durum Screening Nursery:*** The 2nd National Durum Screening Nursery (NDSN) comprising 91 lines from various international durum nurseries (41), YCSN (27), QCSN (8) and NGSN (5) were shared with 13 centres for identification of promising entries for yield components and disease resistance. The feedback reports of NDSN indicate that a large number of lines were selected by the breeders at different centres.

Trait-wise promising entries from NDSN

Trait	Entries
Days to maturity (<120 days)	GW 2015-676, GW 2011-361, GW 2014-565, AKDW 4905, GW 2015-678, GW 2015-679
Tillers/m (>110)	46thIDSN 7175, 46thIDSN 7214, 46thIDSN 7177
Thousand grains weight (>50g)	GW 2014558, 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
Spike length (>8.7cm)	GW 2015-690, GW 2014-558, GW 2015-682, GW 2012-436, GW 2015-675,
Grains per spike (>60)	46thIDYN 723, 46thIDYN 716, 46thIDSN 7013, 46thIDSN 7035, 46thIDSN 7175
Grain yield/plot (>510g)	46thIDSN 7040, 46thIDYN 723, 46thIDSN 7175, 46thIDSN 7173, 46thIDYN 749
Black rust resistance (tMR to 5MS)	46thIDSN 7179, 46thIDSN 7180, 46thIDSN 7188, GW 2014-566, GW 2014-668, HI 8770, HI 8774, GW 2015-675, GW 2015-683, GW 2015-684, GW 2015-690
Yellow rust resistance (tR)	46thIDYN 706, 46thIDYN 723, 46thIDYN 725, 46thIDYN 726, 46thIDYN 736, 46thIDYN 739, 46thIDYN 742, 46thIDYN 748, 46thIDYN 749, 46thIDSN 7012, 46thIDSN 7031, 46thIDSN 7034, 46thIDSN 7035, 46thIDSN 7081, 46thIDSN 7091, 46thIDSN 7116, 46thIDSN 7117, 46thIDSN 7121, 46thIDSN 7151, 46thIDSN 7155, 46thIDSN 7173, 46thIDSN 7174, 46thIDSN 7175, 46thIDSN 7186, 46thIDSN 7188, 46thIDSN 7214, 46thIDSN 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

Segregating stock nurseries

(i) Segregating Stock Nursery: The 19th Segregating Stock Nursery (SSN) comprising 83 segregating populations (F_2/F_3) was shared with 18 wheat breeding centres under AICW&BIP to enabling them to evaluate and select suitable plants as per the breeding objectives and cultural conditions. The utilization report indicated that the nursery could achieve 47.2% utilization and almost all the segregating populations were utilized by one or the other centre.

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**

(ii) Spring x Winter wheat Segregating Stock Nursery: The Spring x winter wheat segregating stock nursery comprising 41 crosses from F_2 generation was shared with six cooperating centres. More than 949 single plants were selected at Malan followed by Powarkheda (170).

Utilization report from cooperating centres

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

International Nurseries and Trials

During the crop season 2015-16, 137 sets of seven nurseries and five trials from CIMMYT comprising 1259 bread wheat and 191 durum wheat lines were evaluated at various wheat breeding centres across zones in the country.

One set of each nursery/trial was planted at Karnal in order to evaluate and multiply seeds to facilitate large number of wheat breeders from different centres for exercising *in-situ* selection during the field day (27th March, 2016) at Karnal. The best performing lines from these nurseries are utilized to constitute the Elite International Germplasm Nursery (EIGN) for bread wheat and National Durum Screening Nursery (NDSN) for supplying elite lines to cooperating centres for evaluation and utilization in wheat improvement. The promising genotypes identified from these nurseries and trials are summarized below.

Promising lines identified for various traits in CIMMYT international nurseries/trials

Trial/Nursery	Grain Yield	1000-grains weight
	Bread wheat	
23rd SAWYT	*(>44q/ha):* 306, 312, 315, 319, 323, 330, 337, 340,	*(>40g):* 317, 318, 321, 324, 325, 326, 337, 338
36th ESWYT	*(>50q/ha):* 104, 106, 107, 112, 115, 117, 118, 121, 128, 131, 133, 136, 142, 144,182	*(>40g):* 109, 110, 117, 125, 133, 150
14th HTWYT	*(>44q/ha):* 7, 25, 39, 40	*(>40g):* 7, 21, 27, 28, 36
23rd HRWYT	*(>60q/ha):* 205, 206, 207, 218, 223, 225, 226, 240, 242, 248	*(>40g):* 205, 206, 230, 239, 240, 248
48th IBWSN		*(>42g):* 1029, 1059, 1089, 1090, 1091, 1115, 1116
33rd SAWSN		*(>43g):* 3027, 3050, 3051, 3092, 3106, 3116, 3152, 3191, 3205, 3216, 3241, 3268
10th STEMRRSN		*(>44g):* 6002, 6038, 6041, 6142, 6152, 6155, 6159, 6160, 6173, 6178
26th HRWSN		*(>40g):* 2006, 2042, 2056
	Durum	
47th IDYN	*(>53q/ha):* 706, 710, 713, 716, 742, 743,748	*(>40g):* 737, 734, 707, 744
47th IDSN		*(>44g):* 7055, 7070, 7113, 7089, 7082

Bread wheat lines showing resistance to rusts and leaf blight

Trial / Nursery	Disease	Entry number
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

Seed Production

An indent of 20365.93q breeder seed of 155 wheat varieties was placed with the DAC for *Rabi* 2015-16. Variety HD 2967 was the most indented variety (2429.20q) in the seed chain. Other varieties from NWPZ included RAJ 4079 (985q), WH 1105 (911.40q), DPW 621-50 (628.80q), PBW 550 (565.60q) and DBW 17 (438q) ranking at 2nd, 3rd, 8th, 9th and 12th positions in overall indent. The indent of Rajasthan state notified variety RAJ 4079 has been further increased from 666q to 985q. Similarly, RAJ 4238 (343q) and RAJ 3765 (328q) were the popular varieties for late sown condition.

In North Eastern Plan Zone, apart from variety HD 2967, RAJ 4120 (723q), CBW 38 (359.40q), DBW 39 (350.40q) were the important varieties for timely sown condition. However, under late sown condition HI 1563 (439.20q) and HD 2985 (285.20q) were the main indented varieties. In CZ, GW 322 was highest indented with 905.40q followed by Lok 1 (709.20q), GW 366 (753.40q), HI 1544 (525.40q). Late sown variety HD 2932 had 328.80q breeder seed indent. The indent of PZ varieties HD 2987 and RAJ 4037 was 226.20q and 180.60q, respectively.

Breeder seed indent & production of top ten varieties

SN	Variety	Production year Indent (q)			Production (q)
		2013 - 14	2014 - 15	2015 - 16	2015- 16
1.	HD 2967	1313.88	2886.65	2429.20	4050.59
2.	Raj 4079	177.00	666.00	985.00	926.00
3.	WH 1105	39.00	200.00	911.40	1202.82
4.	GW 322	1162.20	763.60	905.40	2593.95
5.	Lok 1	729.30	709.20	860.80	930.00
6.	GW 366	833.95	674.40	753.40	1444.97
7.	Raj 4120	557.60	955.60	723.00	891.00
8.	DPW 621-50	621.37	660.60	628.80	860.00
9.	PBW 550	757.30	1100.40	565.60	498.50
10.	HI 1544	270.20	529.60	525.40	522.00

Breeder seed production: Breeder seed allocation to the tune of 19409.83q was finalized for production against the total indent of 20365.93q in the wheat workshop held at Dantiwada (Gujarat) in 2015. During the crop season a total of 28405.68q breeder seed production was reported from all the centres. Thus the breeder seed production showed a surplus of 8229.65q over the indented quantity. The maximum breeder seed was produced at

JNKVV-Jabalpur (5653.93q) followed by PAU-Ludhiana (3818.20q), IARI-Indore (1760.50q), SKNAU-Bikaner (1747q), GBPUAT-Pantnagar (1572q), MPUA&T-Kota (1319q), IARI-Karnal (1264.40q), CCSHAU-Hisar (1262q), BISA-Jabalpur (1100q).

The breeder seed production of varieties RAJ 4083, RAJ4229, RAJ 6560 at SKNAU Durgapura; K 9351, K 9423 and K 9465 at CSAUAT Kanpur; NW 1067 at NDUA&T Faizabad, UAS 428 at UAS Dharwad and PBW 226 at PAU Ludhiana failed. A net short fall in breeder seed production was reported in thirty three varieties. The major deficient breeder seed production observed at different breeder seed production centres is given below.

Varieties with deficient breeder seed production

Variety	Target (q)	Production (q)	Deficit (q)
SKNAU, Bikaner			
Raj 4079	822.00	672.00	150.00
Raj 4238	243.00	100.00	143.00
Raj 1482	200.00	90.00	110.00
Raj 3765	255.00	145.00	110.00
Raj 3777	143.00	100.00	43.00
CSAUAT, Kanpur			
K 9423	137.40	0.00	137.40
K 9351	88.00	0.00	88.00
K 9533	88.00	31.10	56.90
IIWBR, Karnal			
DBW 39	350.40	230.00	120.40
DBW 16	205.20	110.00	95.20
CBW 38	100.00	75.00	25.00
IARI, Pusa, Samastipur			
HI 1563	439.20	70.00	369.20
HD 2985	57.00	25.00	32.00
CCS HAU, Hisar			
WHD 943	80.00	53.00	27.00
GBPUAT, Pantnagar			
HD 2329	38.20	8.00	30.20
NDUA&T, Faizabad			
NW 1067	40.00	0.00	40.00
PAU, Ludhiana			
PBW 226	42.60	0.00	42.60
SKNAU, Durgapura			
Raj 4037	180.60	122.50	58.10
IARI, New Delhi			
HD 3043	183.80	66.80	117.00

Nucleus seed production: This year 850.45q nucleus seed of 133 varieties was allocated for production and a total 1517.17q nucleus seed of 160 varieties was produced. The maximum nucleus seed was produced for the variety GW 322 (96.10q) followed by GW 366 (87.75q), LOK 1 (86.90q), HD 2967(86.07q), HI 1544(48.20q), WH 1105(46.10q), MP(JW) 3211 (40q), HI 8663 (39q), GW 273 (38.85q), HD 2932 (38.21q), PBW 550 (35.30q), MP(JW) 3288 (30q), RAJ 4238 (27.30q), HD 2733 (27.05q), MP(JW) 1203 (26.20q), DBW 17 (25.60q), HD 3043 (24q), HI 8737 (23q), HD 3086 (22.50q).

Physiological investigations on thermal stress in wheat

The multilocation heat tolerance trial (MLHT) is conducted to identify heat tolerant genotypes among the AVT genotypes. Two trials, MLHT-1 (1st year AVT of NWPZ, NEPZ, CZ and PZ) and MLHT-2 (AVT 2014-15 genotypes in IR-LS trial of NWPZ, NEPZ, CZ and PZ and AVT-IR-TS of CZ and PZ) were conducted during crop season 2015-16. Each trial consisting of 25 genotypes including checks was evaluated at 14 centres (Values in parenthesis are HSI).

MLHT-2: The heat tolerant genotypes were identified based on the extent of reduction in grain yield under late sown conditions as compared to timely sown. The genotypes with HSI<0.5 were considered as less sensitive to high temperature. The two years pooled data analysis across locations indicated that the genotypes DBW 150 (0.35), GW 463 (0.48), HD 3118 (0.38), WH 1179 (0.50) were less sensitive to thermal regimes prevailing under late sown conditions.

MLHT-1: The HSI values ranged from 0.7 to 1.3 in the trial. Though none of the genotypes showed HSI<0.5, the genotypes having lower HSI viz., AKAW 4842 (0.7), MACS 6660 (0.9), NW 6046 (0.9) and PBW 737 (0.9) were found to be relatively less sensitive to thermal regimes under late sown conditions. Data on growth and yield parameters were recorded at all the centres. There was reduction in plant height, number of productive tillers, days to heading, anthesis and maturity, and thousand grains weight under late sown condition as compared to timely sown.

Marker assisted gene prospecting in AVT entries of wheat

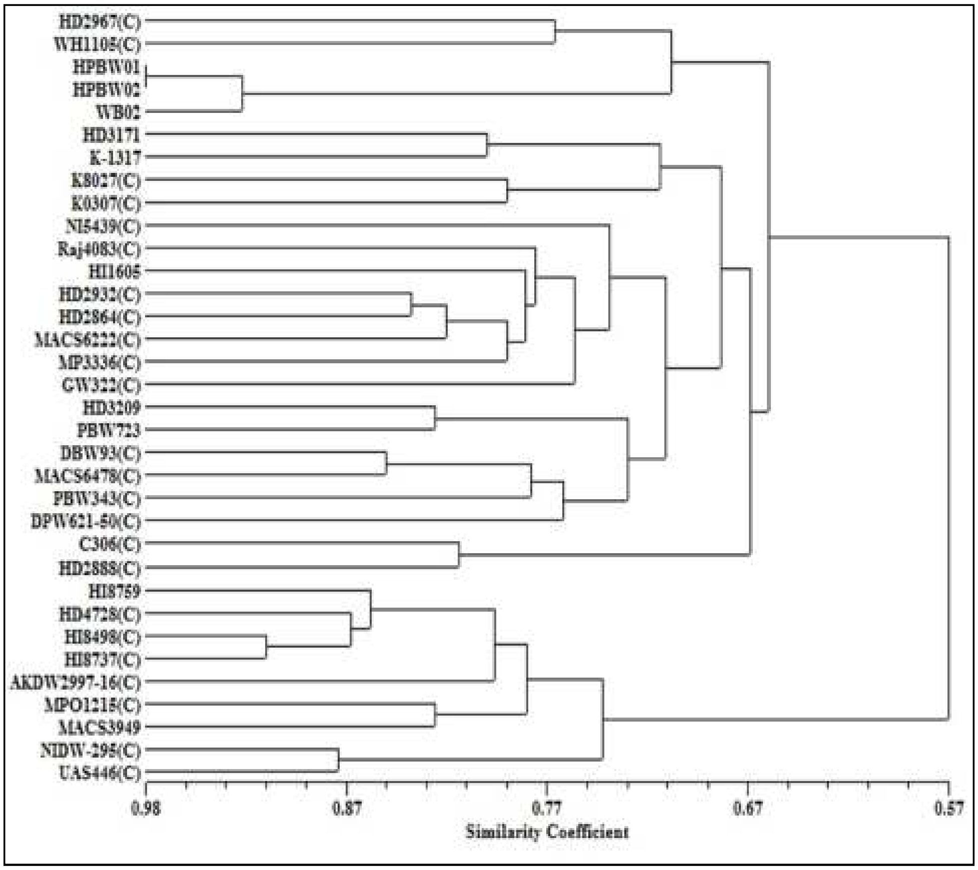
Molecular markers are used as selection tools by plant breeders to identify differences in DNA sequence which are less ambiguous as compared to phenotypic markers. The final year (2015-16) AVT test entries in different coordinated trials were screened using various STS/ AS-PCR markers for vivipary (*Vp1B3a*), polyphenol activity (*PPO*), leaf rust resistance (*Lr*) and vernalization (*Vrn*). The dendrogram depicted the genetic relationships among genotypes. Cluster analysis showed that genetic relatedness among the genotypes ranged from 0.57 to 0.98 i.e., 57–98%. There were two distinct clusters; one for the durum wheat varieties and the other primarily for bread wheat which gets reflected in the dendrogram based on genetic similarity. The set of markers utilized for the study could not distinguish HPBW 01 and HPBW 02. The allele distribution using STS / AS-PCR markers in the genotypes screened is given below.

Profile of the AVT entries and checks using STS/AS-PCR markers

Variety	*Lr10*	*Lr34*	*Vr01a*	*Vr01bR1*	*VP1B3*	*WxB1*	*PPO18*	*DUPW004*	*Ppd-D1*						
	380	180	230	965	800	600	620	500	450	685	875	250	350	228	414
HD2967 (C)	-	-	-	-	-	-	-	-	-	+	-	-	+	+	-
WH1105 (C)	-	-	-	+	+	-	-	+	+	+	-	+	-	+	-
HD3171	+	-	+	-	+	-	+	+	+	+	-	-	+	+	-
K1317	-	-	+	+	+	+	-	-	+	-	+	-	+	+	-
C306 (C)	-	-	+	-	-	+	-	+	+	-	-	+	-	-	+
HD2888 (C)	-	-	+	-	-	+	-	+	+	-	-	+	-	-	+
K8027 (C)	-	-	-	-	-	+	-	+	+	-	+	-	+	+	-
K0307 (C)	-	-	-	-	+	+	-	+	+	+	-	-	+	+	-
HI8759 (d)	-	-	-	+	-	+	-	-	+	-	-	+	-	+	-
HD4728 (d)(C)	-	-	-	-	+	+	-	-	+	-	-	+	-	+	-
HI8498 (d)(C)	-	-	-	+	+	+	-	-	+	-	-	+	-	+	-
HI8737 (C)	-	-	-	+	+	+	-	-	+	-	-	+	-	+	-
MPO1215(d)(C)	-	-	-	+	-	+	-	-	+	-	-	+	-	+	-
MACS3949 (d)	-	-	-	+	-	+	-	-	+	-	-	-	+	+	-
HI1605	-	-	+	+	+	+	-	+	+	-	-	-	+	+	-
AKDW2997-16(d)(C)	-	-	-	+	-	+	-	-	+	-	-	+	-	+	-
DBW93(C)	-	-	+	-	-	+	-	+	+	+	-	-	+	+	-
HD2932(C)	-	-	+	+	+	+	-	+	+	-	-	-	+	+	-
MACS6222 (C)	-	-	+	+	-	+	-	+	+	+	-	-	+	+	-
MACS6478(d)(C)	+	-	+	-	-	-	-	+	+	-	+	-	+	+	-
NI5439(C)	-	-	+	+	+	+	-	+	+	-	-	-	+	-	+
NIDW295(d)(C)	-	-	-	-	-	-	-	-	+	-	-	+	-	+	-
Raj4083 (C)	+	-	-	+	+	+	-	+	+	+	-	-	+	+	-
UAS446(d) (C)	-	-	-	+	-	+	-	-	+	-	-	+	-	+	-
HD3209	-	-	+	-	-	-	+	+	+	-	-	-	+	+	-
PBW723	-	-	-	-	-	-	+	+	+	-	-	-	+	+	-
WB02	-	-	+	-	-	+	-	-	+	-	-	-	+	+	-
HPBW01	-	-	+	+	+	-	-	+	-	-	+	+	-	+	-
HPBW02	-	-	+	+	+	-	-	+	-	-	+	+	-	+	-
DPW621-50(C)	+	-	+	+	-	+	-	+	+	-	-	+	-	+	-
GW322(C)	-	-	+	+	+	+	-	+	+	-	+	+	-	+	-
HD2864(C)	-	-	+	-	+	+	-	+	+	-	-	-	+	+	-
MP3336(C)	-	-	-	-	+	-	-	+	+	-	-	-	+	+	-
PBW343(C)	-	-	-	+	-	-	+	+	+	+	-	-	+	+	-

+ Present - Absent

Dendrogram showing relative diversity in AVT entries based on molecular markers



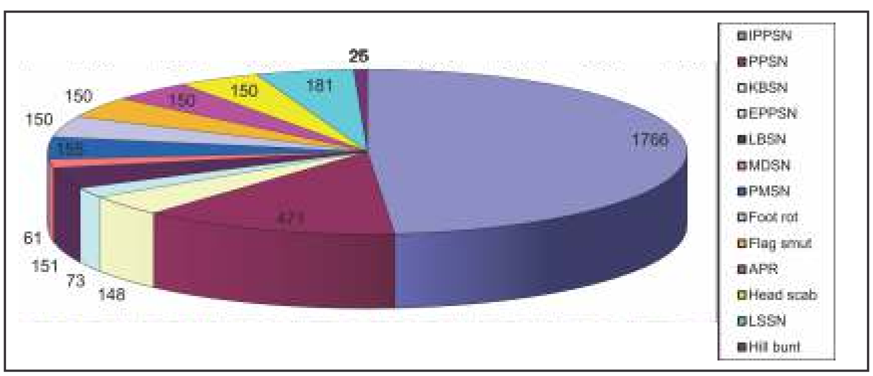
Crop Protection

The major thrust areas of Crop Protection include crop health monitoring (pre and post harvest), distribution of rust pathotypes, host resistance, rust resistance genes postulation and pest management (host resistance, tillage options, chemical control and IPM modules). The highlights of the programme during the reporting period are given here as under:

Host Resistance

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

The Initial Plant Pathological Nursery (IPPSN), with 1766 entries and Plant Pathological Screening Nursery (PPSN) with 471 genotypes including checks, are the main nurseries which are the major components of the Decision Support System in promotion of entries from one stage to the other, and finally the identification of genotypes for release. The other nurseries that are evaluated at hot spot multilocations are, LBSN, KBSN, LSSN, PMSN, nurseries for diseases of limited importance (FHB, Foot rot, hill bunt, flag smut), EPPSN, MDSN, MPSN and the evaluation against nematodes and insect pests. AVT entries were also evaluated at specific locations for Race Specific Adult Plant Resistance (APR) to three rusts (brown, black and yellow). Slow rusting lines for different rusts were identified by calculating the Area Under Disease Progress Curve (AUDPC) at Karnal (stripe rust) and Mahabaleshwar (leaf & stem rusts) centres. Constitiution of plant pathological nurseries during 2015-16 has been shown below:



Rust resistance materials in AVT IInd and Ist Year (2015-16) with ACI upto 10.0 are given below:

Stem, Leaf and Stripe Rusts : AVT IInd Year
PBW 723, HD 4728 (D) (I) (C), HI 8498 (D) (C), HI 8737 (D) (C), HI 8759 (D), HS 507 (C), MPO 1215 (d) (C), NIDW 295 (D) (C), PBW 644 (C), TL 2942 (C), TL 2969 (C), UAS 428 (d) (C) and WH 1080 (C)

AVT Ist Year
DBW 173, HI 8774 (D), HPBW 05, HPW423, HPW433, HS622, HS623, HS626, HS628, PBW 725, PBW 756, PBW 757, PBW 760, RKD 283 (D), TL 3006, TL 3007, TL 3008, TL 3009, TL 3010, UAS 459 (D), UP2954, UP2955, VL 3002, VL1008, VL3010, VL3011, VL3012, WH 1181, WH 1216 and WH 1310

Stem and Stripe Rusts

AVT IInd Year: DBW 71 (C)
AVT Ist Year: HS 580 and VL1009

Stem and Leaf Rusts
AVT IInd Year: HS 375 (C), HS 490 (C), HS 542 (C), HW 1098 (C), HW 2044 (C), HW 5216 (C), K 1317, MACS 6222 (C), NIAW 1415 (C), NIAW 34 (C), RAJ 4083 (C), VL 829 (C), VL 892 (C), WB 2, WH 1021 (C) and WH 1105 (C)
AVT Ist Year: AKAW 4842, DBW 168, DBW 179, DBW 216, DBW 217, DBW 219, DDK 1050, DDK 1051, GW 477, MACS 5044, MACS 5046, NW 6094, PBW 621, RKD 292 (D), VL 4001 and WH 1215.

Leaf and Stripe rusts
AVT IInd Year: DBW 90 (C), HD 3086 (C), MACS 3949 (d), UAS 446 (d) (C) and WH 1124 (C)
AVT Ist Year: DBW 179, DBW 220, HI 1612, HPBW 02, HPBW 08, HPBW 10, HPW424, HS625, HS627, NW 6046, PDW 344 (D) and WH 1184

Seedling resistance in wheat genotypes

To identify rust resistant lines of wheat and to characterize rust resistance genes, 173 lines of AVT I and II were evaluated at seedling stage using an array of pathotypes of black (*Puccinia graminis tritici*), brown (*P. triticina*) and yellow rust (*P. striiformis*) having different avirulence/virulence structures. In addition to all the lines having *Sr*31 were resistant to black rust of wheat, whereas lines possessing *Lr*24, some with *Lr*26 were resistant to brown rust and few lines with *Yr*9 showed resistance to yellow rust of wheat. Rust resistance to all the pathotypes of black, brown and yellow rust was not observed in any of entries of AVT II. WB2 was found resistant to yellow rust whereas resistance to brown rust was conferred by HD 2864(C). Five entries *viz*. HD 3043(C), HS 542(C), NIDW 295(D)(C), TL 2942(C) and TL 2969(C) showed resistance to all the pathotypes of black rust. All the lines carrying *Sr*31 were resistant to black rust. Like AVT II entries, rust resistance to all the pathotypes of black, brown and yellow rust was not observed in any of entries of AVT I. Entries AKAW 4842, HS 623 and TL 3006, WB 2 were found to be resistant to all the pathotypes of black and brown rusts; whereas resistance to black and yellow rusts was conferred by PBW 756. Ten entries *viz*. DBW 172, HD 3184, HS 590, HS 625, PBW 725, PBW 757, UP 2954, VL 1008, VL 3002 and WH 1215 showed resistance to yellow rust and two entries *viz*. DBW 220, WH 1310 were resistant to brown rust.

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

Resistant to all three rust +LB+KB+FS+PM: DBW 129, VL 1003

Resistant to all three rust + KB+FS: HI 8751 (d), HPW 373, HS 593, TL 2995 (T), TL 2999 (T), TL 3000 (T)

Resistant to all three rust + KB+FS: DDW 30 (d), HD 4728 (d), HD 4730 (d), UAS 451 (d)

Resistant to all three rust + PM+FS: HI 8737 (d), TL 2996 (T)

Resistant to all three rust +LB+PM+FS: HI 8750 (d), PBW 677,

Resistant to all three rust +PM+KB: HI 8751 (d), TL 2995 (T), TL 2999 (T), TL 3000 (T),

Resistant to all three rust +LB: PBW 723

Resistant to all three rust: PBW 681, HPW 411

Resistant to Stem and leaf rust+ KB: HUW 666, VL 967, DBW 154, GW 451, HD 2932- Lr 19 / Sr 25, HD 3133, HPW 401, HUW 675, VL 1004, VL 3004

Resistant to Stem and leaf rust +KB+PM: DBW 110, VL 977

Resistant to Stem and leaf rust +LB: HD 3132,HS 547, HS 595, NIAW 2030, PBW 704

Resistant to Stem and leaf rust : GW 455, HD 3146, HUW 677, PBW 701, UP 2864, UP 2891

Resistant to leaf and yellow rust +LB+KB+PM+FS: HI 8755 (d)

Resistant to leaf and yellow rust +LB+KB: HS 592, HUW 661, K 1204

Resistant to leaf and yellow rust +PM+KB: UAS 446

Resistant to leaf and yellow rust + KB: PBW 695, PBW 698, PBW 703

Resistant to leaf and yellow rust +PM+FS: TL 2997 (T)

Resistant to leaf and yellow rust: PBW 697, PBW 722

Resistant to stem and yellow rust +KB+FS: K 1217, PBW 692, VL 3002

Utilization of resistance sources through NGSN

The confirmed sources of multiple disease and insect pests resistance were contributed in the NGSN and were planted at 23 breeding centers across different agro climatic zones of country for their utilization in breeding for resistance to biotic stresses. All 25 entries were utilized in the range of 8.7 – 52.2% by the most of the breeding centres. The most utilized entries at many centres were HPW 381, PBW 660, UP 2843, UP 2847, HI 1588 and HW 5224. Sagar centre, utilized maximum 21 entries in their breeding programme followed by Durgapura and Pune.

Rust resistance genes in AVT material

To know the genetic diversity in Advance Varietal Trial material, rust resistance genes were characterized using host- pathogen interaction data and applying gene matching technique. Mostly rust resistance genes were inferred in those wheat lines where differential response to rust pathotypes were observed, however, morphological markers, genetic linkage and characteristic infection types were also used to reach at a conclusion.

***Yr* genes:** In AVT II material, 5 *Yr* genes/patterns (*Yr*9, 27, 2, 18 and A) were characterized in 38 lines. *Yr*2 was found to confer resistance in maximum number of lines (23) followed by *Yr*9 and *Yr*18 in 14 and 5 lines, respectively. Other resistance genes like *Yr*A and *Yr*27 were postulated in few lines only. Four *Yr* genes (*Yr*9, A, 2 and 27) were postulated in 45 lines of AVT I material. Among these, *Yr*2 was inferred in 29 lines. *Yr*9 which is linked to *Lr*26 and *Sr*31 was identified in 14 lines. *Yr*A was characterized in 5 lines whereas *Yr*27 was identified in one line only.

***Lr* genes:** In AVT II material, seven *Lr* genes (*Lr*1, 3, 10, 13, 23, 26 and 34) were characterized in 51 lines. Most of the lines possessed more than two resistance genes. *Lr*13 was the most common resistance gene and was characterized in 24 lines followed by *Lr*23 and *Lr*26 in 16 and 14 lines, respectively. *Lr*13 is known to confer high temperature resistance. Therefore, the lines possessing *Lr*13 will have less terminal disease severity as the temperatures towards maturity go up in most wheat growing areas in India. *Lr*10 was inferred in 10 lines, *Lr*3 in 4 lines and *Lr*1 was confirmed in five lines each. *Lr*34 was present in three lines only. Eight *Lr* genes (*Lr*1, 2a, 3, 10, 13, 19, 23 and 26) were characterized in 65 lines of AVT Ist. Many of the lines possessed combination of resistance genes. *Lr*13 was the most common resistance gene and was characterized in 38 lines followed by *Lr*23 (17 lines) and *Lr*10 (16), whereas *Lr*26 was characterized in 14 lines. Rust resistance genes *Lr*19, *Lr*3 and *Lr*1 were inferred in 1, 7 and 10 lines, respectively.

***Sr* genes:** Ten *Sr* genes (*Sr*2, 5, 7b, 8a, 9b, 9e, 11, 25, 28 and 31) were characterized in 51 AVT IInd lines. *Sr*2, whose postulation is based on characteristic micro-flecking, was postulated in 43 lines followed by *Sr*11 in 17 and *Sr*31 in 14 lines. *Sr*8a and *Sr*9b were identified in 2 lines each, whereas *Sr*9e and *Sr*25 were conferred in one line each. *Sr*5 and *Sr*7b were postulated in four and seven lines, respectively. Ten *Sr*genes (*Sr*2, 5, 7b, 8a, 11, 13, 25, 28, 30 and 31) were characterized in 75 lines of AVT Ist. *Sr*2 was highly frequent and postulated in 40 lines followed by *Sr*7b and *Sr*11, which were postulated in 19 and 18 lines, respectively. Most of the durum wheat varieties had resistance based on *Sr*7b and *Sr*11. *Sr*31, which confer resistance to all the known pathotypes from India including SAARC countries, was confirmed in 14 lines only. *Sr*5 and *Sr*8a were postulated in 12 lines each, whereas four lines confirmed the presence of *Sr*30.*Sr*28 and *Sr*13 were postulated in eight and three lines, respectively.

Diversity for rust resistance in Indian varieties and advance lines

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Yellow	72	5: *Yr*2, *Yr*9, *Yr*A, *Yr*18, *Yr*27
Brown	116	9: *Lr*1, *Lr*2a, *Lr*3, *Lr*10, *Lr*13, *Lr*19, *Lr*23, *Lr*26, *Lr*34
Black	126	12: *Sr*2, *Sr*5, *Sr*7b, *Sr*8a, *Sr*9b, *Sr*9e, *Sr*11, *Sr*13, *Sr*25, *Sr*28, *Sr*30, *Sr*31

SURVEY AND SURVEILLANCE

Pre- Harvest Crop Health Monitoring

Crop health was rigorously monitored during the crop season as well during the off season in the high hills of Himachal Pradesh and Nilgiri hills (Tamil Nadu). Major focus was on the occurrence of yellow rust and surveillance for the stem rust pathotype, Ug99. Status of other diseases, including leaf rust was also monitored during these survey trips. The extensive surveys were also conducted by the wheat crop protection scientists of different cooperating centers including ICAR-IIWBR Karnal. Special teams of scientists were also constituted during the 54th All India Wheat Workers' Meet held at Sardarkrushinagar, Dantiwada during August, 2015. Advisory for stripe rust management was issued during December-February regularly. Information on wheat crop health was disseminated through the "*Wheat Crop Health Newsletter*", Vol. 21 which was issued during the crop season. This was also put on ICAR-IIWBR website. All the issues of the Newsletter brought out during the crop season, are given as an annexure at the end of this report. Except for the yellow rust in NHZ and NWPZ, the overall crop health status was satisfactory in the country. Ug99 was not reported from any place in the country. Wheat blast disease was first time reported from Bangladesh. Wheat blast was not reported from any place in India during 2015-16 crop season. Details are given in Newsletter as Annexure.

Strategy Meetings: A meeting on evolving strategies for enhancing wheat production with special reference to management of wheat rusts and Karnal bunt was organized by DAC on November 29, 2015 at ICAR-IIWBR, Karnal.
Advisory for stripe rust management: Advisory for stripe rust management was issued three times i.e. in December, January and February for northern states. Awareness among farmers for stripe rust management was created through newspapers and delivering lectures in farmers training programmes.

Preparedness for wheat blast disease keeping in view its report from Bangladesh in 2016

- Wheat blast, present in the primary wheat production areas of Brazil, Bolivia, and Paraguay, and recently identified in a small area in northeast Argentina, it is a potential threat to wheat production worldwide. The disease was first reported from Brazil in 1985. Wheat blast pathogen is a distinct population of *M. oryzae* (referred as *M. oryzae* Triticum population).
- As soon as first report was announced by Bangladesh Govt in last week of March, 2016, ICAR took note of the disease. As per the guidance of ICAR authorities, a team of scientists conducted extensive survey in West Bengal in 1st week of April. Earlier also scientists conducted survey in different parts of the country. There was no report of wheat blast from any part of India so far.
- In off season, surveys will be undertaken in different parts of the country with special emphasis of wheat blast.
- During normal crop season, survey efforts will be intensified in border areas of Bangladesh for keeping a strict vigil on wheat blast.
- As an immediate step, in collaboration with CIMMYT, Mexico, evaluation of Indian released varieties / advance wheat lines in Latin America (Bolivia, Brazil, Paraguay and Argentina) – the hot spot for this disease has been approved by DARE, Ministry of Agriculture and Farmers Welfare on May 19, 2016. For this, a set of 40 Indian popular varieties and advance lines has been sent immediately to CIMMYT for evaluation against blast disease. On the basis of evaluation of Indian wheat lines in Brazil, resistant lines identified will help in developing resistant varieties in India against this disease.
- Search on identifying resistant lines for blast is going on. Crossing of Indian wheat varieties with the blast resistant lines has been initiated in off season nurseries at Lahaul Spiti, HP.

WHEAT DISEASE MONITORING NURSERY (WDMN)

The 48th wheat disease monitoring nursery was planted at 43 locations covering all the major wheat growing areas in the country, especially those situated near the bordering areas to the neighboring countries. The data have been received from 37 locations only. There were a total of 20 entries in the WDMN. However, one extra entry was added for northern hill and high altitude zone. Of the total entries first 15 constitute the common set for all zones, rest of the five (six in northern hill and high altitude zone) entries were zone specific varieties. Keeping into account the changed varietal situation there was some change in the constitution of WDMN for NWPZ and NEPZ.

Disease in WDMN during crop season 2015-16 was noticed one week ealier than previous year. Yellow rust was noticed at all the location of NHZ and NWPZ except at Durgapura, where WDMN entries were disease free. All the entries of WDMN in other zones were free from yellow rust. Yellow rust was very severe at many locations at NWPZ and NHZ, where severity of more than 80S was reported on some entries. Brown rust was reported from few locations of NHZ (Shimla) and NWPZ (Udhaywalla, Pantnagar, Hisar, Abohar and Ludhiana). In NEPZ, all the entries of WDMNs, were free from brown rust except at Kanpur, Faizabad and Varanasi. Of the 37 locations of WDMNs black rust was observed only at Vijapur, Indore and Powarkheda in central zone, suggesting uncongenial climatic conditions for black rust development during the season. Leaf blight was reported from Almora, Udhaywalla, Kathua, Rajouri, Hisar, Sabaur, Pusa, Ranchi, Faizabad, Kanpur, Varanasi, Pune, Niphad and Ugar khurd (Dharwad). Malan, Kathua and Almora were the only locations where powdery mildew was observed on WDMN entries.

SAARC Wheat Disease Monitoring Nursery

Under the umbrella of Regional Station, ICAR-IIWBR, Shimla and CIMMYT, Nepal, SAARC wheat disease monitoring nursery is being conducted in SAARC countries with the objectives similar to the wheat disease monitoring nursery (WDMN) in India. During 2015-16, SAARC wheat disease monitoring nursery was planted at 29 locations across the six SAARC countries. Data from Afghanistan, Bangladesh, Bhutan, Nepal and Pakistan is awaited.

Wheat disease situation in India

Yellow rust was observed at all the SAARC nursery locations in NHZ and NWPZ except at Durgapura (Jaipur). First report of yellow rust on SAARC WDMN was from Udhaywalla (02.01.16) followed by Kathua (05.01.16), Pantnagar (10.02.16), Delhi (03.03.16), Rajouri (06.03.16) and Almora (07.03.16). Brown rust was observed at eight locations (Delhi, Udhaywalla, Kathua, Rajouri, Abohar, Faizabad, Ropar and Pantnagar). The date of first appearance of brown rust is received from few locations, according to which the earliest appearance of brown rust was from Pantnagar (03.02.16) followed by Udhaywalla (02.03.16), Faizabad (05.03.16), Kathua (06.03.16) and Delhi (10.03.16). Of the data received from SAARC nursery locations in India, black rust was not observed at all.

Leaf Blight (LB) was observed at six locations (Udhaywalla, Kathua, Rajouri, Pusa, Faizabad and Almora). Severity of leaf blight was maximum at Pusa, where range of LB score was from 45 to 87. The earliest report of powdery mildew (PM) was from Almora (11.02.16) followed by Udhaywalla (15.02.16) and Kathua (18.02.16). All the entries were infected with powdery mildew at all the locations. Maximum severity of powdery mildew was observed at Kathua, where 16 entries were showing PM severity of 5 or more.

PATHOTYPE DISTRIBUTION OF WHEAT RUSTS

Incidence of wheat rusts in India

Wheat crop health was monitored in all the wheat growing areas by different monitoring teams during the crop season and advisory was issued by ICAR-IIWBR, Karnal; Department of Agriculture Cooperation and Farmers Welfare, Government of India and State Department of Agriculture to combat rusts. Yellow rust of wheat was distributed throughout NWPZ with high intensity at few locations in Punjab, Jammu and Kashmir and Himachal Pradesh. Yellow rust was first observed by scientists from PAU, Ludhiana on December 18, 2015 on variety HD 2967 in village Brahampur near Shri Anandpur Sahib in Punjab. In Jammu and Kashmir stripe rust appeared a bit late and was first reported in the third week of January in Gaughmanhasa area in Jammu. Brown rust was observed first on 16th December, 2015 in sick plot of G.B. Pant University of Agriculture and technology, Pantnagar. Wheat stripe rust was observed in traces in few fields of Tarai area of district Udham Singh Nagar on 12th February 2016. In Pali district of Rajasthan, stripe rust was first observed on wheat variety K 65 on February 10, 2016 by scientists of the KVK, Pali. There was no major incidence of black and brown rusts during this year. Brown rust was first observed on 18th February at Amminbhavi, Gokak and Yaragatti and Ugar taluk/villages around Dhardwad. Barley was almost free from rusts.

Yellow rust of wheat (*Puccinia striiformis*)

During this crop year, 302 samples of yellow rust of wheat and barley were analyzed from six Indian states and Nepal. Despite the detection of 5 new pathotypes during 2014-15, Indian population of *P. striiformis* is still avirulent to *Yr*5, *Yr*10, *Yr*11, *Yr*12,*Yr*13, *Yr*14, *Yr*15, *Yr*Sp and *Yr*Sk. Most of the yellow rust samples from wheat were analyzed from Punjab (100) followed by Himachal Pradesh (94). Like previous crop season, the frequency of 46S119 (virulent on *Yr*2, *Yr*3, *Yr*4, *Yr*6, *Yr*7, *Yr*8, *Yr*9, *Yr*17, *Yr*18, *Yr*19, *Yr*21, *Yr*22, *Yr*23, *Yr*25, *Yr*A) was maximum during current season also. It was observed in more than 50% of the samples. Pathotype 110S119, first identified in 2013-14, was present in 72 samples, which is the second highest after 46S119. Presence of barley yellow rust was negligible during this year also. The barley yellow rust pathotypes M (1S0) and 57 (0S0) were observed only in one samples each from Rajasthan.

Black rust of wheat (*Puccinia graminis tritici*)

Seven pathotypes of black rust of wheat were observed on 54 samples received/collected from five Indian states. Population analyzed during the year has avirulence to *Sr*26, 27, 31, 32,35, 39, 40, 43, Tt3 and Tmp. Most of the samples were received from Gujarat followed by Uttarakhand and Tamil Nadu. Pathotype 11 (79G31=RRTSF), virulent on*Sr*2, *Sr*5, *Sr*6, *Sr*7b *Sr*9a, *Sr*9b,*Sr*9c, *Sr*9d, *Sr*9f, *Sr*9g, *Sr*10, *Sr*13, *Sr*14, *Sr*15, *Sr*16, *Sr*17, *Sr*18, *Sr*19, *Sr*20, *Sr*21, *Sr*28, *Sr*29, *Sr*30, *Sr*34, *Sr*36, *Sr*38, *Sr*McN was recorded from more than 50% of the samples, which was followed by 40A (62G29=PTHSC) and 21A-2(75G5 =CHTSC) in overall frequency. Other pathotypes such as 21-1 (24G5=CKMSC), 40-2 (58G13-3=PKRSC), 40-3 (127G29=PTTSF) and 122 (7G11=RRHSC) were observed in few samples only. Diversity of black rust pathotypes was maximum in Tamil Nadu.

Brown rust of wheat (*Puccinia triticina*)

Nineteen pathotypes of *P. triticina* were identified in 232 samples analyzed from 13 states of India, Nepal and Bhutan. Indian population produced resistant infection type on *Lr*24, *Lr*25, *Lr*29, *Lr*32, *Lr*39, *Lr*42 and *Lr*45. Unlike previous year, the pathotype 77-9 (121R60-1=MHTKP) virulent on *Lr*1, *Lr*3, *Lr*10, *Lr*11, *Lr*12, *Lr*13, *Lr*14a, *Lr*14b,*Lr*14ab, *Lr*15, *Lr*16, *Lr*17a, *Lr*17b, *Lr*18, *Lr*20, *Lr*21, *Lr*22a, *Lr*22b, *Lr*23, *Lr*26,*Lr*27+31, *Lr*30, *Lr*33, *Lr*34, *Lr*35, *Lr*36, *Lr*37, *Lr*38, *Lr*44, *Lr*46, *Lr*48, *Lr*49, was most frequent and observed in 93 samples, followed by 77-5 (121R63-1 =THTTM) and 104-2 (21R55 =PHTTL), which were identified in 46 and 38 samples, respectively. *P. triticina* population was highly diverse in Karnataka and Himachal Pradesh as 19 pathotypes each were observed in these two states. The prevalence of brown rust of wheat was maximum in Karnataka followed by Himachal Pradesh and Maharashtra. In Karnataka pathotype 77-9 was most frequent followed by pathotype 77-5 and 104-2, whereas other pathotypes were identified in few samples only. In Uttarakhand, pathotype 104-2 was most frequent whereas in Himachal Pradesh pt 77-9 and 104-2 were more predominant. In Chhattisgarh, pathotype 77-9 was found in maximum number of samples whereas 77-5 and 104-2 were identified only in one and three samples, respectively. Pathotypes 11, 12-1, 12-6, 77-8, 77-10, 106, 107-1, 162 and 162A were observed only in one sample each.

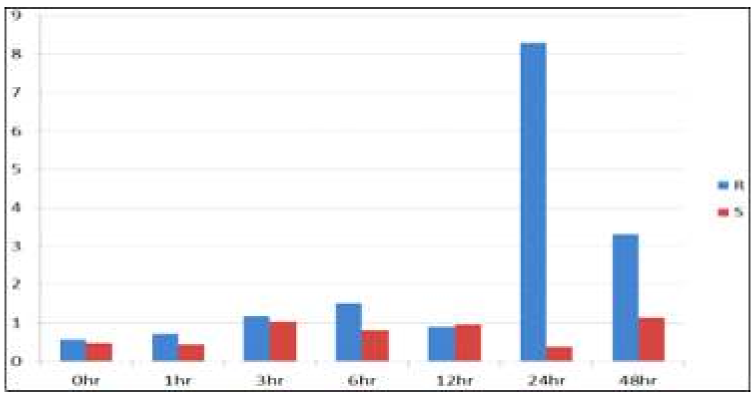
Predominant pathotypes of *Puccinia* on wheat in India

Wheat Rusts	Predominant pathotypes
Black	79G31(11), 62G29(40A)
Brown	121R60-1 (77-9) followed by 121R63-1(77-5) and 21R55 (104-2)
Yellow	46S119 followed by 110S119

Studies on molecular basis of host-pathogen interactions

R gene mediated plant defense involves induction of several plant defense genes which are called as Pathogenesis related protein (PR) genes. Induction of PR genes is governed by the activation of the transcription factors by the defense hormones. Expression profiles of these basic defense genes and transcription factors induced by different *R* genes have been studied at detail in the model plant Arabidopsis. Understanding the molecular mechanism underlying each *R* gene mediated response is essential devising strategies to control diseases as wells as developing resistant cultivars. However, in wheat there are few expression profiling studies on the basic defense genes induced by different pathogens resulting in sparse understanding of defense strategy mediated by a particular *R* gene.

This study was aimed to understand expression pattern of basic defense genes induced by *Lr*24 in both incompatible and compatible interactions between *P. triticina* and wheat. Two NIL lines: HW 2020 (HS240+*Lr*24) and HS240, the resistant and susceptible NILS, respectively, were chosen for studying incompatible and compatible interactions with *P. triticina*. The orthologous counterparts of different Arabidopsis defense genes (PR and TFs) in wheat were identified through Protein-BLAST and designed primers for total of 28 genes. The expression profiling of these 28 selected genes was conducted over different time intervals from 0 to 48 hpi using Real time PCR. The results of Real time PCR analyses showed that expression profiles of these defense related genes varied significantly between the two NILS at particular time intervals indicating the defense genes are induced in sequential order to thwart the different offense mechanisms of rust pathogen.



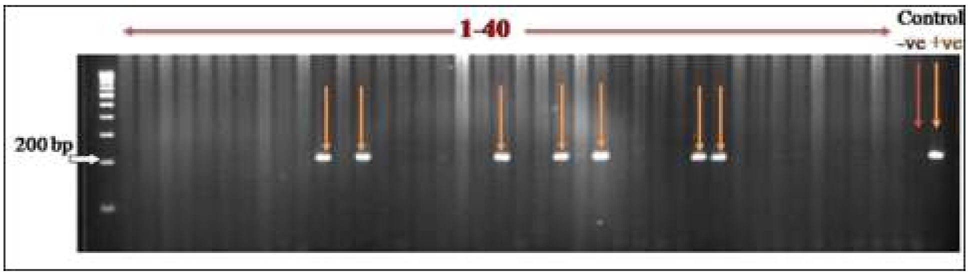
Expression profile of type 1 non-specific Lipid transfer protein showing high levels of expressions at 24hpi and 48hpi in resistant NIL (R, HW2020) whereas low levels of expression in susceptible NIL (S, HS240).

For instance peroxidases and b-1,3-glucanases showed highest expressions at early stage of infection (3–6 hpi) whereas, endochitinase and lipid transfer protein showed highest expression levels at later stage of infection (24–48 hpi) (Figure 1). The expression analyses of defense-related genes provide a valuable information on *Lr*24 gene mediated resistance as well as source of genes controlling leaf rust resistance for wheat breeding.

Genetic studies and development of rust resistant genetic stocks

Marker assisted selection and validation of rust resistance genes

Forty varieties of wheat released between 2010-2014 were used for identification of rust resistance genes *Lr*24/*Sr*24, *Lr*19/*Sr*25, *Yr*15, *Yr*17, *Yr*18/*Lr*34, *Yr*9/*Lr*26/*Sr*31, *Sr*28 and *Lr*68 through known gene based molecular markers and successfully validated. Marker assisted selection was done in the segregating population of breeding programme to select the plants for presence of *Yr*15, *Sr*26, *Sr*32, *Sr*43 and *Lr*24/*Sr*24 rust resistance genes and the plants which were confirmed to carry resistance genes were selected and harvested. Figure 2 shows the presence of *Lr*24/*Sr*24 gene in seven varieties namely HD3090, HI1563, HW5216, MP3288, NIAW1415, Raj4229 and Raj 4238 with the help of dominant marker *Sr*24#50.



Dominant marker *Sr*24#50 showing presence of 200bp band in seven wheat varieties

Development of rust resistant genetic stocks.

Three rust resistant genetic stocks, namely FLW31, FLW32 and FLW33 carrying *Sr*43, *Sr*26 and *Sr*32, respectively were developed. These provide complete resistance against black rust pathotypes of Indian sub-continent and are resistant against Ug99 and its variants when evaluated in Kenya during 2013.

FLW31 is derived from the cross between HI1500 and exotic line KS10-2 C83.4 (*Sr*43). This genotype is completely resistant to black and brown rusts. FLW31 carries *Sr*24/ *Lr*24 and *Sr*43. This genotype has an average plant height of 105 cm and matures in 155 days under Shimla conditions. Its grains are amber coloured and thousand grain weight is 41.6 g. Yield per meter row is 124 g which is at par with the parent variety HI1500.

FLW32 has been developed from cross Raj3765/Eagle. Eagle is a source of *Sr26* derived translocation on 6A from an alien segment from *Agropyron elongatum.* 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 *Lr*10, *Lr*13, *Sr*2, *Sr*26 and *Yr*2Ks.This genotype has an average plant height of 99cm and takes 152 days to mature under Shimla conditions. The grains are amber and on an average weigh 42.1 g per 1000 grains. The yield of FLW32 is 131g per meter row length which is at par with the recipient parent Raj3765.

FLW33 has been developed to enrich Ug99 resistant sources available to the Indian wheat breeders, particularly in Central Zone (CZ) and Peninsular Zone (PZ). This genotype is a derivative of cross between HI1500 and donor line C77.19 (*Sr32*) though pedigree selection method. It is completely resistant to black and brown rusts of wheat. Its yield is slightly less than HI1500. Average plant height is 93 cm and maturity duration is 145 days under Shimla conditions. FLW33 possesses rust resistance genes *Sr*24/*Lr*24 and *Sr*32.

Maintenance and supply of nucleus inoculum of wheat and barley rusts

A collection of more than 127 pathotypes of different rust pathogens of wheat, barley, oat and linseed was maintained in live culture as well as cryo-preserved. To enable researchers conduct research on wheat and barley rusts, nucleus/bulk inocula of different rusts of wheat and barley was supplied to more than 30 centers/scientists working under public and private sector across India for the smooth conduct of rust research.

POST HARVEST ANALYSIS

Karnal Bunt and black point

A total of 8732 grain samples collected from various mandies in different zones, were analyzed for Karnal bunt (KB). The highest incidence (53.33 %) was recorded from Jammu region of J & K followed by Punjab (33.71 %). Based on the overall KB occurrence, it emerged that the KB incidence this year was less than the previous year. No sample from Maharashtra (Pune, Niphad) and Karnataka (Dharwad) was found infected with KB. Out of

7494 grain samples analyzed for black point from different zones in the country, 73.92 per cent samples showed black point.

Identification of new *Lr* gene

LWH-2 (Local Wheat Hango-2), a bread wheat landrace collected from the Hango, higher hills of district Kinnaur, Himachal Pradesh, India in 2006 possessed a unique type of leaf rust resistance. LWH-2 exhibited 0; to ;- response at seedling and adult plant stage to all the Indian pathotypes except for pathotype (pt.) 16-1(5R9-7=DBBPB), which produced 3+ reaction. Pt. 5R9-7, in general is avirulent on bread wheat but is virulent to Khapli, a tetraploid Emmer wheat. This pathotype, though exists in National Repository at this station, however, doesn't occur in field population. A cross was made with leaf rust susceptible bread wheat land race Agra local and LWH-2. F_2 populations derived from crosses of Agra local and LWH-2 revealed its monogenic inheritance of resistance to leaf rust. The gene was temporarily named as *LrLWH*. Molecular mapping of 172 F_3 populations was conducted by using 300 SSR markers well distributed on all the chromosomes. Of the few specific markers for 2DS, seven were found polymorphic to the new gene. Mapping studies placed *LrLWH* in the short arm of chromosome 2D, about 6.7 cM proximal to the SSR marker *gdm35* and the marker *cau96* and *barc124* mapped at 1.9 cM and 2.5 cM, respectively distal to *LrLWH*. Six leaf rust resistance genes *Lr2a*, *Lr2b*, *Lr2c*, *Lr15*, *Lr22* and *Lr39* are also present on 2DS chromosome are at different location than that of *LrLWH*. These 2DS *Lr* genes were also evaluated against an array of leaf rust pathotypes. *Lr39* was resistant to all the Indian leaf rust pathotypes whereas *LrLWH* was susceptible to pt. 5R9-7 only. *Lr15* on the other hand is susceptible to 14 pathotypes of 77 group and few others. *Lr2a*, *Lr2b, Lr2c* and *Lr22* (an adult plant resistance gene) were susceptible to many pts. of leaf rust in India. The RILs were also produced and phenotyped using leaf rust pathotypes of India. Based on the genomic location and phenotypic data, *LrLWH* was concluded to be a new leaf rust resistance gene. Flanking DNA markers that are tightly linked to *LrLWH* in a wide array of genotypes can be utilized for selection of resistance to wheat leaf rust in the improved wheat lines.

EVALUATION OF WHEAT GENOTYPES FOR INSECT PEST RESISTANCE AND MANAGEMENT

Screening against brown wheat mite

A total of 68 AVT II year lines and 82 AVT I year lines were screened at Ludhiana and Durgapura centres. Among AVT II year genotypes, based on the average incidence of both locations, TL 2942 (C) and K 8027 (C) showed less than 10% infestation of brown wheat mite. Among AVT I year genotypes, HS 590, HI 1621 and WH 1181 showed less than 10% infestation of brown wheat mite.

Screening against Root aphid

Out of 68 AVT II year entries, only four lines *viz.* HD 2967 (C), K 0307 (C), AKDW 2997-16 (d) (C) and HD 3209 showed moderately resistant reaction at Ludhiana.

Chemical Control of insect pest of wheat

Imidacloprid 600 FS (Gaucho) @ 0.72 g a.i. /kg seed treatment was identified as quite effective for the control of termite damage and improving yields. Fipronil 5 Sc (Seed treatment) @ 0.3 g a.i./kg seed or 6ml /kg seed treatment was identified as effective for management of termite damage through broadcasting of insecticides in standing wheat crop. Propargite 57 SC (Omite) @ 1.5 ml/l and Spiromesifen 240 SC (Oberon) @ 1.0 ml/l of water was effective for brown mite management. The results of initial studies indicated that seed treatment with Imidaclorprid 500 FS 6.00 ml per kg of seeds + Foliar spray of Fipronil 5 SC @ 500 ml per ha at 12 DAE were effective for integrated management of shootfly on wheat crop.

RESOURCE MANAGEMENT

The food and nutritional security of any country is dependent upon the efficient management of its available natural resources. Despite shrinking land and water resources, climate abrasions and little genetic gain, India harvested more than 93.5 million tonnes of wheat during the current year. This has been made possible by Indian farmers and scientists through efficient management of natural resources and various external inputs like chemical fertilizers and pesticides for achieving the food security in addition to the increased coverage under disease resistant varieties. The imbalanced fertilisation and intensive tillage are still matters of concern leading to the degradation of natural resources. The multiple nutrient deficiencies are being reported from various parts of the Indo-Gangetic plains, the food basket of the country which is a result of continuous mining of the soil coupled with imbalanced fertilisation.

The Resource Management group of the "All India Co-ordinated Wheat and Barley Improvement Project" (AICW&BIP), in addition to evaluating the performance of newly developed genotypes, is also actively engaged in developing and fine tuning the farmers' and eco-friendly, location specific and cost effective technologies for higher productivity and profitability. The work on cost effective technologies is being executed through special trials depending on the priorities of various wheat growing zones. The results of the multi-location varietal evaluation and special co-ordinated trials are summarised hereunder.

Varietal Evaluation in Different Wheat Growing Zones

In four wheat growing zones (NWPZ, NEPZ, CZ and PZ), eleven varietal evaluation trial series were conducted at a number of locations under different growing conditions. The newly developed genotypes were evaluated against the existing varieties used as checks. In addition, eleven special coordinated trials were also conducted to address the zone-wise problems and priorities.

In all, 69 varietal evaluation trials were proposed of which 63 were conducted. Out of the conducted trials, 02 trials were rejected. The overall conduct of trial was 91.3 percent with a success and rejection rate of 95.2 and 4.8 per cent, respectively.

The performance of test entries in NWPZ showed that out of 10 test entries in the AVT-II, only two namely, WB 02 and HPBW 02 for irrigated timely sown condition were numerically superior to best checks with a yield gain of 1.23 and 0.73 percent. In NEPZ, two test genotypes namely HPBW 02 and HPBW 01 for irrigated timely sown conditions were found numerically better than the respective best check K0307 with yield gain of 1.83 and 0.33 percent, respectively. The test entry K1317 in rainfed conditions also gave numerically better yield than the respective best check C 306 with a yield gain of 3.66 percent. In CZ, durum test entry HI 8759 gave numerically better yield than the respective best check HD 4759 with a yield gain of 1.41 percent.

PRODUCTION TECHNOLOGIES

Various special coordinated trials on site specific nutrient management, tillage and nitrogen management, irrigation methods, relay cropping and tillage, spacing and nutrient management for maximising productivity were conducted to address various issues in different wheat growing zones. The results of various experiments on updating package of practices are summarised hereunder.

Precision nutrient management in wheat

In NHZ, the highest yield was obtained in N-rich plot where 150% N was applied with a yield gain of 2.5 q/ha over recommended dose but the difference was not significant. In NWPZ, the tillage and interaction effects were not significant but the nutrient effect was significant. The lowest yield was recorded in recommended NPK treatment where top dressing of N was done after irrigation and top dressing N just before irrigation gave yield gain of 1.86 q/ha and the gain in nutrient expert treatment was 3.67 q/ha over recommended practices. In NEPZ, non significant effect of tillage options and fertiliser treatments on grain yield was observed. In CZ, application of 70% nitrogen through nutrient expert and rest with green seeker technology gave the maximum grain yield (59.52 q/ha) with lower dose than recommended nitrogen, which was much higher than all other treatments except nitrogen rich treatment in which 150% nitrogen was applied.

Based on the nitrogen applied in various nutrient management options and the grain yield obtained, the agronomic nitrogen use efficiency was worked out for various locations. It was observed that the nitrogen use efficiency was higher in the treatment in which 70% of nitrogen and full P and K as well as micronutrient, if any, as recommended by Nutrient Expert for wheat were applied and the rest, if required, were applied using Green Seeker technology. Since the nitrogen applied using Green Seeker was the lowest with comparable yields at most of the locations, the agronomic nitrogen use efficiency was the highest in this treatment. In general, across all the four wheat growing zones, the trend was similar except few exceptions. The results indicate that Nutrient Expert for Wheat and Green Seeker combination may be best option for higher productivity at lower costs leading to more profitability.

Management of lodging and yield maximization using nutrient expert

There was drastic reduction in lodging when either of growth regulator treatments (Lihocin-GR1 and Lihocin+Folicur-GR2) were imposed. The reduction was more prominent, where combination of Lihocin and Folicur was applied. The reduction in lodging was due to reduction in plant height. In NHZ, the highest yield with a yield gain of 3.63% over recommended practices was obtained in recommended dose of fertilizer+GR1 (44.28 q/ha) but was statistically at par with recommended dose of fertilizers. In NWPZ, the highest yield was obtained in fertilizer application for a target of 8 t/ha + GR2 (59.02 q/ha) which was significantly higher than recommended fertilization with a yield gain of 16.16%. In NEPZ, the maximum grain yield (46.29 q/ha) was recorded with fertiliser application for target of 6 t/ha + GR2 application with a yield gain of 11.22%. In CZ, the maximum grain yield (53.46 q/ha) was recorded with fertiliser application for target of 7 t/ha + GR2 application with a yield gain of 10.09% over recommended practices. In PZ, the maximum grain yield (45.009 q/ha) was recorded with fertiliser application for target of 7 t/ha + GR2 application with a yield gain of 11.61% over recommended practices.

Efficient nutrient management in maize-wheat system

For efficient nutrient management in maize-wheat system an experiment was conducted at two locations in PZ. The targeted wheat yield could not be achieved and the maximum grain yield was produced by recommended dose of fertiliser (RDF) for targeted yield of 6 t/ha (42.19 q/ha) followed by RDF for targeted yield of 5 t/ha (42.14 q/ha). Both the treatments remained statistically at par but significantly higher over all other treatments.

Validation of leaf colour chart (LCC) for different wheat varieties

To validate the leaf colour chart for different varieties for higher nitrogen use efficiency an experiment was conducted in NHZ and NWPZ. The varieties used were HPW 349, VL 907 and HS 507 in NHZ and WH 1105, HD 2967 and DPW 621-50 in NWPZ. In NHZ, the N management had significant effect on wheat productivity and highest yield was recorded in N-Rich plot (51.81 q/ha) followed by using LCC -apply 55 kg N/ha if LCC<4 and 45 kg N/ha if LCC ≥4 (51.13 q/ha). Among genotypes HPW 349 produced significantly higher grain yield (54.83 q/ha) when N management done by N by LCC - apply 55 kg N/ha if LCC<4 and 45 kg N/ha if LCC ≥ 4. On mean data basis, the genotype HPW 349 gave significantly higher grain yield (48.36 q/ha) over HS 507 (44.45 q/ha) and VL 907 (44.56 q/ha). In NWPZ, the highest yield was recorded when N was applied as 1/3rd N (50 kg/ha) as basal, 1/3rd N at first irrigation and the remaining LCC based – applied @ 55 kg N/ha if LCC<4 and 45 kg N/ha if LCC ≥4. Among genotypes, WH 1105 produced on an average significantly higher yield than DPW 621-50 but at par with HD 2987. The highest grain yield (52.06 q/ha) was obtained with WH 1105 when N was applied using LCC with dose of 55 kg N/ha if LCC<4 and 45 kg N/ha if LCC ≥4. Under no fertilizer application, HD 2967 produced highest grain yield.

Efficient water management in wheat using micro-irrigation

Water management is the key issue for economising the irrigation water use efficiency of wheat crop. To optimize the water requirement for yield maximisation in wheat, a special coordinated trial was planned and conducted in NWPZ at Karnal and CZ at Vijapur. At Karnal in NWPZ, the highest yield (53.23 q/ha) was recorded in drip irrigation at 100% potential/PAN evaporation (PE) with water saving of 9.50%, which was significantly higher than other irrigation treatments except six irrigations at critical growth stages and Drip Irrigation at 80% PE with saving of 24.41%

water. The maximum water used was in check basin irrigation system (463 mm). At Vijapur in CZ, the highest yield was recordedat IW/CPE of 1.00 with 14.29% saving of water.

Improving productivity of cotton-wheat system through relay cropping

This trial was conducted only at two locations at HAU Hisar and Hisar Farm of IIWBR to explore the possibility of relay seeding of wheat with cotton for increased productivity of wheat leading to improved productivity and profitability of Cotton-Wheat system. At both the locations minimum cotton yield was recorded when wheat was sown after cotton harvest in December. At IIWBR Hisar farm there was significant improvement in wheat yield with relay cropping compared to wheat seeding after cotton harvest. At HAU Hisar, wheat seed either sprouted or non sprouted was broadcasted in standing water and wheat seed broadcasted followed by power till mixing yielded significantly better. Yield improvement was also observed when alternate cotton rows were removed and seeding was done using ZT till drill.

Wheat yield maximization under different tillage options

To identify the varieties for Conservation Agriculture an experiment was conducted at four locations (Hisar, Karnal, Ludhiana and Pantnagar) in NWPZ. Six timely sown varieties namely WH 1105, HD 2967, DPW 621-50, DBW 88, HD 3086 and PBW 550 were evaluated in CT and CA system. This experiment was under rice-wheat system except Hisar centre where cotton-wheat system was adopted. The effect of tillage options and varieties was significant with 3.20% yield difference. Among varieties, the highest yield was recorded with cultivar WH 1105. The highest yield (54.00 q/ha) was recorded in conventional tillage with WH 1105 cultivar and this variety was also top yielder (52.67) under CA system with 2.49% yield difference.

Effect of tillage, mulch and irrigation on productivity in NEPZ

In this experiment mulching (0 & 4 t/ha) and irrigations (0, 1 and 3) were evaluated under three tillage options (ZT, Bed, CT) at Coochbehar and Shillongani. The data showed that there was no significant difference in grain yield among tillage options. Rice straw mulch at 0, 1, and 3 irrigations recorded significantly higher grain yield compared to no mulch treatment.

Mulching to mitigate the climate change effect

This experiment was conducted in three zones (NWPZ, NEPZ and CZ) with the aim to mitigate the terminal heat effect using straw mulch and organic manure and the chemical spray ($ZnSO_4$ and KCl). In NWPZ, in late sown wheat the yield reduction of 24.1% recorded compared to timely (60.27 q/ha) sown. Application of 0.2% KCl along with mulch and FYM produced numerically (5.29%) higher grain yield (54.18 q/ha) across sowing dates compared to recommended fertilisation and only 1.5% due to spray of KCl. Application of FYM (10 t/ha) along with recommended fertiliser recorded higher grain yield (53.31 q/ha) than RFD alone (51.46 q/ha) with the difference of 3.60% in grain yield. In NEPZ, the effect of sowing time and fertilisation were significant whereas interaction effects were not significant. In CZ, timely sowing (58.13 q/ha) produced significantly higher grain yield than late sowing (41.81 q/ha). Delaying wheat sowing reduced the grain yield by 28.1%.

Comparative performance of line versus dibbling in wheat

The performance of two wheat varieties was evaluated under five planting methods at six locations in CZ and three locations in PZ. Two wheat varieties were HI 1544 and HI 8737 in CZ and UAS 304, NIAW 301 in PZ. In CZ, there was significant difference in grain yield between two varieties. The wheat variety HI 8737 (45.09 q/ha) produced significantly higher grain yield than HI 1544 (44.42 q/ha). Among planting methods dibbling at 15 cm x 15 cm produced the highest and significantly higher grains yield (47.68 q/ha) than all the other treatments. In PZ, the significant effect of seeding method and spacing was observed on grain yield. The maximum and significantly higher yield was obtained in dibbling at 15x15 cm (43.06 q/ha) as compared to all other treatments except dibbling at 15x20 cm (40.87 q/ha). The 20 cm row spaced wheat with seed rate of 100 and 50 kg/ha produced statistically similar yields *i.e.* 39.15 and 38.38 q/ha, respectively. The variety UAS 304 produced marginally higher yield (40.29 q/ha) than wheat variety NIAW 301 (39.73 q/ha).

Wheat Quality

Eight thousand seven hundred eighty two (8782) wheat grain samples belonging to different AVTs, NIVTs, IVTs, QCSN and special trials were analyzed during 2015-16 for different quality traits that including evaluation of all the AVT-II entries and checks for identification of promising genotypes for chapati, bread, biscuit and pasta.

Promising genotypes identified for wheat products

Products	Genotypes
Chapati (>8.0/10.0)	K 1317, HI 1605, HD 2888, C 306, K 8027, MACS 6478, HD 2932, NIAW 1415.
Bread (>575ml loaf volume)	HI 1605, MACS 6222, MACS 6478, HD 2932, Raj 4083, NI 5439, NIAW 1415, DBW 93
Biscuit (>10 spread factor)	HS 490
Pasta (>7.0/9.0)	HI 8759, MACS 3949, MPO 1215, UAS 446
Extraction Rate (%)	K 1317, HI 1605, HD 2888, C 306, K 8027, NI 5439, NIAW 1415

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

Promising genotypes identified for processing and nutritional quality parameters

Parameter	*T. Aestivum*	*T. Durum*
Protein Content	HS 623, HPW 432, UP 2955, UP 2907, MACS 6222 (C), DBW 168, HD 2932 (C), Raj 4083 (C), NIAW 34 (C), AKAW 4842, HI 1605, NI 5439, NIAW 1415, DBW 93, MACS 6660, UAS 375 (> 13.50 %).	KD 1418, UAS 446 (C), UAS 459, HI 8777, MACS 4028 (>14.5%).
Sedimen-tation value	HS 625, HS 627, HPW 432, PBW 725, WH 1184, DBW 90 (C), DBW 172, WH 1080 (C), HD 2967 (C), HD 3184, HI 1612, HD 3171, HI 1605 (≥ 60 ml).	MPO 1215 (C), PDW 344, MACS 3949, UAS 428 (C), UAS 446 (C) (~ 40 ml).
Grain Hardness Index	HD 3043 (C), C 306 (C), NIAW 1415 (C), UAS 375 (> 80). VL 1010, HS 490 (C), VL 3012, DBW 168 (< 45).	HI 8498 (C), AKDW 2997-16 (C), RKD 283, RKD 292 (> 80).
Yellow Pigment	VL 829 (C), HPW 251 (C), HS 542 (C), HS 623, HS 490 (C), VL 3011, UP 2955 (> 4.2 ppm).	HI 8759, MPO 1215 (C), MACS 3949, NIDW 295 (C), UAS 428 (6.00 ppm).
Iron Content	HPW 251 (C), HS 542 (C), HPW 423, HS 622, HS 623, UP 2954, VL 892(C), HPW 432, UP 2955, HD 3171, MACS 6660 (> 45.0 ppm).	HI 8759, HI 8737 (C), HD 4728 (C), HI 8774, RKD 292, KD 1418, MACS 4028 (> 41.0 ppm)
Zinc Content	HPW 251 (C), HPW 423, HPW 424, HS 623, VL 1009, UP 2954, NIAW 34 (C), AKAW 4842 (> 45.0 ppm)	HI 8759, MPO 1215 (C), HD 4728 (C), HI 8774, PDW 344, NIDW 295 (C), UAS 428 (C), UAS 459, HI 8777, MACS 4028 (> 41.0 ppm).

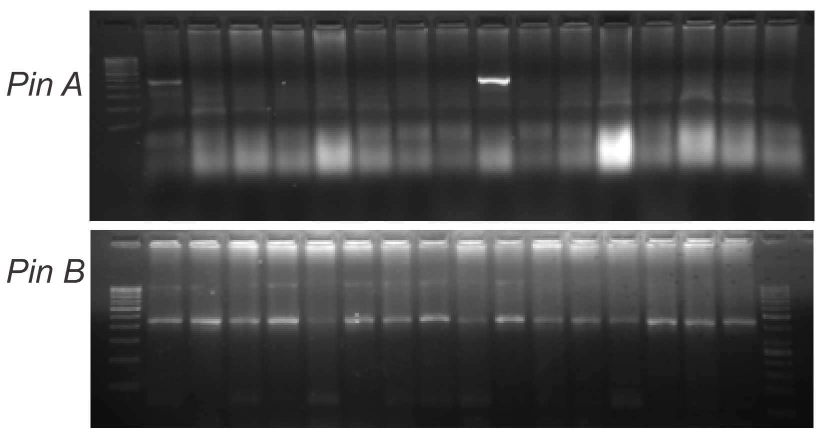
Different quality parameters have shown wide variability. If we can make segregated procurement it is possible to have better quality wheat products within country.

Variability in quality and nutritional parameters

Parameter	*T. aestivum*		*T. durum*	
	Mean	Variability	Mean	Variability
Test weight (kg/hl)	78.8	71.5-86.6	81.2	76.0-83.8
Protein content (%)	12.61	6.56-16.90	13.52	11.00-15.83
Grain hardness index	68	22-93	76	62-94
Sedimentation value (ml)	51	32-66	37	26-44
Extraction ate (%)	68.7	61.3-73.8	-	-
Yellow pigment (ppm)	3.36	1.96-4.79	5.20	3.69-6.55
Iron content (ppm)	40.8	30.7-68.2	40.6	33.3-48.6
Zinc content (ppm)	38.9	17.7-69.0	41.1	23.9-58.0

Likewise, about three hundred lines belonging to National Genetic Stock Nursery (NGSN), Elite International Germplasm Nursery (EIGN) & National Durum Screening Nursery (NDSN) were grown and analysed for processing quality traits, nutritional quality parameters, baking evaluation and molecular characterization.

PCR amplification of Puroindolines *PinA* and *PinB* with allele-specific PCR marker



1. Lok 59, 2. KRL 238, 3. DBW 37, 4. K 0615, 5. MP 1911, 6. CBW 38, 7. VW 648, 8. LBPY 06-2, 9. UP 2727, 10. LBYP 06-14, 11. MP 4106, 12. UAS 316, 13. WH 1080, 14. DBW 50, 15. MACS 6222, 16. KYZ 9772

Breeding efforts to enrich grain quality

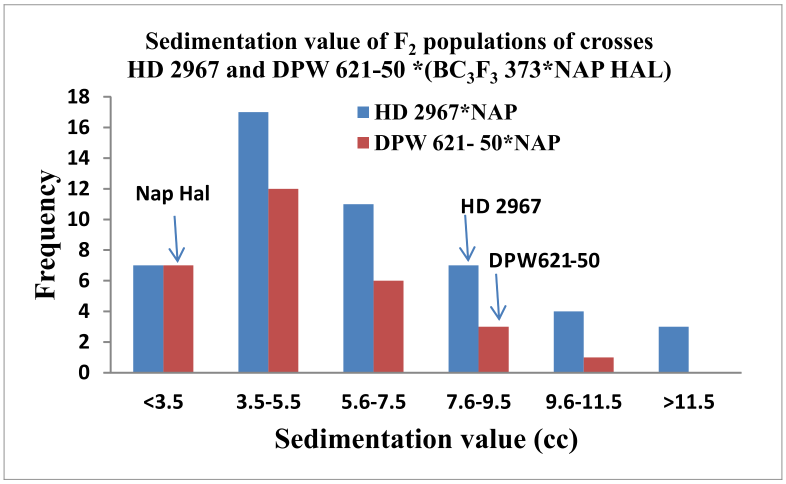
Concerted efforts to enhance grain and end-product quality at IIWBR have yielded many advance lines with good combination of grain yield and grain quality. Few of them have been evaluated in the station and coordination trials.

- Several derived lines tested under preliminary yield evaluation trial of IIWBR had GPC ≥14.5%, sedimentation value 60-64ml, genotypes of hard (index 82-83) and soft grain (2-25) texture, flour recover (72.5 to 73.2%), bread loaf volume 575-590cc, chapati score 7.9-8.3 and yield at par or higher than the check HD 2967.
- Several advance lines (F_6) have quality characteristics under highly desirable range.
- Ten genotypes of soft grain texture (9 from IIWBR and one from IARI) are being tested in QCSN and shared with the breeders.
- Some QLD lines like QLD 28, QLD 49, QLD 67, QBP 12-9 and QLD 73, have biscuit spread factor in the range 9.2 to 10.4.
- One soft genotype with grain softness index 33 and biscuit spread factor 9.20 i.e. DBW 168 had reached to the stage of final year testing. Its yield in previous two years was significantly higher than the local check MACS 6222.

Improving processing and nutritional quality of wheat using molecular approach

Transfer of *Glu-D1* double null and soft grain characteristics into high yielding backgrounds for improving biscuit making quality of wheat:

Molecular markers and microlevel tests were used to transfer *Glu-D1* double null of NAP HAL into high yielding backgrounds of wheat such as PBW 373, UP 2425, Raj 3765, DPW 621-50 & HD 2967. Materials are at different stages of development. Advanced backcross lines of a cross between NAP HAL and PBW 373 and UH 2425 were used in making crosses with DPW 621-50 and HD 2967. The segregating generations of these crosses showed Glu-D1 double null lines with very low sedimentation value indicating great potential for improving biscuit making quality. BC_3F_6 seeds harvested from selected BC_3F_5 plants of a cross between PBW 373 and NAP showed low sedimentation value and some of them exhibited transgressive segrergants towards low sedimentation under soft background and exhibited significant increase in the spread factor. The lines with high spread factor and higher yield potential were selected for further testing for yield traits and disease resistance. The selected entries will be further tested under preliminary yield trails.

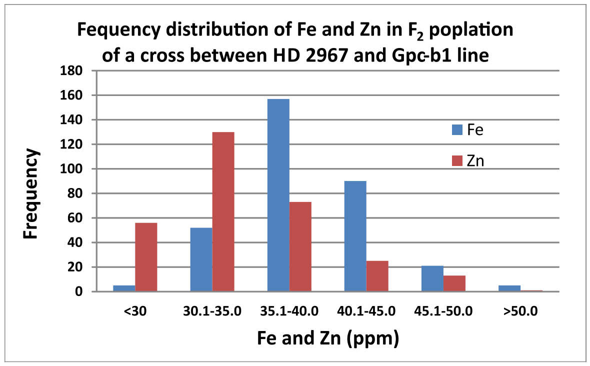


Improving Fe and Zn and protein content in wheat using *Gpc-B1*:

Recently *Gpc-B1* locus transferred from dicoccoides into hexaploid background was used for making crosses with high yielding backgrounds. There was large variation in grain protein content of F_2 population of a cross between HD 2967 and GPC-B1 derived lines. Surprisingly, it ranged from 11.0 to 20% at 14% moisture basis. The F_2 generations were further advanced into F_4 during 2015-16 crop season and phenotypic and genotypic analyses were conducted. Fe content varied from 27 ppm to 55 ppm and Zn content from 25 to 47 ppm indicating great potential for improving micronutrient and grain protein content. There was large variation in sedimentation value also indicating possibility of increasing both grain protein content and gluten strength simultaneously.

Identification and utilization of high phytase genotypes in wheat

Absorption of micronutrients such as Fe and Zn is significantly inhibited in human beings by the presence of substances such as phytic acid (PA) leading to deficiency of these micronutrients Therefore, degradation of phytate present in the grain is needed to overcome the problem of micronutrient deficiency in humans and monogastric animals. In humans, phytic acid breakdown in the stomach and the intestine is influenced mainly by the dietary phytases, which are active in the human stomach. Evaluation



of more than 1000 lines of bread wheat and synthetic hexaploid exhibited large variability in synthetic hexaploids. The high phytase lines of synthetic hexaploids were used in making crosses with high yielding varieties such as PBW 343. There was normal distribution of phytase levels in BC_1F_2 population and transgressive segregants were observed in both the directions (low and high). Large numbers of lines in BC_3F_2 population showed high phytase levels. This demonstrated the utility of synthetic hexaploids in increasing phytase levels in wheat and thus improving micronutrient bioavailability in human beings.

Characterization of Pyrroline 5 carboxylate synthetase gene (TaP5CS1) associated with salt tolerance in wheat

Full length gene sequence of *TaP5CS1* gene was obtained in Kh 65 (KT218497) and HD 2009 (KT868850) using internal primers. Based on CDS sequence, internal primers were identified and used in amplification followed by sequencing and development of contigs consisting of full length gene. The sequence showed the presence of 7407 nucleotides with nineteen exons separated by eighteen introns and encoding polypeptide of 716 amino acids. It has a predicted molecular weight of 77.64 kDa and an isoelectric point of 6.17. P5CS protein belongs to glutamate family with EC 2.7.2.11. The gene was mapped on chromosome 3B. The relative expression of *TaP5CS1* showed 33.59 fold increase in leaf and 19.69 fold in the root of Kh65 while it was 3.69 fold and 4.59 increase in both leaf blade and root of HD2009 under salt treatment respectively. The up-regulated transcript level of P5CS was associated with the increase in proline concentration under salt stress. The full length gene sequence of *TaP5CS1* obtained from the present study can be used for allele mining studies and will be useful for improving wheat genotypes for salt tolerance.

Variability in antioxidant activity & total phenolic content of Indian wheat varieties

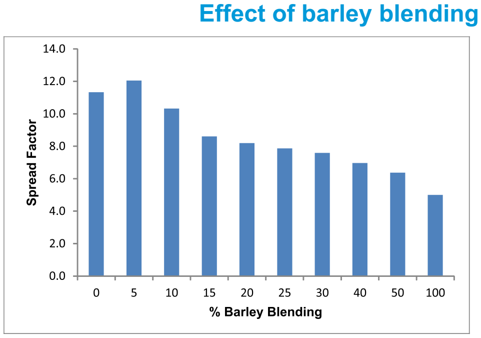
The whole meal flour from 376 Indian wheat varieties including bread wheat, *durum*, *dicoccum* and *triticale* was analysed for the antioxidant activity and total phenolic content. Two methods were used for estimating the antioxidant activity. Using ABTS assay, the activity range was 2.5 – 11.5 µM Trolox Eq./g and using DPPH assay the range was 3.2 – 17.5 % Discoloration. These results indicate a 5-6 fold variation in the antioxidant activity of Indian wheat varieties. Using both the methods, varieties WH 291, COW2 (HW 1095), TL 1210, WH 416, HD 3059, DDK 1009, DDK 1025, DDK 1029, TL 2098 and PV 18 were found to have high antioxidant activity. The total phenolic content was found to be in the range 160-1240 µg GAE/g showing 7-8 fold variation. The varieties PBW 443, GW 1139, MACS 1967, COW 2 (HW 1095), DDK 1029, VL 616, VL 719, HP 1761 and HI 784 were found to have high content of phenolics.

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

Barley has higher levels of antioxidants including phenolics and can provide additional health benefits if included in the diet. Biscuits were prepared using the hulless barley variety BHS 352 in different ratios with wheat flour of HS 490. The spread factor of the biscuits decreased as the percentage of barley flour added increased.

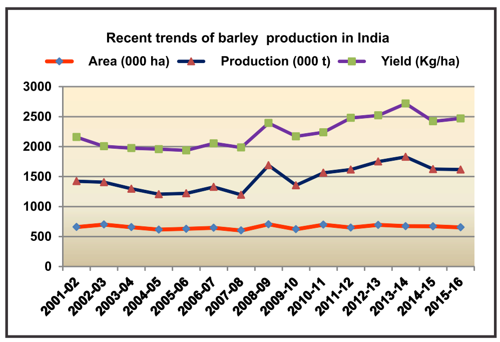
The antioxidant activities and phenolic content of the blended flours and biscuits were estimated. The initial antioxidant activity of wheat flour (*maida*) was negligible by ABTS method while barley flour had the activity of 8.4 µM Trolox Eq./g. After blending with barley flour the antioxidant

Effect of barley blending on wheat biscuit quality



activity increased considerably upto 5.9 μM Trolox Eq./g at 50% blending. In the biscuits, the initial activities was 0.9 which increased considerably after barley blending (50%) to 3.3 μM Trolox Eq./g. Negligible amount of phenolics were observed in wheat flour. But the barley flour had high content of phenolics (1065 μg GAE/g) and as a result of 50% blending the phenolic content increased upto 667 μg GAE/g. In case of biscuits no regular increasing trend was observed after blending. The initial phenolic content in the wheat biscuits was 63 μg GAE/g which increased upto 130 μg GAE/g after 50% blending with barley flour. Thus, BHS 352, a hulless barley variety is good source of antioxidants and phenolics and can be used for blending with wheat flour for biscuit preparation to increase their nutritional value.

BARLEY NETWORK



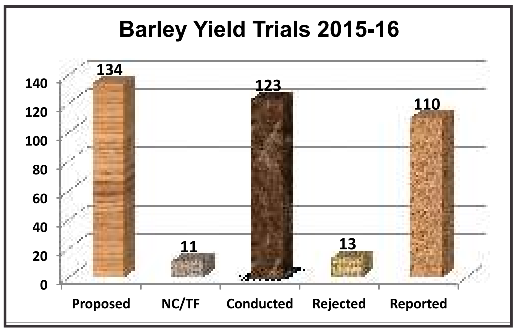
The crop season 2015-16 was quite good in terms of production. According to 4th advance estimates for Rabi 2015-16, nearly 1510 thousand tons of barley production in 655.0 thousand ha area with a productivity of 24.7 q/ha. During the season crop damage due to lodging was observed in pockets because of rains and strong winds at maturity stage. There was also aphid infestation in congenial atmosphere where not much winter rains occurred and caused damage in certain areas. A concern is usually raised at various platforms for barley area decline, however, in last 15 years, the area has stabilized and there has been gain in productivity resulting in higher production. Though the MSP of barley (Rs.1225) is much lower than wheat (Rs.1525), but during current season the market price of barley remained higher (up to Rs. 1300/q and in August it went up to Rs 1500/q).

The monitoring teams surveyed the major barley growing areas during the season in addition to visiting the experiments at coordinated centres. The observations indicate that the crop season was by and large a disease year in major barley growing areas, with some incidence of yellow rust in foothills and mid hills. The incidence of leaf blight was observed in the eastern zone. New initiatives were undertaken to improve productivity of food purpose barley through screening of germplasm and pre-breeding and to popularize the health benefits of barley (higher beta glucan content, improvement in lodging resistance and to enhance yield and quality. Linkages with national and international organisations, industries and farmers were also strengthened.

Novel Genetic stock Registered during 2015-16

Genetic stock	Characteristics
DWRB 30	High beta Glucan
BK 1127	High thousand grain weight with high protein

Coordinated Yield evaluation trials



Out of 134 yield evaluation trials proposed, 123 (91.8%) trials were conducted. After the analysis, only 110 trials (82.1% of proposed 89.4% of conducted) were found good for reporting. These trials were conducted at 12 main centres and 47 testing centres (including ICAR, SAUs and State Department of Agriculture) during *rabi* 2015-16. In all, 114 test entries contributed by 12 centres, were evaluated against 30 checks in the coordinated yield trials under rainfed (plains and hills), Irrigated (plains) and saline soils conditions under timely/ late sown conditions. The new barley entries included malt, feed or dual purposes types and mostly were hulled type with a few hull-less types in northern hills zone.

Malt Barley Evaluation: Timely sown

- In AVT malt barley timely sown trial the mean grain yield was exhibited as 45.3 q/ha, which ranged from 32.3 q/ha (Karnal) to 64.2 q/ha (Sri Ganganangar) indicating a wide difference across the centres. The entry RD 2917 (47.1 q/ha) ranked first followed by the best check DWRB 101 (46.7 q/ha.
- The IVT malt barley timely sown was proposed and conducted at 9 locations in NWPZ with 20 entries including 5 checks. The trial mean ranged from 32.0 q/ha (Bathinda) to 64.2 q/ha (Durgapura), with 42.2 q/ha mean value of NWPZ. The feed barley check BH 902 ranked first (49.5 q/ha) followed by the test entry DWRB 150 (47.3 q/ha).

Late sown

• The AVT malt barley late sown evaluated 6 test entries and 3 checks. The trial mean ranged from 26.9 q/ha (Pantnagar) to 48.4 q/ha (Sriganga Nagar), with 34.1 q/ha NWPZ mean. The genotype RD 2917 ranked first (37.5 q/ha) followed by check DWRB 91 (37.00 q/ha) and feed barley check BH946 (36.9 q/ha).

• The IVT Malt Barley late sown was conducted at 7 locations in NWPZ with 14 entries. The trial mean grain yield was observed as 33.7 q/ha, which ranged from 30.7 q/ha (Karnal & Modipuram) to 38.0 q/ha (Durgapura). The feed barley check BH 946 ranked first (39.1 q/ha) followed by the test entries DWRB 154 (38.6 q/ha), DWRB 152 (38.3 q/ha) and malt barley check variety DWRB 91 (37.4 q/ha).

Feed Barley Evaluation: Irrigated

• The AVT (Irrigated) was conducted at 10 locations in NWPZ. The trial consisted of one test entry and four checks. The best check BH 902 ranked first with 50.80 q/ha mean grain yield.

• The AVT (Irrigated) for NEPZ comprising one test entry and four checks was evaluated at six locations. The test entry DWRB 137 showed first rank with 38.8 q/ha mean grain yield and was in the first non-significant group.

• The AVT trial in central zone involved three test entries and three checks. The test entry DWRB 137 ranked first with 45.26 q/ha mean grain yield followed by RD 2899 (45.16 q/ha). Both entries were numerically superior over the checks.

• The IVT feed barley trial consisted of 21 test entries and 6 checks was evaluated at 17 locations. In NWPZ and Central zone check varieties BH 946 (45.9 q/ha) and RD 2552 (51.44 q/ha) ranked first, respectively. However, In NEPZ, test entry HUB 250 (40.2 q/ha) ranked first for grain yield and was in first non-significant group. This test entry outperformed over the best check BH 902 (36.37 q/ha).

Rainfed Plains

• AVT-RF-NEPZ trial consisted of 4 test entries and three checks and was evaluated at nine locations in NEPZ. The best check K 603 ranked first with 30.47 q/ha mean grain yield followed by test entry HUB 242 (29.58 q/ha).

• The IVT (rainfed) trial was conducted at nine locations in NEPZ with 19 entries including checks. Test entry JB 328 ranked first with 30.40 q/ha grain yield and was in the first non-significant group.

Rainfed Hills

• AVT-RF-NHZ was evaluated at 11 locations in the northern hills. This trial comprised of 15 test entries and four checks. The test entry VLB 149 (33.37 q/ha) ranked first and was significantly superior over the best check BHS 400 (31.0 q/ha).

Salinity-alkalinity

• A special alkalinity/salinity trial comprising of 15 test entries and 4 checks was conducted at 8 locations. Test entry RD 2907 (31.85 q/ha) ranked first and followed by check RD 2974 (31.84 q/ha).

Dual purpose

• The IVT dual purpose trial comprising of 14 test entries and 4 checks was conducted at 16 locations. Check variety RD 2552 (32.88 q/ha) was first in ranking in grain yield while the test entry RD 2928 (182.84 q/ha) ranked first for forage yield.

• The AVT for dual purpose in NHZ was conducted at 5 locations under rainfed conditions with 17 entries and three checks. The test entry VLB 147 ranked first with grain yield (19.74 q/ha) while entry VLB 149 (41.53 q/ha) showed rank first for forage yield.

Germplasm evaluation and exchange

An Elite International Barley Germplasm Nursery (EIBGN) constituted with 45 genotypes selected from different international trials and nurseries was supplied for evaluation to all the twelve cooperating centres of Barley Network. A National Genetic Stock Nursery (NBGSN) was constituted with 22 promising genotypes. During the season, three International trials and three nurseries received from ICARDA, were evaluated along with suitable national checks at different locations. A total of 291 promising entries were selected by the breeders pursuing barley improvement.

International trials and nurseries evaluated during crop season 2015-16

Trial/ Nurseries	Origin	Entries received	National check	Number of Sets	Locations
3rd GSYT	ICARDA	24	K603	4	Kanpur, Faizabad, Rewa, Karnal
IBYT-HI	ICARDA	24	BH946	4	Durgapura, Hisar, Ludhiana, Karnal
INBYT-HI	ICARDA	24	BHS352/Gitanjali	2	Bajaura, Karnal
3rd GSBSN	ICARDA	145	Lakhan	4	Kanpur, Faizabad, Rewa, Karnal
IBON-HI	ICARDA	134	BH946	4	Durgapura, Hisar, Ludhiana, Karnal
INBON-HI	ICARDA	74	BHS352/ Gitanjali	2	Bajaura, Karnal

Breeder seed production

A consolidated indent of 1138.43q breeder seed of 36 varieties was received from Ministry of Agriculture & Farmers Welfare, Govt. of India. The indent included requirement of eight states (Rajasthan, Uttar Pradesh, Uttarakhand, Haryana, Madhya Pradesh, Punjab, Jharkhand and Himachal Pradesh), National Seeds Corporation and National Seed Association of India for the season Rabi 2016-17. The major proportion of the breeder seed indent was placed from NSAI (359.95q) followed by Rajasthan (325.00q), Uttar Pradesh (244.23q), National Seed Corporation (93.00q) ,Madhya Pradesh (85.00q) etc. The lowest demand of breeder seed was made from Uttrakhand (1.10q) followed by Jharkhand (1.20q) and Punjab (3.35q). The highest indent was received for variety RD 2786 (137.00q) followed by RD 2715 (107.00), BH 902 (103.40) etc. A net production of 1123.57q breeder seed was reported.The maximum production was reported for RD 2035(125.00q) followed by BH 902 (114.4q), RD 2786 (112.0q) etc. 47.45q nucleus seed was produced against the targeted quantity of 45.60q of 29 varieties.

Barley crop protection

Barley Crop Health Report

During crop season 2015-16, stripe rust appeared at very few places with very low intensity. There was no report of natural occurrence of black rust in barley from any of the barley growing areas of India. Covered smut and loose smut were observed in some of the barley fields in the Rajasthan. In the central India, leaf blight and foliar aphids were observed in few areas.

Seedling Resistance Test (SRT) in NBDSN lines

During 2015-16, 143 entries from AVT and IVT yield trials including checks were screened for seedling resistance test against stripe rust, leaf rust and stem rust races. Entries VLB 147 and PL 891 were resistant to all three rusts. Eight entries (HBL 113, HBL 748, RD 2715, RD 2928, RD 2930, RD 2932, RD 2935, and RD 2938) were resistant to brown and yellow rusts. BH 1008, BHS 448, KB 1434 and NDB 1445 were resistant to black and brown rust only.

Rust resistance in EBDSN lines

During the crop season 2015-16, 66 entries were screened for seedling resistance test against stripe rust, leaf rust and stem rust races in EBDSN. Two EBDSN lines viz. BCU 7911 and VLB 140 were resistant to all the tested pathotypes of black, brown and yellow rusts. There was only one entry

(BH 995) showing resistance to black and brown rusts and two entries (BH 981 and VLB 130) showing resistance to black and yellow rusts. Eight entries were resistant to both brown and yellow rusts.

Adult plant resistance (APR)

Out of 442 IBDSN entries tested, 52 entries were found free from yellow rust (ACI = 0) and 243 entries showed resistant reaction have ACI less than 10. In case of leaf blight screening, 40 entries were found moderately resistant with average score upto 35 and the highest score below 57. Among 143 NBDSN lines, 17 were free from yellow rust infection whereas three lines viz. BH 1003, PL 891 and HBL 113 (c) found moderately resistant to leaf blight. Out of 66 EBDSN lines 15 were free from yellow rust and 9 were moderately resistant to leaf blight.

Chemical control of barley foliar blight and stripe rust

Seed treatment with Vitavax @ 2g/Kg followed by two sprays with Propiconazole/ Tebuconazole @ 0.1% spray effective for management of leaf blight. Spraying with Propiconazole @ 0.1% recorded lower stripe rust severity.

Screening of NBDSN barley entries against CCN and barley aphids

Majority of the entries, tested at locations affected by aphids, were categorized as either susceptible (grade 4) or highly susceptible (grade 5) to aphids. However, few entries were also categorized as either moderately resistant (grade 3) or resistant (grade 2). At Durgapura location, two entries; DWRB 154, and RD 2945 showed moderately resistant reaction. Similarly, three entries at Pantnagar; NDB 1639, RD 2922 and RD 2932 and at Karnal; NDB 1639, RD 2922 and RD 2932 were categorized moderately resistant. One entry at Pantnagar RD 2928 gave resistant reaction. All the entries were found to be either S or HS to CCN and none of the entries shown resistance.

Barley Resource Management

The AVT entries were evaluated under irrigated conditions with different nitrogn levels and sowing conditions in North Western Plains Zone. In special trials (weed management, integrated nutrient management, spacing, PGRs, N doses & its scheduling, different source of potash effects), out of 46 proposed at different locations, 42 are reported here.

Irrigated, timely sown malt barley (different N levels) NWPZ

The performance of test entry DWRB 123 was evaluated against four checks (DWRUB 52, DWRB 101, BH 902 and RD 2849) at different nitrogen levels. The test entry DWRB 123 recorded highest grain yield (4906 kg ha-1) when N was applied @ 90 kg ha^{-1}. On mean basis, the test entry DWRB 123 was numerically superior to all checks except BH 902. In late sown conditions, the grain yield reduced by 20.2 % as compared to normal sown crop.

Effect of dose and time of nitrogen application under rainfed condition in NHZ

The trial was conducted with an objective to optimise dose (0, 20, 40, 60 and 80 kg/ha) and time (Full basal, 1/2 at basal+1/2 after 1st rain, 2/3 at basal+1/3 1st rain) of N application to increase barley productivity in NHZ. Three year results showed that the grain yield increased significantly with the increase in the level of nitrogen only up to 60 kg N ha^{-1}, whereas significantly higher grain yield was recorded by applying half N as basal and remaining half after 1st rain or ⅔ N as basal and remaining ⅓ after 1st rain.

Weed management in Barley

The trial was to manage the broad leaved weeds through herbicides and conducted at Kanpur and Varanasi in NEPZ and at Durgapura in NWPZ. Eleven treatments of metsulfuron and carfetrazone in combination or alone, weedy check and weed free were used. Grain yield in Metsulfuron+ Carfentrazone @ 20g+ NIS 0.2% and Metsulfuron+Carfentrazone @ 25g+ NIS 0.2% treatments was significantly superior to other herbicide treatments and weedy check condition. Application of Metsulfuron+ Carfentrazone @ 25g+ NIS 0.2% also resulted in maximum reduction in dry weight of weeds.

To manage the grasses and broad leaved weeds through herbicides eleven treatments of pinoxaden and isoproturan in combination with metsulfuron /carfentrazone / 2,4 D or alone were evaluated. The application of Pinoxaden @ 40g ha^{-1} +Carfentrazone @ 20g ha^{-1} and Pinoxaden @ 40g ha^{-1} followed by Metsulfuron @ 4g ha^{-1} were at par with weed free treatment. Application of Pinoxaden @ 40g ha^{-1} +Carfentrazone @ 20g ha^{-1} and Pinoxaden @ 40g ha^{-1} followed by Metsulfuron @ 4g ha^{-1} resulted in maximum reduction in dry weight of weeds.

Integrated Nutrient Management in Barley

The objective was to reduce the dependency on chemical fertilizers and to sustain barley productivity. A significantly higher grain yield was obtained with the application of 100 % recommended dose of fertilizer with biofertiliser. Reduction in dose of fertilizer with biofertiliser reduced the grain yield. Similar results were obtained in all other zone except NHZ where no significant effect on grain yield was noticed by the use of bio-fertilizers.

N levels X PGRs

The trial was conducted with an objective to observe the effect of different plant growth regulators on barley productivity. Three levels of nitrogen (100, 125 and 150% recommended dose of nitrogen (RDN), with three PGRs (Chlormequat-chlorid (CCC) @1.25 L ha^{-1} at GS_{30-31}, Ethephon(Cerone) @1.0 L ha^{-1} at GS_{39-40}, CCC + Ethephon) and one control treatment were undertaken. A significantly higher grain yield was obtained with the application of PGRs as compared to control. Grain yield reduced significantly with increase in dose of nitrogen to 150% of RDN. Lodging score increased significantly with increase in nitrogen dose whereas, lodging score was reduced significantly with chlormequat-chlorid (CCC) @1.25 L ha^{-1} at GS_{30-31} followed by ethephon(Cerone) @1.0 L ha^{-1} at $GS_{39-40.}$

Barley Quality Evaluation

Malting quality

Grain samples of Advanced Varietal Trial (AVT) and Initial Varietal Trial (IVT) were evaluated for malting quality. 354 grain samples were received from Hisar, Karnal, Bawal, Ludhiana, Mathura, Bathinda, Durgapura and Pantnagar.

Several entries were observed, after the detailed analysis across locations in the NWP Zone. Based on the ten important traits (a maximum possible score of 30), entry DWRB 123 was having better overall malting quality score under timely sown conditions. In late sown trials BH 1003, DWRB 154, RD 2946 were found promising.

Molecular Profiling of AVT Final Year Entries

A total of 45 SSR/STS markers covering all the seven chromosomes of barley were screened with final year test entry (DWRB 123) and five check varieties (BH 902, DWRUB 52, DWRB 92, DWRB 101 and RD 2849) to develop molecular profiles. In total 80 alleles were scored in selected genotypes for PCR based amplification profiles of AVT final year entry. The

Promising entries* for individual malting quality trait

Traits	Promising entries: Timely sown	Promising entries: Late sown
Test Weight	BH 1011, BH 1013	RD 2919, PL 890, DWRB 140, BH 1014
Bold Grains (%)	DWRB 123, RD 2943, BH 1012, RD2940, DWRB 147, DWRB 148	RD 2919, DWRB 154, RD 2946
Thousand grain weight	RD 2943, KB 1405	DWRB 153, RD 2946, DWRB 154,
Protein content	-	DWRB 154
Husk Content	DWRB 123	RD 2919, DWRB 140, PL 890
Beta glucan	PL 890	BH 1001, RD 2919, BH 1003, RD 2945, RD 2946, RD 2944
Malt Friability	RD 2917, RD 2940, RD2943	BH 1003, DWRB 141, BH 1001, RD 2917, DWRB 140, BH 1016, DWRB 154
Hot water extract	RD 2939, BH 1011, BH 1013	-
Filtration Rate	DWR 123, PL 890, RD 2943, BH1011	BH 1003, DWRB 141, BH 1001, RD 2917, DWRB 140, BH 1016, DWRB 154
Diastatic Power	DWRB 136	RD 2946, BH 1016, BH 1015, DWRB 153, DWRB 153
Kolbach Index	RD 2940	BH 1003, RD 2917
Over all MQ	DWRB 123	BH 1003, DWRB 154, RD 2946

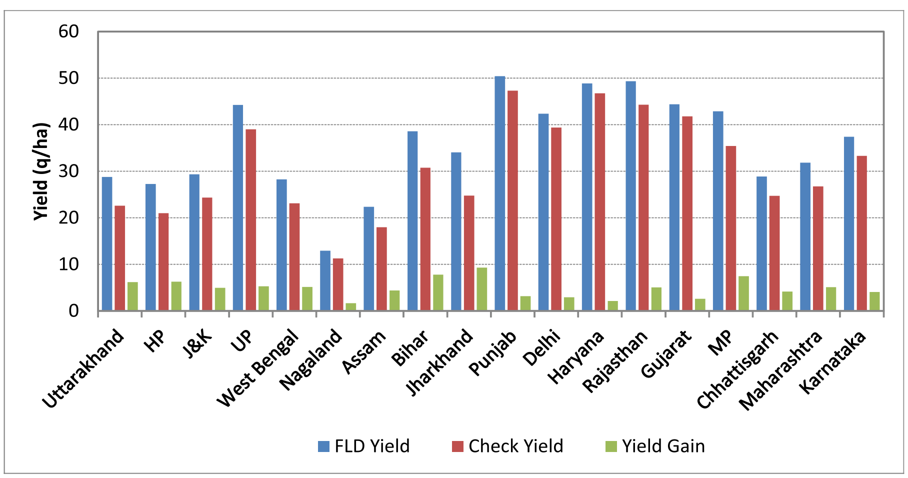
**Superior or at par to best check*

number of alleles ranged from 1 to 3 with an average of 1.69 alleles per locus. The band fragment size varied from 109 bp to 1500 bp with PIC values ranging from 0 to 0.67. Out of 45 molecular markers screened, 28 were found polymorphic for the entry and checks thus indicating sufficient coverage of barley genome during molecular screening. Molecular statistics were comparable with previous crop season (2014-15) final year AVT entries. This suggested that genetic variability of barley genotypes has maintained for major barley sowing region (NWPZ) of India. During molecular analysis, chromosome 7H was found most variable followed by 6H whereas chromosome 5H was observed least variable followed by 2H chromosomes. Average PIC across seven linkage groups of barley varies from 0.34 to 0.55 for final year AVT. The dendrogram generated clearly indicates that the final year test entry does not cluster at one place and is quite diverse from five check lines. The six genotypes grouped within similarity coefficient (GS) value from 0.57 to 1.0 and showed sufficient genetic variability at molecular level. The cluster tree for six genotypes is divided into two sub-clusters at GS= 0.57. The cluster I grouped four genotypes including test entry (DWRB 123) and three check varieties viz. DWRUB 52, DWRB 101 and RD 2849 developed for NWPZ sowing zone for similar end use i.e. malt barley whereas group II comprised rest of two checks (DWRB 92 and BH 902). All six genotypes under study could be distinguished using screened markers.

TECHNOLOGY TRANSFER

Wheat Front Line Demonstrations (2015-16)

To disseminate a new technoly among farmers, it is necessary that the technology is demonstrated at famers' field. Under this program, 600 Wheat Front Line Demonstrations (FLDs) of around one hectare each were allotted to 82 cooperating centres across the country, out of which 568 were conducted through 79 cooperating centers. The technologies such as improved wheat (*T.aestivum, T.durum and T. dicoccum*) varieties with complete package of practices, rotavator, zero tillage/rotary disc drill, bio-fertilizer and drip irrigation were demonstrated at the farmers' field. These FLDs covered 578.25 hectares area of 1359 farmers in 19 states. The maximum number of WFLDs were conducted in UP (74) followed by MP (62), Rajasthan (47), Haryana (45), HP (39), Assam (38), Bihar (35), Punjab (34), Maharashtra (34), Jharkhand (24), J&K (20), West Bangal (20), Gujarat (18), Chhattisgarh (17), Tamilnadu (15), Delhi (14), Uttarakhand (12), Nagaland (10) and Karnataka (10).



The maximum yield gain including all technologies was observed in Jharkhand (37.51 %) followed by HP (29.92 %), Uttarkahand (27.35 %), Bihar (25.36 %), Assam (24.40 %), West Bengal (22.23 %), MP (21.04 %), J&K (20.46 %), Maharashtra (19.04 %), Chattisgarh (16.74 %), Nagaland (14.70 %), UP (13.52%), Karnataka (12.25 %), Rajasthan (11.38 %), Delhi (07.49%), Gujarat (06.22 %), Punjab (06.06 %) and Haryana (04.56 %).

The variety wise mean yield data has revealed that timely sown/early sown variety HS 542 gave significantly higher yield (34.36 q/ha) at Tutikandi

Shimla followed by the same variety HS 542 (29.96 q/ha) at Bajaura center in NHZ. In NEPZ, the highest average yield was recorded by variety HD 2967 at Kaimur Bhabua (51.50 q/ha) followed by the same variety HD 2967 at Kanpur (47.14 q/ha) and Morabadi Ranchi (44.12 q/ha). In NWPZ, the highest significant average yield was recorded WH 1105 at Ludhiana (60.00 q/ha) followed by 58.20 q/ha at Saharanpur and 57.10 q/ha at Durgapura, Jaipur. In CZ, DBW 110 gave highest significant average yield of 51.45 q/ha at Kota centre followed by DBW 110 (51.06 q/ha) at Sawai Madhopur and DBW 110 (50.31 q/ha) at Junagarh center. In PZ, NIAW 1415 gave highest and significant yield (38.05 q/ha) at Niphad followed by MACS 6478 (37.96 q/ha) at Pune centre. At Wellington centre of SHZ, HW 5207 variety recorded the average yield of 20.94 q/ha followed by HW 5216 (17.00 q/ha).

In late sown varieties HD 3118 gave significantly higher yield (33.91 q/ha) at Varanasi center in NEPZ. In PZ, the significant average yield was recorded in AKAW 4210 at Akola (22.75 q/ha) center.

Zone wise productivity under wheat FLDs over check during 2015-16

Zone	Mean yield(q/ha)		% Gain
	Wheat FLDs	Check	
NHZ	25.40	19.56	29.86***
NEPZ	31.60	25.72	22.86***
NWPZ	48.58	44.67	08.75***
CZ	42.26	36.66	15.28***
PZ	32.44	27.46	18.14***
SHZ	21.22	-	-

*** Significant at 1 percent level

The yield gain due to improved varieties over check was highest in NHZ (29.86 %) followed by NEPZ (22.86 %), PZ (18.14 %), CZ (15.28 %) and NWPZ (08.75 %).

FLDs on bio-fertilizer (*Azotobacter & PSB*) along with 100 % inorganic fertilizer as compared to check (100% recommended dose of inorganic fertilizer) showed that the significant yield gain was 11.77 per cent at Dimapur in NEPZ, 11.63 per cent at Bijnor in NWPZ.

In case of improved durum varieties, the variety HD 8713 (d) recorded a significant average yield of 71.67 q/ha followed by HD 4728 (d) at Indore centre in CZ. The variety HW 1098 (dic.) gave an average yield of 32.50 q/ha at Pune center, though it was non-significant.

For effective and efficient use of water, demonstrations on sprinkler/drip irrigation were organized at Bhiwani and Vijapur centers. There was significant yield gain due to sprinkler irrigation at Bhiwani center. There was not significant yield gain due to drip irrigation at Vijapur center. The aim of **'Per drop more crop'** can be realised by the micro irrigation technologies at farmers' fields. The main limitation with this technology is that many small farmers do not possess the required infrastructure for micro irrigation technologies.

The analysis of wheat production constraints revealed that small land holding was the most serious constraint faced by farming community in the country as these farmers are unable to use farm machinery in their fields. Economically, it is also not viable to purchase farm implements and machines for small holders. The other constraints which were also perceived most serious included, non-availability of seeds of newly released variety, lack of knowledge among the farmers about recent technologies, late sowing with early varieties, temperature fluctuations during crop growth period, high cost of inputs, poor quality of locally available seeds, non-availability of labour, low organic matter in the soil, non-availability of farm machinery and low price of wheat.

Farmers need to be educated and trained on recent wheat production technologies, complete package of practices and soil health management. The concept of conservation agriculture and adoption of resource conservation technologies at farmers' field can be propagated at a larger scale. To ensure better price, farmers have to go for quality wheat production.

Barley Front Line Demonstrations 2015-16

During the period under report, 130 Barley Front Line Demonstrations (FLDs) were allotted to 25 different cooperating centers in six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP. Out of these 125 were conducted by 24 centers, covering 265 farmers. Improved barley varieties with complete package of practices (irrigation management, fertilizer dose and method of application, weed control, seed treatment etc.) were demonstrated. The highest increase in barley yield was recorded in HP

(32.52 %) followed by UP (26.74 %), Madhya Pradesh (20.54 %), Rajasthan (19.38 %) and Haryana (10.86 %). The lowest increase in yield was reported in Punjab (06.90 %).

Zone wise productivity under barley FLDs over check during 2015-16

Zone	Mean yield (q/ha)		% Gain
	Barley FLDs	Check	
NHZ	25.63	19.34	32.52***
NEPZ	35.03	27.64	26.74***
NWPZ	48.48	43.46	11.55***
CZ	41.74	34.17	22.15***

*** Significant at 1 per cent level.

The yield gain due to improved varieties over check was highest in Northern Hills Zone (32.52 %) followed by North Eastern Plains Zone (26.74%), Central Zone (22.15 %) and North Western Plains Zone (11.55 %).

In NHZ, the BHS 400 was the highest average yielding (26.55 q/ha) variety at Bajaura centre. In NEPZ, HUB 113 at Varanasi (40.77 q/ha), DWRB 101 at Ludhiana (57.75 q/ha) in NWPZ and BH 959 at Morena (46.04 q/ha) in central zone were found the highest average yielding varieties.

The analysis of constraints impeding barley production in the country revealed that erratic power supply, low price of barley, high temperature at maturity, high cost of inputs, non-availability of labour, small land holdings, low organic matter in the soil, high cost of inputs, non-availability of farm machinery and lack of facility of canal irrigation were identified as major constraints affecting barley production and productivity of the country.

Costs and Returns for Wheat and Barley FLDs vis-à-vis Check Plots

Profitability on investment is one of major deciding criterions for adoption of any crop production technology. At IIWBR, Karnal, costs and returns analysis for wheat and barley FLDs have been attempted across regions for the improved production technologies.

Costs and Returns for Wheat (FLDs vis-à-vis Check Plot)

On an average, wheat varieties or technologies demonstrated in FLDs gave Rs. 2.53 per rupee of investment in comparison to the check varieties

(Rs. 2.19). A significant difference in returns per rupee of investment was noticed between the FLD and check plots across states, zones and technologies. The returns from FLDs ranged from Rs. 5.35 (Tamil Nadu) to Rs.1.66 across states, Rs. 5.35 (SHZ) to Rs. 1.89 (NHZ) across zones and Rs. 5.26 (Dicoccum) to Rs. 1.76 (Sprinkler) across technologies. Tamil Nadu registered the highest returns per rupee of investment owing to the low operational costs, followed by Punjab (Rs. 3.67) and Haryana (Rs. 3.28).

The profit per hectare in FLDs was highest in Punjab (Rs. 72813), followed by Rajasthan (Rs. 68075) and Gujarat (Rs. 64376). The difference in profit between FLDs and check ranged from Rs. 18945 in Madhya Pradesh to Rs. 1944 in Haryana. Interestingly, operational costs in Punjab, Madhya Pradesh, Rajasthan and Jammu & Kashmir were lower in FLDs than check plots. The probable reason might be demonstration of resource efficient zero tillage and rotavator techniques which reduced the operational costs. Estimates of cost of production indicated that the cost incurred in producing a unit quantity of output was least in Punjab (Rs. 542 per quintal) owing to less operational costs and the likelihood of getting more yield being a progressive state. Among wheat growing zones, the returns per rupee of investment were highest in the SHZ due to less operational costs in raising the crop and high price (Rs. 2600 per quintal). NWPZ also realized a good return per rupee of investment which is mainly due to the higher productivity.

Among the wheat production technologies demonstrated at the farmers field, durum cultivation gave the highest profit per hectare (Rs. 84427) and the least profit was observed for the late sown wheat varieties (Rs. 29783). Overall, on an average, an Indian farmer by adopting a new wheat variety or production technology will earn Rs. 45840 per hectare at his/her farm. Further, Rs. 914 has to be spent to produce a quintal of wheat through adoption of a new wheat variety or production technology against Rs. 1064 (check varieties).

Costs and Returns for Barley (FLDs vis-à-vis Check Plot)

Improved barley varieties demonstrated in FLDs gave around 16 per cent better returns in comparison to the check. A significant difference in returns per rupee of investment was noticed between the FLD and check plots across states and zones. Punjab registered the highest returns per rupee of investment (Rs. 5.58) through demonstrations, followed by Haryana

(Rs. 3.42) and Uttar Pradesh (Rs. 3.17). However, the difference in the returns per rupee of investment between FLDs and Checks was highest in Uttar Pradesh. The profit per hectare in FLDs was highest in Punjab (Rs. 59990), followed by Haryana (Rs. 57605) and Rajasthan (Rs. 55076). The difference in profit between FLDs and check ranged from Rs. 16047 in Uttar Pradesh to Rs. 5120 in Punjab. Interestingly, operational costs in Madhya Pradesh and Uttar Pradesh were lower in FLDs than check plots. The valid reason might be reduction in the use of inputs based on the recommendation. The returns per rupee of investment across barley growing zones were highest in the NWPZ (Rs. 3.41) followed by NEPZ (Rs. 3.20) and CZ (Rs. 2.84). Estimates of cost of production indicated that the cost incurred in producing a unit quantity of output was least (Rs. 289) in Punjab (NWPZ) owing to less operational costs and relatively higher yield.

Overall, the costs and returns analysis on wheat barley indicated that profit per hectare from FLDs was more than the check varieties by Rs. 10650 and Rs. 10650 respectively establishing the fact that FLDs carry the successful technologies from lab to land. In a few cases it was found that the operational costs under check varieties were more than FLDs. However, the present estimates are only the indicators for comparison within the current year and may not have a complete inter-year relevance as the demonstrations were conducted in different sites.

Technology Transfer

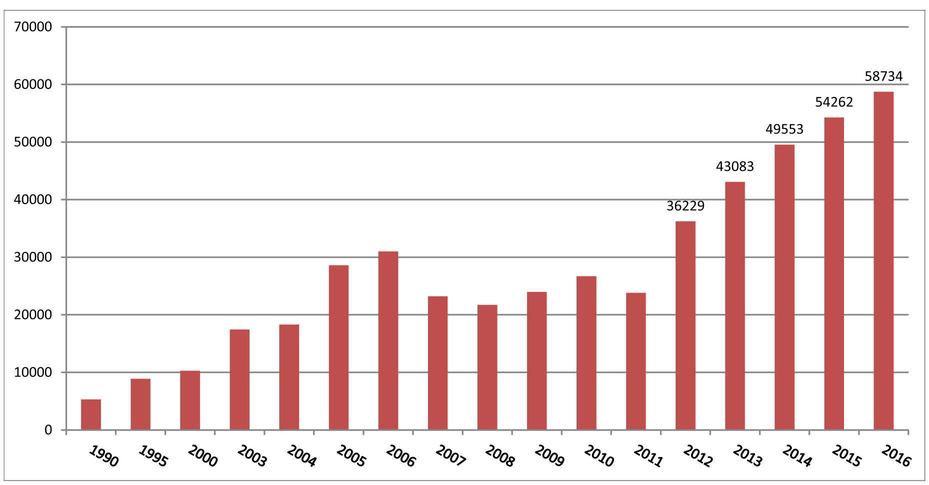
The technologies developed at the institute and other cooperating centers were made aware to the farmers through organising foundation day, three field days, six agriculture awareness programmes under 'Mera Gaon Mera Gaurav' scheme and 'Jai Kisan Jai Vigyan' week, participation in fifteen exhibitions and kisan melas, four TV programmes. Apart from these, ten lectures delivered benefitting students, farmers and scientific community; and coordinated 62 visits of farmers/students/trainees/scientists /Agriculture Officers. The advisory services were also provided to the farmers through letters, phone calls, emails and SMS. The IIWBR, Karnal conducted 15 training programmes for the farmers and also organized one 'Training-cum-Workshop' for the TSP Centers' cooperators. A WhatsApp Group named 'Farm Advisories_IIWBR' was created to help the farmers timely in case of any disease and pest outbreak and also linked the scientific advisory services to MANAGE Portal.

IIWBR-Regional Station, Dalang Maidan (HP)

The IIWBR, Regional Station located at Dalang Maidan, Lahaul & Spiti (Himachal Pradesh) acts as a national facility for providing environment for growing wheat, barley, mustard, lentil and chickpea crops during the off-season. This regional station of IIWBR is situated on the right bank of the River *Chandra* at Dalang Maidan in tribal district of Lahaul-Spiti in Himachal Pradesh. It is located approximately at 32^{0}30'N and 76^{0}59'E at an altitude of 10,000 feet above sea level. The climatic conditions at the station are favorable to grow wheat, barley, mustard, lentil and pea during summer (May to October) as off season nursery. The progress made under different mandated activities of the centre during the year 2015 is presented under following heads.

Generation advancement of wheat and barley:

During the year 2015, about 53700 lines of wheat, 322 lines of barley, 170 lentil, 50 peas and 20 lines of mustard from 21 cooperators of different institutes were advanced at ICAR-IIWBR Regional Station, Dalang Maidan. The material from cooperating centres across the country was advanced at the station. The maximum material was obtained from different centres in the North Western Plains Zone.



No. of entries grown during 1990 to 2016 at Dalang Maidan

All the research material was harvested and supplied to the respective researchers well in time. The station received three species of wheat i.e. *Triticum aestivum*, *T. durum* and *T. dicoccum* which were advanced at the station during this season. Apart from this, some wild species were also grown at the centre. Besides Indian Institute of Wheat & Barley Research, Karnal, Indian Agricultural Research Institute, New Delhi; Chaudhary Charan Singh Haryana Agricultural University Hisar; National Agri-Food Biotechnology Institute Mohali, Banaras Hindu University Varanasi, Punjab Agriculture University, Ludhiana were the major contributors those extensively utilized this national facility for their wheat and barley research programs.

Corrective Hybridization

During the season 1000 corrective crosses were attempted by the researchers across the institutes during a months of June.

Screening important wheat and barley material against rusts

The station provided all facilities for screening for yellow rust and powdery mildew. During the season 2015 about twenty thousand lines were screened under natural conditions.

Demonstration of Barley Varieties

Five Barley varieties viz. BHS 400, BHS 532, HUB 113, UPB 1008 and VLB 118 were sown in demonstration plots for popularization of barley cultivation in the valley.

High altitude wheat and barley trials

As a part of wheat coordinating system, AVT-TS-VHA trial was conducted during summer of 2015 at IIWBR, Regional Station, Dalang Maidan. During the year under report 08 entries were evaluated in four replications under AVT-TS-VHA trials. All the ancillary and disease data were recorded successfully.

Training for farmers of Lahaul valley

Three days training and awareness program under PPV&FRA was organized for the farmer's of Lahaul valley from 15th to 17th September, 2015. Main focus of this training was on farm identification of Problems and their solutions, weed and nutrient management and PPV&FRA Awareness.

SALIENT ACTIVITIES UNDERTAKEN BY IIWBR, KARNAL DURING 2015-16

Date	Activity
September 10-11	Dr. Indu Sharma and Dr. Sewa Ram attended Training programme on Bio fortification research in wheat. Harvest Plus Wheat Crop Meeting, ICRISAT, Hyderabad.
September 15	Dr. Om Prakash Gangwar visited the University of Sydney, Plant Breeding Institute, Cobbitty, Australia for training (Sept.15 to Dec. 01, 2015) on "Characterization of rust resistance in wheat" under ICAR-ACIAR project.
September 22	A meeting of Network project on Barley improvement under climate change conditions was held at Karnal on 22 September, 2015 and attended by networking scientists from Hisar, Durgapura, Faizabad and Rewa centers.
September 24	A Nepali delegation led by Shri Pradeep Jung Shah, visited ICAR- IIWBR Karnal.
October 7-9	The ICAR-IIWBR organized the Agritech world: International Exhibition on Agriculture & Horticulture on 7-9th October, 2015.
Octomber 19	Dr Amit Sharma participated in the brain storming session on Quality Breeder Seed Production at DGR, Junagarh.
October 24	Dr Ankita Jha attended a training (Oct 24 to Nov 7, 2015) programme on Conservation Agriculture: Gateway for production and sustainable cropping system at CIMMYT, BISA, Ludhiana
November 23	Dr Arun Gupta, attended Indo-German Bilateral Cooperator meet in Seed Sector and

	DUS workshop organized by Protection of Plant Varieties and Farmers Rights Authority, New Delhi at LBS auditorium, NRCPB, IARI, New Delhi
December 3-5	World Soil Day was organized in December 2015 at ICAR-IIWBR. Around 277 soil health cards were distributed to the farmers.
December 16-17	Research Institute Committee meeting of ICAR-IIWBR was held during 16-17th December 2016 to review the progress of projects completed duing 2010-15 and finalize the new research proposals for 2015-20.
December 19	A Brain Storming Session on 'Targeting maximum achievable yield in wheat' was organized at the ICAR-IIWBR Karnal, under the aegis of National Academy of Agricultural Sciences (Regional Chapter - Karnal). The Session was Chaired by Dr.JS Sandhu, DDG (CS), ICAR, New Delhi.
January 5-6	Mr. Gopalareddy K and Mr. Senthilkumar K M attended training on Durum Wheat Production, Marketing & Consumption at ICAR-IIWBR, Karnal.
January 16	Dr. J.S. Sandhu, DDG (CS) visited the Seed and Research unit of ICAR-IIWBR, Hisar station of institute.
January 19-22	Dr Amit Sharma attended Corell University, Seed Industry Program at Bengaluru
January 27-29	Dr Pradeep Shama, Dr B. S. Tyagi and Dr Mamrutha organized a training on Phenotyping aids and data recording in field experiments at ICAR-IIWBR, Karnal.

February 5-11	A meeting on barley cultivars adoption in Rajasthan was organised by ICARISAT at Durgapura, Rewa and Kanpur on 24th September, 2015; 05th Feb. 2016 and 11th Feb. 2016 respectively.
February 9	Dr. J.S. Sandhu, DDG (CS) visited IIWBR Karnal and delivered the foundation day lecture.
February 10-12	Dr. Davinder Mohan, attended training on Competency Development for HRD Nodal Officers of ICAR at NAARM, Hyderabad.
February 12-13	Urmil Bansal, Dept of Plant and Food Sciences, The University of Sydney, Australia, visited the IIWBR Regional Research station Shimla. She discussed about new rust resistant gene identification and designation in wheat.
February 16-17	The DBT funded project on "Indo-UK centre for the improvement of Nitrogen Use Efficiency in Wheat (INEW)" was launched at ICAR-IIWBR. The collaborating partners from India and UK participated in the meeting.
February 19	Dr. S .Ayyappan (Secretary DARE & DG, ICAR) and Dr. Gurbachan Singh, (Chairman, ASRB), New Delhi visited ICAR-IIWBR.
February 27-29	Dr. RK Gupta, attended 4thRegional Coordination Meeting of ICARDA-SACRP at NARC, Kathmandu, Nepal.
March 4	ICAR-IIWBR, organized 20th meeting of Research Advisory Committee. All the members of the committee reviewed the research work of the institute under the chairmanship of Dr. S. K. Sharma .

March 9	Prof. RR Hanchinal, Chairperson, PPV&FRA, and Dr. RC Agrawal, Registrar General, PPV & FRA visited the institute and interacted with scientists regarding registration of wheat and barley varieties.
March 17	Dr. Cathrine Ingvordsen, (CSIRO Canberra) visited and delivered a seminar on "Going below ground in India and Australia - and future root-work Down Under".
March 19	Dr. Suresh Kumar Balasubramanian, (Associate Professor, Monash University Melbourne, Australia) visited ICAR-IIWBR and delivered a seminar on "Temperature induced flowering in plants".
March 23	An Afghani delegation led by Mr. M.A Haidari (Deputy Minister of Agriculture, Afghanistan) made visit of IIWBR, Karnal.
March 29	The wheat and Barley field day was organized at ICAR-IIWBR, Karnal on 29th March 2016. The wheat and Barley scientists from across India participated in the field day and made *insitu* germplasm selections.
June 6-10	Dr Anuj Kumar attended Training Programme on Impact Assessment of Agricultural Extension at NAARM, Hyderabad.
July 4-5	Smt. Promila and Ms. Sushila attended Workshop on Income Tax at ISTM, New Delhi.
July 15-Jan 16	Dr Vikas Gupta attended Six months training (July.13 2015 to Jan. 11, 2016) on doubled haploids production for developing mapping populations for heat tolerance in wheat at Washington State University, Pullman, USA

Conduct of trials at funded centres during 2015-16

S.N.	Location	Zone	State	Wheat								Barley						Total		% Response
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection				
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
1	Bajaura	NHZ	HP	4	4			3	3	3	3	2	2	4	4	4	4	20	20	100.00
2	Dhaulakuan	NHZ	HP	6	6					19	17	2	2			3	3	30	28	93.33
3	Imphal	NHZ	Mnp	1	1													1	1	100.00
4	Palampur/Malan	NHZ	HP	5	5			3	3	9	9	1	1	4	3			22	21	95.45
5	Shrinagar/Khudwani	NHZ	J&K	2	2			2	2									4	4	100.00
6	Chatha/Jammu	NWPZ	J&K	7	7			3	3	10	10					3	3	23	23	100.00
7	Durgapura	NWPZ	Raj	7	7	2	2	6	6	36	36	7	7	7	7	7	7	72	72	100.00
8	Hisar	NWPZ	Hr	11	11	2	2	6	6	20	20	8	8	6	6	3	3	56	56	100.00
9	Ludhiana	NWPZ	Pb	10	10	2	2	8	7	51	51	7	7	6	6	7	7	91	90	98.90
10	Modipuram	NWPZ	UP	8	8							5	5					13	13	100.00
11	Pantnagar	NWPZ	UK	7	7	2	2	5	5	16	14	6	6			5	5	41	39	95.12
12	Coochbehar	NEPZ	BH	8	8			5	5	4	4							17	17	100.00
13	Faizabad	NEPZ	UP	9	9	2	2	2	1	7	7	7	7	2	1	4	4	33	31	93.94
14	Kalyani	NEPZ	WB	8	8			3	3	2	2							13	13	100.00
15	Kanpur	NEPZ	UP	9	9	2	2	3	3	10	10	5	5	4	4	4	4	37	37	100.00

S.N.	Location	Zone	State	Wheat Breeding		Wheat Physiology		Wheat Agronomy		Wheat Crop protection		Barley Breeding		Barley Agronomy		Barley Crop protection		Total		% Response
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
16	Ranchi	NEPZ	JK	7	7			4	4	1	1							12	12	100.00
17	Sabour	NEPZ	BH	9	9			4	4			4	4					17	17	100.00
18	Shillongani	NEPZ	As	5	5			4	4	3	3							12	12	100.00
19	Varanasi	NEPZ	UP	9	9			5	5	8	8	5	5	4	3	4	4	35	34	97.14
20	Bilaspur	CZ	CG	5	5			4	4									9	9	100.00
21	Gwalior	CZ	MP	4	4			4	4	1	0	2	2					11	10	90.91
22	Jabalpur	CZ	MP	6	6			4	1			1	1					11	8	72.73
23	Junagarh	CZ	Guj	5	5	2	2	5	3	2	2	3	3	2	2			19	17	89.47
24	Kota	CZ	Raj	5	5			4	3			2	2					11	10	90.91
25	Powarkheda	CZ	MP	6	6			4	4	4	4							14	14	100.00
26	Rewa	CZ	MP	1	1							5	5	1	1			7	7	100.00
27	Sagar	CZ	MP	4	4	2	2			1	0	1	1					8	7	87.50
28	Udaipur	CZ	Raj	5	5			7	6									12	11	91.67
29	Vijapur	CZ	Guj	6	6			5	5	4	4					2	2	17	17	100.00
30	Dharwad	PZ	KR	12	12	2	2	7	7	7	7					4	4	32	32	100.00
31	M'baleshwar	PZ	MH							8	8							8	8	100.00
32	Niphad	PZ	MH	11	11	2	2	8	8	11	9							32	30	93.75
33	Pune	PZ	MH	12	12			6	5	3	3							21	20	95.24
	Total			214	214	20	20	124	114	240	232	73	73	40	37	50	50	761	740	97.24

A= Allocated ; C= Conducted

Annexure-II-B

Conduct of trials at non-funded ICAR centres during 2015-16

No.	Location	Zone	State	Wheat Breeding		Wheat Physiology		Wheat Agronomy		Wheat Crop protection		Barley Breeding		Barley Agronomy		Barley Crop protection		Total		% Response
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
1	Almora/Howalbagh	NHZ	Uk	5	4			2	2	6	6	2	2	4	3	2	2	21	19	90.48
2	CPRI, Muthorai	SHZ	TN	0	0													0	0	0.00
3	CSSRI, Karnal	NWPZ	Hr	1	1													1	1	100.00
4	IIWBR Dalang Maidan	NHZ	HP	1	1					2	2							3	3	100.00
5	Delhi	NWPZ	Delhi	10	10			4	2	23	23							37	35	94.59
6	IIWBR, Karnal	NWPZ	Hr	9	9	2	2	9	8	35	35	6	6	6	6	6	6	73	72	98.63
7	IARI-PUSA	NEPZ	Bh	8	8													8	8	100.00
8	Indore	CZ	MP	8	8	2	2	5	5	6	6							21	21	100.00
9	Jhansi	CZ	UP	0	0							1	1					1	1	100.00
10	Kodaikanal-CSWRI	SHZ	TN	1	1													1	1	100.00
11	Mau, DSR	NEPZ	UP	0	0													0	0	0.00
12	Nain (Panipat)	NWPZ	Hr	1	1													1	1	100.00
13	Patna-ICAR	NEPZ	Bh	1	1													1	1	100.00
14	Shikohpur/Gurgaon	NWPZ	Hr	1	1													1	1	100.00
15	Shimla	NHZ	HP	5	5			2	1	8	8	2	2			2	2	19	18	94.74
16	Wellington	SHZ	TN	3	3					9	8							12	11	91.67
	Total			54	53	4	4	22	18	89	88	11	11	10	9	10	10	200	193	96.50

A= Allocated ; C= Conducted

Conduct of trials at non-funded volunteer centres during 2015-16

No.	Location	Zone	State	Wheat								Barley						Total		% Response
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection		Total		% Response
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
1	Adilabad	PZ	AP	0	0													0	0	0.00
2	Agra	NWPZ	UP	0	0			3	3	3	3							6	6	100.00
3	Akola	PZ	MH	9	9			6	3	1	1							16	13	81.25
4	Arkot	NHZ	HP	1	1													1	1	100.00
5	Allahabad	NEPZ	UP	1	1													1	1	100.00
6	Alwar	NWPZ	Raj	0	0													0	0	0.00
7	Ambala	NWPZ	Hr	0	0													0	0	0.00
8	Ambikapur	CZ	CG	0	0													0	0	0.00
9	Amravati	PZ	MH	2	2													2	2	100.00
10	Ambejagai	PZ	Mh	1	1					1	0							2	1	50.00
11	Amreli	CZ	Guj	1	1													1	1	100.00
12	Anand	CZ	Guj	1	1							1	1					2	2	100.00
13	Annegiri	PZ	Kr	1	0					1	1							2	1	50.00
14	Araul	NEPZ	UP	1	1													1	1	100.00
15	Arbhavi	PZ	Kr	2	2													2	2	100.00
16	Arnej	CZ	Guj	1	1													1	1	100.00
17	Badnapur	PZ	Kr	0	0													0	0	0.00
18	Bagalkot	PZ	Kr	3	3					1	1							4	4	100.00
19	Baharaich	NEPZ	UP	1	0													1	0	0.00
20	Bailhogal	PZ	Kr	3	1													3	1	33.33

No.	Location	Zone	State	Wheat								Barley								
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection		Total		% Response
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
21	Balachaur	NWPZ	Pb	2	2													2	2	100.00
22	Banasthali	NWPZ	Raj									1	1					1	1	100.00
23	Banka	NEPZ	BH	1	1													1	1	100.00
24	Banswara	CZ	Raj	1	1							3	3					4	4	100.00
25	Barabanki	NEPZ	UP	1	1													1	1	100.00
26	Bara-KVK	NHZ	HP	1	1													1	1	100.00
27	Barielly	NWPZ	UP	2	2													2	2	100.00
28	Barpeta-KVK	NEPZ	As	1	1													1	1	100.00
29	Basar	NEPZ	Ar P	1	1													1	1	100.00
30	Bathinda	NWPZ	Pb	2	2													2	2	100.00
31	Bawal	NWPZ	Hr	3	3							4	4					7	7	100.00
32	Belatal	CZ	UP	0	0													0	0	0.00
33	Berthin	NHZ	HP	1	0							1	1					2	1	50.00
34	Bharuch	CZ	Guj	1	1													1	1	100.00
35	Bhatinda	NWPZ	Pb	0	0							5	5					5	5	100.00
36	Bhilwara	CZ	Raj	0	0													0	0	0.00
37	Bhopal	CZ	MP	1	1					1	0							2	1	50.00
38	Bidar	PZ	Kr	0	0													0	0	0.00
39	Bijapur	PZ	Kr	1	1													1	1	100.00
40	Bikaner	NWPZ	Raj	0	0							1	1					1	1	100.00

No.	Location	Zone	State	Wheat								Barley						Total		% Response
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection				
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
41	Bikramganj	NEPZ	Bh	1	1													1	1	100.00
42	Bulandshahr	NWPZ	UP	5	5													5	5	100.00
43	Burdwan	NEPZ	WB	3	3			1	0									4	3	75.00
44	Chakrauta	NHZ	Uk	0	0													0	0	0.00
45	Chamba	NHZ	HP	1	0													1	0	0.00
46	CSWRTI, Ooty	SHZ	TN	2	2													2	2	100.00
47	Chianki	NEPZ	Jk	2	2													2	2	100.00
48	Chirang-KVK	NEPZ	As	2	2													2	2	100.00
49	DalipNagar	NEPZ	UP	1	1							1	1					2	2	100.00
50	Darang-KVK	NEPZ	As	2	2													2	2	100.00
51	Damoh	CZ	MP	0	0													0	0	0.00
52	Deegh	NEPZ	UP	2	2													2	2	100.00
53	Dhakarani	NWPZ	Uk	1	1													1	1	100.00
54	Dhanauri	NWPZ	Uk	0	0													0	0	0.00
55	Dhandhuka	CZ	Guj	1	1													1	1	100.00
56	Dhindori	CZ	MP	0	0													0	0	0.00
57	Dhubri-KVK	NEPZ	As	1	1													1	1	100.00
58	Diggi	NWPZ	Raj	1	1													1	1	100.00
59	Dumka	NEPZ	Jk	2	2													2	2	100.00
60	Entikhedi	CZ	MP	0	0					3	3							3	3	100.00

No.	Location	Zone	State	Wheat								Barley						Total		% Response
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection				
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
61	Faridabad	NWPZ	Hr	0	0														0	00.00
62	Faridkot	NWPZ	Pb	2	2														2	2100.00
63	Gagar	NHZ	Uk	0	0														0	00.00
64	Gangtok	NHZ	Sk	1	1														1	1100.00
65	Ganjbasoda	CZ	MP	0	0														0	00.00
66	Ghaghraghat	NEPZ	UP	2	2														2	2100.00
67	Ghazipur	NEPZ	UP	1	1														1	1100.00
68	Gumla-KVK	NEPZ	Jk	1	1														1	1100.00
69	Gurdaspur	NWPZ	Pb	10	10			4	2	6	6								20	1890.00
70	Hardoi	NWPZ	Up	0	0														0	00.00
72	Jagdalpur	CZ	CG	0	0														0	00.00
73	Jalalgarh	NEPZ	Bh	0	0														0	00.00
74	Jalgaon	PZ	Mh	1	1														1	1100.00
75	Jalore	CZ	Raj	0	0							1	0						1	00.00
76	K.Digraj	PZ	MH	3	3														3	3100.00
77	Kalimpong	NHZ	WB	1	1														1	1100.00
78	Kalloli	PZ	Kr	3	2														3	266.67
79	Kangra	NHZ	HP	0	0							1	1						1	1100.00
80	Kapurthala	NWPZ	Pb	3	3														3	3100.00

No.	Location	Zone	State	Wheat								Barley						Total		% Response
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection				
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
81	Karad	PZ	MH	3	3														3	3100.00
82	Kargil	NHZ	J&K	1	0														1	00.00
83	Kashipur	NWPZ	Uk	3	3														3	3100.00
84	Katrain	NHZ	HP	0	0								1	1					1	1100.00
85	Kaul	NWPZ	Hr	1	1														1	1100.00
86	Kenthorai	SHZ	TN	0	0														0	00.00
87	Kharibari (UBKV)	NEPZ	WB	2	2														2	2100.00
88	Kodaikanal-TNAU	SHZ	Tn	1	0														1	00.00
89	Kolhapur	PZ	MH	1	1														1	1100.00
90	Kotagiri	SHZ	TN	0	0														0	00.00
91	Kukumseri	NHZ	HP	1	1														1	1100.00
92	Kumher	NWPZ	Raj										2	2					2	2100.00
93	Leh	NHZ	J&K	2	1														2	150.00
94	Lucknow	NEPZ	UP	1	1														1	1100.00
95	Majehra	NHZ	Uk	3	3					1	1		2	2					6	6100.00
96	Majhian(S Dinajpur)	NEPZ	WB	1	1														1	1100.00
97	Malda	NEPZ	WB	0	0	2	2												2	2100.00
98	Mandya	SHZ	Kr	3	0														3	00.00
99	Manikchak (UBKV)	NEPZ	WB	4	4														4	4100.00
100	Morigaon-KVK	NEPZ	As	1	1														1	1100.00

No.	Location	Zone	State	Wheat								Barley						Total		% Response
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection				
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
101	Mathura	NWPZ	UP	0	0							2	2					2	2	100.00
102	Mauranipur	CZ	UP	0	0													0	0	0.00
103	Mirzapur	NEPZ	UP	0	0							1	1					1	1	100.00
104	Morena	NWPZ	MP									2	2					2	2	100.00
105	Mohitnagar	NEPZ	WB	0	0													0	0	0.00
106	Mudhol	PZ	Kr	3	0													3	0	0.00
107	Muktsar	NWPZ	Pb	1	1			3	1									4	2	50.00
108	Nagina	NWPZ	UP	3	3													3	3	100.00
109	Nasik	PZ	MH	2	2													2	2	100.00
110	Navgaon	NWPZ	Raj	0	0													0	0	0.00
111	Nippani	PZ	Kr	5	5													5	5	100.00
112	Paiyur	SHZ	TN	0	0													0	0	0.00
113	Pandharpur	PZ	Mh	0	0													0	0	0.00
115	Parbhani	PZ	MH	4	4													4	4	100.00
116	Pimpalgaon	PZ	Mh	0	0													0	0	0.00
117	Patna	NEPZ	Bh															0	0	0.00
118	Parvaranagar	PZ	MH	2	2													2	2	100.00
119	Purnea	NEPZ	Bh	3	3													3	3	100.00
120	Pratapgarh	CZ	Raj	0	0	2	2											2	2	100.00
121	Raipur	CZ	CG	1	1													1	1	100.00
122	Rajendranagar	PZ	AP	0	0													0	0	0.00
123	Rajouri	NHZ	J&K	0	0					1	1	1	1					2	2	100.00
124	Rampura	NWPZ	Raj	0	0							1	1					1	1	100.00
125	Ranichauri	NHZ	Uk	3	2			2	1	1	0	1	1					7	4	57.14

	Location	Zone	State	Wheat								Barley						Total		% Response
				Breeding		Physiology		Agronomy		Crop protection		Breeding		Agronomy		Crop protection				
				A	C	A	C	A	C	A	C	A	C	A	C	A	C	A	C	
126	RAU Pusa	NEPZ	Bh	0	0							3	3					3	3	100.00
127	Rauni	NWPZ	Pb	1	1													1	1	100.00
129	Rudrur	PZ	AP	0	0													0	0	0.00
131	S.K.Nagar	CZ	Guj	2	2							2	2					4	4	100.00
133	Sanosara	CZ	Guj	1	1													1	1	100.00
135	Shalimar/Khudwani	NHZ	J&K	0	0			3	1	2	1							5	2	40.00
137	Sundernagar	NHZ	HP	0	0							1	0					1	0	0.00
139	Tanchha	CZ	Guj	1	1													1	1	100.00
141	Thiruvanmalai	SHZ	TN	0	0													0	0	0.00
143	Uchani	NWPZ	Hr	3	3			2	1									5	4	80.00
145	Ujhani	NWPZ	UP	1	1													1	1	100.00
147	Vanasthali	NWPZ	Raj	1	1													1	1	100.00
149	Washim	PZ	MH	2	2													2	2	100.00
	Total			188	169	4	4	28	15	24	20	46	44	0	0	0	0	290	252	86.90

Annexure III

Action taken report on the major recommendations of the 54th All India Wheat & Barley Research Workers' meet held at GAU, SK Nagar, Gujarat

August 21-24, 2015

S. N.	Recommendations	Action Taken
Crop Improvement		
1.	The foothills of Nilgirs and plains under Sothern Hills Zone would conduct trials formulated for the PZ.	The trials constituted for PZ were allotted to centres located in foothills of Southern Hill Zone
2.	Greater emphasis in the breeding programmes would be accorded to develop Karnal bunt resistant genotypes	Seeds of registered genetic stocks for KB resistance were supplied to breeding centres for hybridization and incorporation of resistance. During 2016, eight new genetic stocks resistant to KB were registered with NBPGR, New Delhi and their seeds would be provided to all centres during the coming crop season.
3.	In order to tackle climatic aberrations leading to large scale lodging of wheat crop, priority would be given to develop genotypes with good straw strength for lodging tolerance	Alternate sources for dwarfism in wheat have been identified and dwarf lines are being used in hybridization for creating lodging tolerant genotypes. Screening of genotypes for straw strength and lodging tolerance was carried out under field and controlled conditions. The identified lines and other sources would be utilized in breeding.
4.	The report of Wellington centre would also be presented along with that of Dalang Maidan in the Crop Improvement review session.	The report of Wellington will be presented alongwith Dalang Maidan during the Workshop
Crop Protection		
1.	A strict vigil be kept on stripe rust in NWPZ/NHZ, leaf and stem rusts in PZ and CZ and leaf rust and blight in NEPZ. Monitoring of rusts during crop season and off season and vigil on other diseases and insect pests also be kept.	A strict vigil was kept on all biotic stresses by extensive surveys during the crop season and off season throughout the country. Advisory for stripe rust was issued during December-February for timely management of disease.
2.	As new pathotype, 110S119 has been recorded in 13% samples, so IIWBR Regional Station, Shimla will provide inoculums to the co-operators for evaluating the material.	Inoculum of new pt. 110S119 was made available for yellow rust research work.
3.	There is dire need to build resistance for stripe rust. Stock based on Yr5, Yr10 and Yr15 will be made available to the breeders of NWPZ/NHZ by IIWBR Regional station Flowerdale, Shimla.	Seeds of rust resistant genetic stocks was made available to 5 Scientists who requisitioned for.

4.	PPSN will be monitored and data will be recorded by duly constituted teams of Plant Pathologists.	PPSN was monitored and data was recorded by duly constituted teams.
5.	New chemicals for stripe rust, KB and powdery mildew management will be tested at multi locations.	New chemicals for stripe rust, KB and powdery mildew management were tested at multi locations.
6.	Virulence analysis for powdery mildew pathogen will be initiated at Malan.	The host differential set of powdery mildew resistance genes has been procured. The isolates of the **B. graminis** tritici have been procured from Lahual Spiti and the work on virulence studies will be initiated by the start of September
7.	Diverse KB resistance sources available in the background of PBW 343 and WH 542 may be utilized extensively for enhancing KB resistance in wheat lines.	Diverse KB resistance sources available in the background of PBW 343 and WH 542 are being utilized extensively for enhancing KB resistance in wheat lines.
8.	Post-harvest survey will be carried out for knowing Karnal bunt and black point status for facilitating export.	Post-harvest survey was carried out for knowing Karnal bunt and black point status for facilitating export.
9.	Trial for termite management in standing crop will be conducted at multi locations.	Trial for termite management in standing crop was conducted at multi locations.
10.	Foliar spray of Propargite 57 SC @ 1.5ml/litre was found effective against brown wheat mite (**Petrobialantens**). The experiment will be repeated again at multi locations (Ludhiana and Durgapura).	The experiment was conducted at multi locations (Ludhiana and Durgapura). Propargite 57 SC (Omite) @ 1.5 ml/l and Spiromesifen 240 SC (Oberon) @ 1.0 ml/l of water was found effective for brown wheat mite management.
11.	Shoot Fly is emerging a problem in Karnataka and Maharashtra (PZ) so nursery would be evaluated at Dharwad and Niphad centres.	Nursery was evaluated at Dharwad and Niphad centres.
12.	For foliar aphids, evaluation of advance lines will also be done at Niphad, Ludhiana, Karnal, Shillongani, Pantnagar and Kharibari (West Bengal) centres.	Advance lines were evaluated at multiple locations.
13.	Eco-friendly management of root knot and CCN nematodes in wheat will be studied at Ludhiana, Durgapura and Hisar.	Eco-friendly management of root knot and CCN nematodes in wheat was studied at Ludhiana, Durgapura and Hisar.
Resource Management		
1.	It is generally believed that puddling in rice adversely affects the yield of subsequent wheat crop. A multi-location trial was conducted at five locations across NHZ, NWPZ and NEPZ with three tillage options in rice i.e. puddle transplanted rice, zero tillage transplanted rice and direct seeded rice and four nutrient management options in wheat. Three years results showed that the puddling in rice had no adverse effect on wheat yield.	The recommendation has been conveyed to the concerned implementing authorities.
2.	There had been thinking that puddle rice must be replaced with direct seeded rice but it was not being adopted by the farmers. To evaluate the reasons behind this, a multi-location trial was conducted at five locations across NHZ, NWPZ and NEPZ with three tillage options i.e. puddle transplanted rice, zero tillage transplanted rice, zero tillage	The recommendation has been conveyed to the concerned implementing authorities.

	transplanted rice and direct seeded and four nutrient management options in wheat. Based on three years data, it has been found that rice yield reduction in direct seeded rice was about 20% and in zero till transplanting was about 10%.	
3.	The multi-location trial at three locations in NWPZ and conducted with two tillage option and two spacing and three integrated nutrient management options. Three year's results showed that 15 cm row spacing gave 2% higher yield compared to 20 cm row spacing.	The recommendation has been conveyed to the concerned implementing authorities.
4.	The multi-location trial was conducted at three locations in NWPZ with two tillage options and two spacing and three integrated nutrient management options. Three years results showed that 15 FYM t/ha along with recommended NPK gave about 4% higher yield.	The recommendation has been conveyed to the concerned implementing authorities.
Quality Improvement		
1.	To strengthen linkages with the industry, wheat quality programme will invite some interested baker/millers in the research planning.	The institute participated in the international seminar on wheat and wheat products organised by Flour Miller Association of India, Goa in July 2016 and the linkages with the wheat Industry are satisfactory.
2.	Making concerted efforts for quality rich materials to milling and baking industry at the regional or national level. The opportunities may be explored under the guidance of Agri- Innovate India Ltd.	The work is in progress. Research bulletin dealing with wheat quality has been published and shared with all concerns.
3.	Characterize the germplasm through molecular marker and the breeders should make use of the indentified genetic stock.	The work on development of product specific varieties using MAS is in progress.
4.	Efforts to generate yellow rust reactions data on the good dicoccum line developed by the Dharwad centre which shall give new option for the NWPZ to examine dicoccum material for yield and quality.	Preliminary studies have been undertaken. One trial on *dicoccum* wheat will be attempted this year.
5.	Hard textured wheat germplasm for improvement in chapatti and bread quality; genetic stocks having soft grain texture to promote biscuit be utilized in the crossing programme	About two dozen soft lines have been identified from indigenous and exotic germplasm and have been extensively utilized in the crossing programme.
Social Sciences		
1.	More involvement of Krishi Vigyan Kendra's (KVKs) to conduct wheat and barley FLDs.	During the year 2014-15, 28 KVKs for wheat FLDs and 9 KVKs for barley FLDs were involved. During the year 2015-16, more number of KVKs i.e. 39 KVKs for conduct of wheat FLDs and 13 KVKs for barley FLDs were involved.
2.	The number of wheat and barley FLDs during 2016-17 need to be increased to facilitate speedy adoption of new technologies.	Approval for conducting 600 ha wheat FLDs and 100 ha barley FLDs during 2016-17 has been received from the Department of Agriculture, Cooperation and Farmers Welfare, Ministry of Agriculture & Farmers Welfare, New Delhi.

Barley Network		
1.	The malt barley analytical standards need to be revised in consultation with the private industry.	The standards have been revised in consultation of private industry in a meeting held on 05.03.2016.
2.	Conservation Agriculture in barley needs to be revalidated for better yield, lodging and seed quality.	The trials on conservation agriculture were conducted for better yield, lodging and seed quality on farmers fields.
3.	More emphasis should be given to parameters like beta glucan, protein, amylose content of food barley.	Work has been started to screen hull less barley genotypes for beta glucan, protein and amylose content.
4.	In GSBYT trials, rainfed barley checks should be included as suggested by barley breeder ICARDA.	The rainfed checks were included.
5.	Possibilities should be explored in NEPZ and problematic soils to enhance the barley area.	New locations viz. Banasthali (AVT-SST), Saini (rainfed), RAU, Pusa, CSSRI, RS, Canningtown (NEPZ) and Kumher (AVT-feed and malt) have been included.
6.	Breeders should pay more attention about purity of their strains and simultaneously about timely data reporting and trial conduction otherwise quota of centre will be reduced.	All the co-operating breeders were advised on the purity issue and resulting less rejections during monitoring.
7.	Looking into the abnormal weather since last few years, lodging tolerance needs to be incorporated into future breeding programme	In preliminary screening, 65 exotic lines showed resistance to lodging as compared to Indian checks.
8.	Issue of increase in MSP of barley should be raised at appropriate platforms	Issue was raised in several meetings held during the year.

Financial Highlights for the Year 2015-16

A. Budget Utilization

Name of Schemes	Target 2015-16	Achievement 2015-16	Reason for shortfall, if any
Plan - IIWBR	1050.00	1050.00	NA
Plan Scheme(AICW&BIP)	2029.00	2029.00	NA
Non-Plan	1807.25	1807.14	NA
Loan & Advances	10.00	9.99	NA
External Aided / Contract Research Projects	527.63	244.44	NA

B. Revenue Generation (Rs. in Lakhs)

	Target 2015-16	Achievement 2015-16	Reason for shortfall
Revenue Receipt	269.02	43.34 (As per schedule 8,10 &12 of Balance Sheet)	Target could not be achieved due to less receipt during the year.

C. Statement of Audit's para

Year of issue	No. of Para outstanding	Position as on 15.07.2016
2012-2015 (Current paras)	9	Reply had been submitted vide this office letter dated 01.06.2016 for ten Audit Paras and out of which three paras have been settled. As per letter dated 05.07.2016 received from the Sr. Audit & Account Officer, Office of the Principal Director of Audit (Central), Chandigarh "the facts will be got verified during next audit" for remaining audit paras.

D. ICAR's inspection report (current report)

Year of issue	No. of Para outstanding	Position as on 15.07.2016
Up to 2006-08	2	Reply has already been furnished to the Council along with evidence/records in order to speedy settlement of Audit Paras.
2010-12	9	
2012-13	03	
2013-14	6	
2014-15	12	

STATEMENT SHOWING NET GRANT RELEASED TO AICW&B/P CENTERS DURING THE YEAR 2015-16

(Amount in Rupees)

Name of Centre	Name of University	PAY	TA	Rec. Conti	NRC	Total
BAJAURA	HPKV V PALAMPUR	3285678	75000	450000		3810678
BILASPUR	IGKV V RAIPUR	3009401	75000	461250		3545651
COOCHBEHAR	UBKV COOCHBEHAR	919639	75000	450000		1444639
DHARWAD	UAS DHARWAD	8538092	225000	1350000		10113092
DHAULAKUAN	HPKV V PLAMPUR	5809956	75000	461250		6346206
DURGAPURA	SKNAU, BIKANER	22453339	375000	2460000		25288339
FAIZABAD	NDUA&T FAIZABAD	5753357	187500	1196250		7137107
GWALIOR	RVS KV V GWALIOR	1164933	75000	450000		1689933
HISAR	HAU ' HISAR	12792640	300000	2010000		15102640
IMPHAL (New Center)	CAU, IMPHAL	0	0	0		0
JAMMU	SKUAS & T JAMMU	2773789	75000	450000		3298789
JUNAGADH	JAU JUNAGADH	3023329	75000	461250		3559579
KALYANI	BCK V V NADIA	2056103	75000	450000		2581103
KANPUR	CSAUAST KANPUR	11462058	225000	1571250		13258308
KOTA	AU, UDAIPUR	7098425	75000	461250		7634675
LUDHIANA	PAU LUDHIANA	14980078	375000	2400000		17755078
MAHABALESWAR	MPK V V RAHURI.	3207051	75000	450000		3732051
MODIPURAM	SVBPUA&T, Meerut	0	0	0		0
NIPHAD	MPKV V RAHURI	4564452	150000	911250		5625702
PALAMPUR	HPKV V PALAMPUR	4717050	112500	686250		5515800
PANTNAGAR	GBPUA & T PANTNAGAR	9871153	187500	1275000		11333653
POWARKHEDA	JNKVV, JABALPUR	2416216	112500	686250		3214966
PUNE	ARI PUNE	6907096	150000	1100000		8157096
RANCHI	BAU RANCHI	4492984	112500	824817	1000000	6430301
REWA	JNKV V JABALPUR	2523646	112500	311250		2947396
SABOUR	RAU SAMASTIPUR	377446	112500	761250		1251196
SAGAR	JNKV V JABALPUR	2350978	37500	386250		2774728
SHILLONGANI	AAU JORHAT	2555497	99750	399750		3054997
UDAIPUR	MPUAT, UDAIPUR	2799057	75000	461250		3335307
VARANASI	BHU VARANASI	8120898	200000	1480000		9800898
VIJAPUR	SDAU, SARDAR, KRUSHI NAGAR	5728159	188000	1274500		7190659
JABALPUR	JNKV V JABALPUR	772500	97500	375000		1245000
SRINAGAR	SKUAS & T SRINAGAR	375000	112500	375000		862500
Grant released to voluntary centres				1961933		1961933
TSP				1900000		1900000
Total		**166900000**	**4297750**	**30702250**	**1000000**	**202900000**

Status of AUC for the year 2015-16 in r/o center under AICW&BP

S. N.	Name of center	Name of SAUs	Status of UC/AUC
1	2	3	4
1	BAJAURA	HPKV V PALAMPUR	UC
2	BILASPUR	IGKV V RAIPUR	NOT RECEIVED
3	COOCHBEHAR	UBKV COOCHBEHAR	NOT RECEIVED
4	DHARWAD	UAS DHARWAD	AUC
5	DHAULAKUAN	MPKV V PLAMPUR	AUC
6	DURGAPURA	RAU BIKANER	AUC
7	FAIZABAD	NDUAST FAIZABAD	UC
8	GWALIOR	RVS KV V GWALIOR	AUC
9	HISAR	HAU ' HISAR	UC
10	IMPHAL	DEPTT. OF AGRI IMPHAL	NOT RECEIVED
11	JAMMU	SKUAS & T JAMMU	UC
12	JUNAGADH	JAU JUNAGADH	NOT RECEIVED
13	KALYANI	BCK V V NADIA	NOT RECEIVED
14	KANPUR	CSAUAST KANPUR	UC
15	KOTA	AU KOTA	UC
16	LUDHIANA	PAU LUDHIANA	UC
17	MAHABALESWAR	MPK V V RAHURI.	AUC
18	MODIPURAM	SVBPUA&T, Meerut	NOT RECEIVED
19	NIPHAD	MPKV V, RAHURI	NOT RECEIVED
20	PALAMPUR	HPKV V PALAMPUR	NOT RECEIVED
21	PANTNAGAR	GBPUA & T PANTNAGAR	NOT RECEIVED
22	POWARKHEDA	JNKVV, JABALPUR	AUC
23	PUNE	AR, PUNE	UC
24	RANCHI	BAU, RANCHI	UC
25	REWA	JNKV V, JABALPUR	NOT RECEIVED
26	SABOUR	RAU, SAMASTIPUR	AUC
27	SAGAR	JNKV V, JABALPUR	NOT RECEIVED
28	SHILLONGANI	AAU , JORHAT	NOT RECEIVED
29	UDAIPUR	MPUAT, UDAIPUR	AUC
30	VARANASI	BHU , VARANASI	NOT RECEIVED
31	VIJAPUR	SDAU, SardarKrushi Nagar	AUC
32	JABALPUR	JNKVV, JABALPUR	NOT RECEIVED
33	SRINAGAR	SKUAS &T, SRINAGAR	NOT RECEIVED

Staff position of AICW & BIPcenters 2015-16

S.N	Name of Centre	Name of SAU/ Host Institution	Scientific staff Sanctioned	Scientific staff in position	Vacant posts Scientific	Technical sanctioned	Technical In position	Vacant posts Technical.	Admin sanctioned	Admin in position	Vacant posts Admin.	Supporting sanctioned	supporting in position	Vacant posts Supporting	Total vancant position	Total sanctioned post
1	Shillongani	AAU JORHAT	2	2	0	3	1	2	1	1	0	0	0	0	2	6
2	Pune (100%)	ARI PUNE	3	2	1	7	7	0	0	0	0	2	2	0	1	12
3	Ranchi	BAU RANCHI	3	3	0	2	2	0	0	0	0	0	0	0	0	5
4	Sabour	BAU SAMASTIPUR BIHAR	3	3	0	6	6	0	0	0	0	0	0	0	0	9
5	Kalyani	BCK V V NADIA	2	1	1	3	3	0	0	0	0	0	0	0	1	5
6	Varanasi (100%)	BHU VARANASI	4	4	0	9	6	3	1	1	0	0	0	0	3	14
7	Hissar	CCS HAU HISAR	8	7	1	17	15	2	1	1	0	1	1	0	3	27
8	Kanpur	CSAUAST KANPUR	6	6	0	13	11	2	3	2	1	2	2	0	3	24
9	Dhaulakuan	CSKHPKV V PALAMPUR	2	2	0	5	4	1	0	0	0	0	0	0	1	7
10	Palampur	CSKHPKV V PALAMPUR	3	3	0	7	7	0	1	1	0	0	0	0	0	11
11	Bajaura	CSKHPKV V PALAMPUR	2	2	0	5	4	1	1	1	0	1	1	0	1	9
12	Imphal (100%)	CENTRAL AGRIL UNIVERSITY, IMPHAL (w.e.f. 01.4.2015)		1	1	0	2	2	0	0	0	0	0	0	0	03
13	Pantnagar	GBPUA & T PANTNAGAR	5	5	0	11	11	0	0	0	0	1	1	0	0	17
14	Bilaspur	IGKV V RAIPUR	2	2	0	3	3	0	1	1	0	0	0	0	0	6
15	Junagarh	JAU JUNAGADH	2	2	0	5	4	1	0	0	0	0	0	0	1	7
16	Rewa	JNKV V JABALPUR	1	1	0	4	4	0	0	0	0	0	0	0	0	5
17	Sagar	JNKV V JABALPUR	1	1	0	6	2	4	1	0	1	0	0	0	5	8
18	Powarkhera	JNKVV, JABALPUR	3	3	0	7	7	0	0	0	0	1	1	0	0	11
19	Mahableswar	MPK V V RAHURI.	2	1	1	4	1	3	0	0	0	4	3	1	5	10
20	Niphad	MPK V V RAHURI.	4	4	0	6	2	4	2	1	1	0	0	0	5	12
21	Kota	MPUA&T UDAIPUR	2	1	1	6	5	1	1	1	0	0	0	0	2	9
22	Udaipur	MPUA&T UDAIPUR	2	1	1	4	1	3	0	0	0	0	0	0	4	6
23	Faizabad	NDUAST FAIZABAD	5	4	1	8	5	3	1	1	0	2	2	0	4	16
24	Ludhiana	PAU LUDHIANA	9	8	1	17	17	0	0	0	0	2	2	0	1	28
25	Gwalior	RVS KV V GWALIOR	2	2	0	2	1	1	0	0	0	0	0	0	1	4
26	Vijapur	SDAU, SARDAR, KRUSHI NAGAR	5	4	1	9	8	1	1	1	0	0	0	0	2	15
27	Durgapura	SKRAU BIKANER	10	10	0	18	17	1	1	1	0	1	1	0	1	30
28	Jammu	SKUAS & T JAMMU	2	2	0	2	2	0	1	1	0	0	0	0	0	5
29	Modipuram	SVBPUA&T, Meerut	1	1	0	0	0	0	0	0	0	0	0	0	0	1
30	Dharwad	UAS DHARWAD	6	5	1	8	7	1	0	0	0	0	0	0	2	14
31	Coochbehar	UBKV COOCHBEHAR	2	2	0	2	1	1	0	0	0	0	0	0	1	4
31	Jabalpur	JNKVV, JABALPUR (w.e.f. 01.04.2015)	1	1	0	2		2			0			0	2	3
33	Srinagar	SKUAS&T, SRINAGAR (w.e.f.01.04.2015)	1	1	0	2		2			0			0	2	3
	Total		**107**	**97**	**10**	**205**	**166**	**39**	**17**	**14**	**3**	**17**	**16**	**1**	**53**	**346**

भाकृअनुप
ICAR

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

Agrisearch with a human touch

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