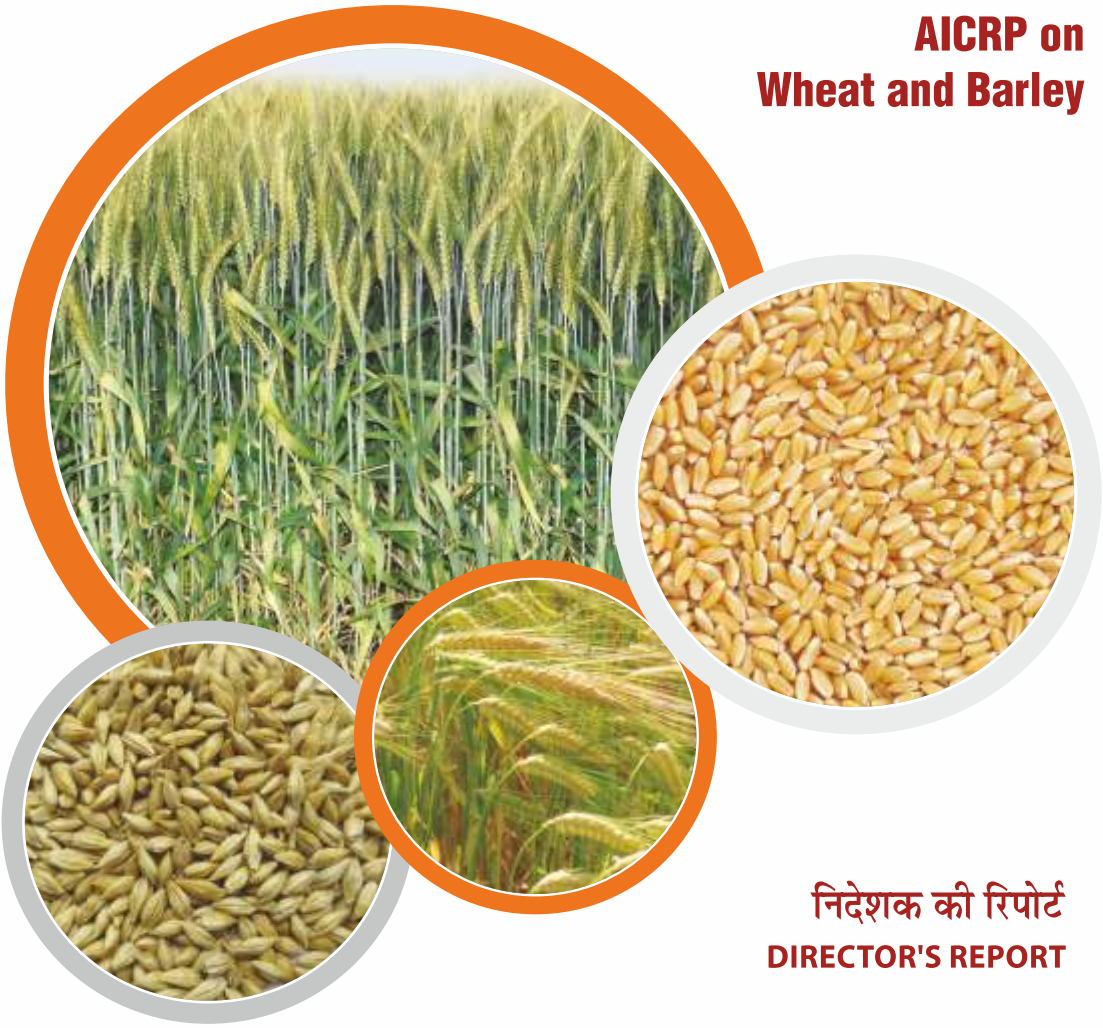
प्रगति प्रतिवेदन
PROGRESS REPORT
2018-19

अखिल भारतीय समन्वित गेहूँ एवं जौ अनुसंधान परियोजना
AICRP on Wheat and Barley



निदेशक की 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 Research Project (AICRP) on Wheat & Barley

DIRECTOR'S REPORT
2018-19

G.P. SINGH
DIRECTOR

भा.कृ.अ.प. – भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल
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Correct Citation
ICAR-IIWBR 2019. Director's Report of AICRP on Wheat and Barley 2018-19, Ed: G.P. Singh. ICAR-Indian Institute of Wheat and Barley Research, Karnal, Haryana, India. P 72.

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Issued on the occasion of 58th All India Wheat & Barley Research Workers' Meet at ICAR-IARI Regional Research Station, Indore during August 24-26, 2019

ACKNOWLEDGEMENTS

It is my proud privilege to express my 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 continuos guidance, encouragement and support to the national wheat and barley improvement programme. I take this opportunity to extend my heartiest thanks and deep sense of gratitude to Dr. AK Singh, DDG (Crops & Horticultural Sciences), ICAR, New Delhi for his valuable support and guidance in successful implementation of the programme during 2018-19 leading to significant achievements. The regular and timely support rendered by Dr. RK Singh, ADG (CC) and Dr. Dinesh Kumar Assistant Director General (FFC), ICAR and their team is also gratefully acknowledged.

The concerted and untiring efforts of the scientific and field staff at different cooperating centres across zones for successful conduction of 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 successful execution of the programme and making contributions towards improving wheat and barley productivity and production in the country.

I greatly appreciate all voluntary centres 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 finance in planning, execution and monitoring of the programme in various ways deserve great appreciation.

The assistance rendered by Dr. Sindhu Sareen, Dr. Sendhil R and Dr. Mamrutha HM in compiling this report is duly acknowledged.

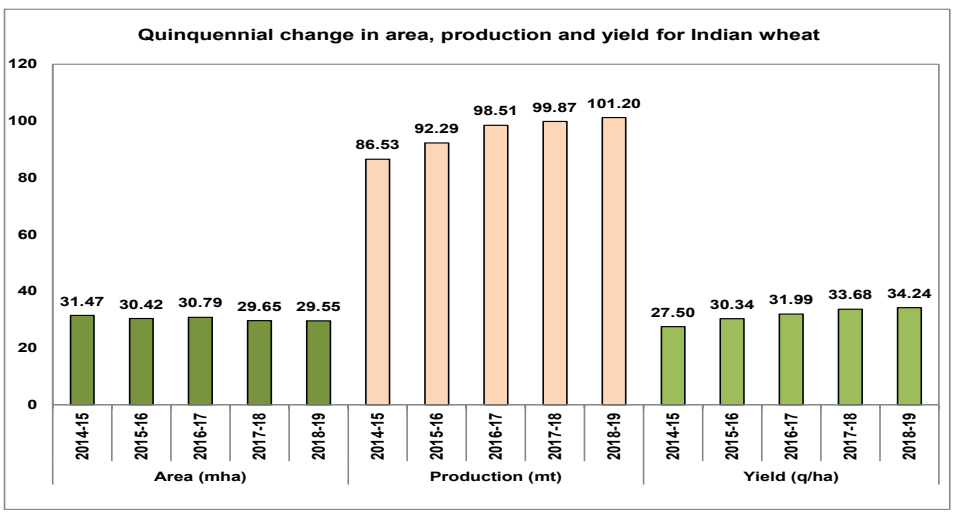
Place: Karnal
Date: 16 August, 2019

(G.P. Singh)
Director

DIRECTOR'S REPORT (2018-19)

Access to quality and nutritious food is fundamental for human life and ensuring food security is a top priority for all economies. Wheat and barley are grown in a majority of the countries and finds a significant share in consumption basket. Globally, wheat is the largest cultivated crop with an estimated area of 220.19 million hectares (mha), and barley is grown in 50.55 mha. The nutritious cereals altogether have been under cultivation in 270.74 mha with an estimated production of 932.89 million tonnes (mt) for the period 2018-19 (UDSA, 2019). In India, during 2018-19 *Rabi* season, wheat was cultivated in 29.55 mha and barley in 0.66 mha, constituting 24.35 per cent of the total crop acreage. In terms of production, the two commodities accounts for 36.32 per cent of the India's total foodgrains production as per the 3rd Advance Estimates released by the Directorate of Economics and Statistics (DES), Ministry of Agriculture and Farmers Welfare (MoA&FW), India.

Scenario for Wheat in India



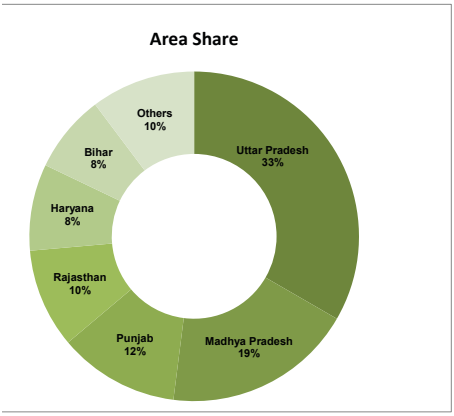
Indian wheat production in 2018-19 has made a landmark achievement by producing 101.20 mt by registering another record in average national productivity *i.e.*, 3424 kg/ha. The past year production was also relatively higher (99.87 mt) and hence the incremental wheat output over the previous season, i.e 2017-18 was marginal, but significant in terms of crossing the magical figure of 100 mt. The additional output over the recent past year has been estimated at 1.33 mt (+ 1.33%). The positive growth in production is attributed to the increased yield by 1.66 per cent despite a fall in the

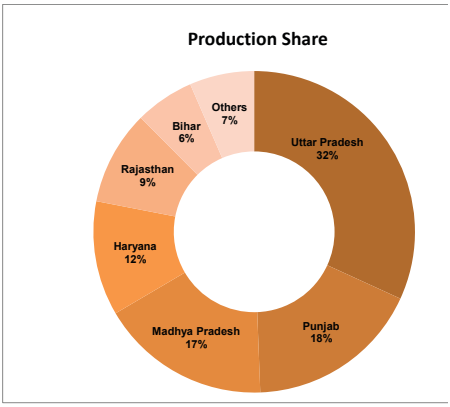
crop acreage by 0.32 per cent. Increase in the support price by ₹105 per quintal in comparison to the past year and announced as ₹1840 per quintal of wheat, didn't had a positive impact on the crop acreage, rather the area has declined marginally (-0.09 mha). The average wheat productivity has increased by 56 kg/ha (+1.66%) which is a major reason for the landmark production. States like Haryana and Madhya Pradesh have shown a significant increase in crop productivity over the past year owing to the favourable cool weather and extended sunshine hours during the day time. However, there existed regional variation in all the three variables in comparision to the previous year final estimates (2017-18).

Quantum change in area, production and yield of wheat

State	2017-18 (Final Estimates)			2018-19 (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)
Assam	18	25	1386	19	28	1465	1	3	79
Bihar	2101	6104	2905	2260	6021	2664	159	-84	-241
Chhattisgarh	101	131	1289	104	142	1373	2	12	84
Gujarat	1059	3069	2898	940	2769	2946	-119	-300	48
Haryana	2440	10765	4412	2510	11654	4643	70	889	231
HP	319	566	1774	319	564	1770	0	-1	-4
J&K	299	487	1628	288	504	1751	-12	17	123
Jharkhand	221	469	2121	164	303	1849	-57	-166	-272
Karnataka	193	230	1193	133	173	1300	-60	-57	107
MP	5316	15911	2993	5520	17349	3143	204	1439	150
Maharashtra	1024	1697	1657	569	725	1275	-455	-971	-382
Odisha	0.07	0.15	2163	0.07	0.11	1571	0.00	-0.04	-592
Punjab	3512	17830	5077	3502	17780	5077	-10	-51	0
Rajasthan	2810	9369	3334	2880	9602	3334	70	233	0
Telangana	4	5.55	1388	4	6.38	1595	0.00	0.83	207
Uttar Pradesh	9753	31879	3269	9852	32206	3269	99	327	0
Uttarakhand	333	915	2749	327	876	2680	-6	-39	-69
West Bengal	117	312	2667	135	386	2859	18.00	73.97	192
Others	30	105	3511	29	111	3759	0	6	247
INDIA	29651	99870	3368	29555	101200	3424	-96	1331	56

Source: DES, MoA&FW, India.





Among states, Uttar Pradesh produces a significant level of wheat with a total record output of 32.21 mt (32%), followed by Punjab (17.78 mt: 18%), Madhya Pradesh (17.35 mt: 17%), Haryana (11.65 mt: 12%), Rajasthan (9.60 mt: 9%) and Bihar (6.02 mt: 6%). The aforementioned six states hold a share of about 93 per cent in total wheat production. With the exception of Bihar, Gujarat, Himachal Pradesh, Jharkhand, Karnataka, Maharashtra, Odisha, Punjab and Uttarakhand, the rest of the states registered an increase in production during 2018-19 in comparison to 2017-18. Overall production from all these states has declined by 1.67 mt owing to the fall in yield levels and/or acreage. The highest fall was noticed in Maharashtra (-0.97mt: -57.24%). The increase in wheat production was maximum in the case of Madhya Pradesh (+1.44 mt: +9.04%), followed by Haryana (+0.89 mt: +8.25%) and Uttar Pradesh (+0.33 mt: 1.03%).

State wise area under wheat exhibited regional differences and it has declined marginally by 0.09 mha (-0.32%) during the current season in comparison to the recent past. The highest increase was noticed in Madhya Pradesh (+2.04 lakh ha), whereas Maharashtra witnessed a significant decline by 4.55 lakh ha (-44.43%). As usual, Uttar Pradesh holds the top slot in wheat acreage (9.85 mha: 33%), followed by Madhya Pradesh (5.52 mha: 19%), Punjab (3.50 mha: 12%), Rajasthan (2.88 mha: 10%), Haryana (2.51 mha: 8%) and Bihar (2.26 mha: 8%). The above mentioned states altogether comprise 90 per cent of the total area and produce 93 per cent of the total wheat. Assam, Bihar, Chhattisgarh, Haryana, Madhya Pradesh, Rajasthan, Uttar Pradesh and West Bengal have shown a positive change in crop acreage. The decline in crop acreage was highest in the case of Maharashtra (-4.55 lakh ha: -44.43%), followed by Gujarat (-1.19 lakh ha: -11.24%) and Karnataka (-0.6 lakh ha: -31.09%).

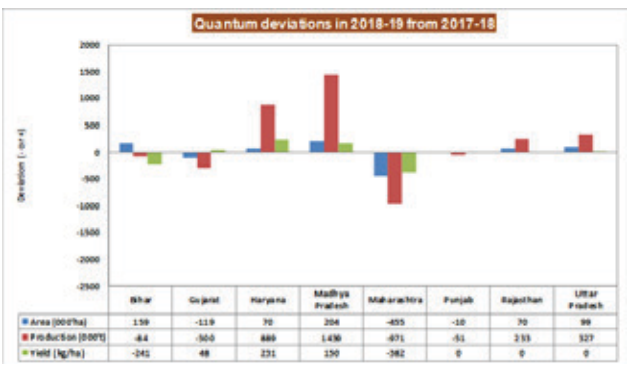
State wise analysis indicated that Assam, Chhattisgarh, Haryana, Madhya Pradesh, Rajasthan, Telangana, Uttar Pradesh and West Bengal have exhibited an increase in both area and yield which resulted in the incremental and record national output.

Analysis on contribution of yield and or area to the current year's overall wheat production indicated that the average national productivity has

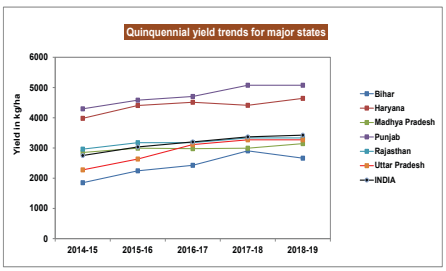
Contribution of yield and/or area to wheat production (2018-19)

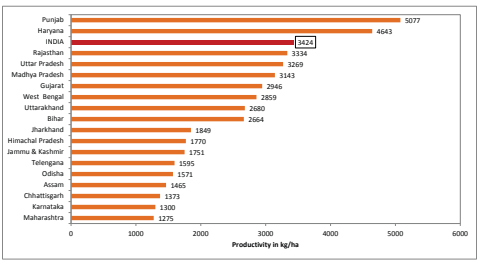
State/Country	Change in production in 2018-19* over 2017-18		% contribution by	
	Quantity (in '000 tonnes)	Deviation (in %)	Area	Yield
Assam	3	12.93	6.83	5.72
Bihar	-84	-1.37	7.55	-8.30
Chhattisgarh	12	8.89	2.23	6.52
Gujarat	-300	-9.77	-11.24	1.66
Haryana	889	8.25	2.87	5.24
HP	-1	-0.23	0.01	-0.24
J & K	17	3.40	-3.86	7.55
Jharkhand	-166	-35.36	-25.85	-12.83
Karnataka	-57	-24.91	-31.09	8.97
MP	1439	9.04	3.84	5.01
Maharashtra	-971	-57.24	-44.43	-23.05
Odisha	-0.04	-27.35	0.00	-27.35
Punjab	-51	-0.28	-0.28	0.00
Rajasthan	233	2.49	2.49	0.00
Telangana	1	14.91	0.00	14.91
Uttar Pradesh	327	1.03	1.02	0.01
Uttarakhand	-39	-4.27	-1.80	-2.51
West Bengal	74	23.71	15.38	7.21
Others	6	5.39	-1.55	7.04
INDIA	1331	1.33	-0.32	1.66

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



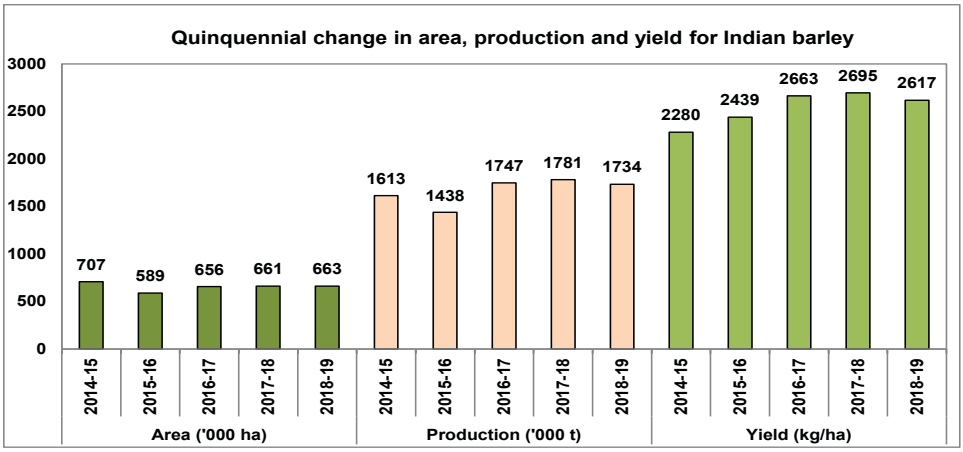
increased by 1.66 per cent (+56 kg/ha) in 2018-19 and it has been the major reason for quantum jump and landmark production despite a marginal decline in the crop acreage by 0.32 per cent (-0.96 lakh ha). State wise estimates indicated that barring Bihar, Gujarat, Maharashtra and Punjab, the rest of the major wheat producers registered a significant increase in the crop output. Similarly, with the exception of Bihar and Maharashtra the rest of the states have witnessed an increase or maintained their yield levels during the current season in comparison to the recent past. The crop yield varied across regions and it ranged from as high as 5077 kg/ha in Punjab to 1275 kg/ha in Maharashtra. Only Punjab and Haryana have registered yield levels much higher than the national average productivity of 3424 kg/ha. The increase in yield during 2018-19 over the previous year was highest in the case of Haryana (+231 kg/ha: +5.24%) and the reduction in yield level was highest in the case of Odisha (-592 kg/ha: -27.35%).

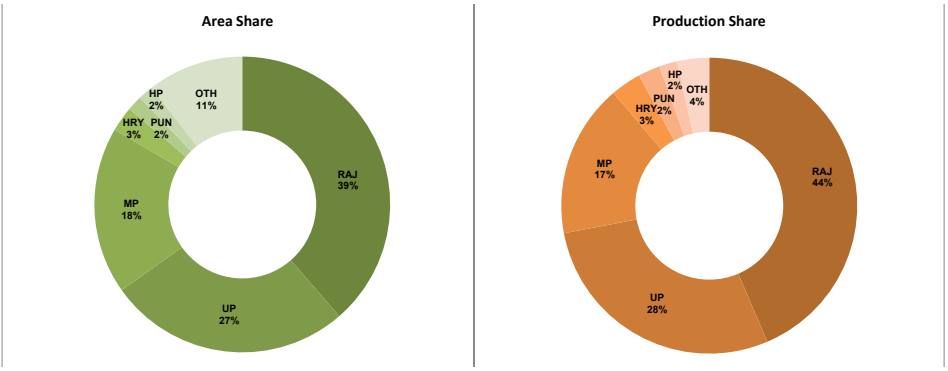




Scenario for Barley in India

Barley, a nutri-rich cereal that competes for wheat acreage has shown a positive change on area but witnessed a decline in overall crop output and average national productivity. During the crop season 2018-19, barley production was estimated at 1.73 mt which is attributed to the increase in crop acreage by 0.26 per cent despite a fall in productivity to the tune of 2.90 per cent (3rd Advance Estimates from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India). The overall increase in area was marginal (+0.02 lakh ha) and shall be attributed to the increase in the support price (+₹ 30 per quintal) in comparison to the previous year and announced as ₹ 1440 per quintal of barley. Year-to-year crop acreage has witnessed a mixed trend, but however, a long-run decline in barley area is a major concern since the selection of commodity for sowing by the farmers depends on market conditions and economic returns.

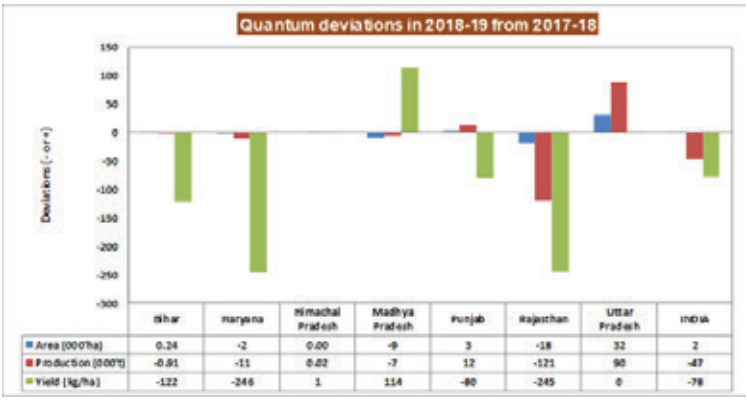




Quantum change in area, production and yield of barley

State/Country	2017-18 (Final Estimates)			2018-19 (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	10.4	16.5	1587	10.62	15.56	1465	0.24	-0.91	-122
Chhattisgarh	2.0	2.1	1052	1.87	1.73	925	-0.10	-0.34	-127
Haryana	20.0	69.0	3450	18.1	57.99	3204	-1.90	-11.01	-246
HP	19.2	33.9	1768	19.16	33.9	1769	0.00	0.02	1
J & K	5.8	3.3	578	6.43	4.21	655	0.67	0.88	77
M P	130.0	297.6	2289	121	290.82	2403	-9.00	-6.75	114
Punjab	7.7	29.9	3880	11	41.8	3800	3.30	11.92	-80
Rajasthan	274.0	876.3	3198	255.81	755.41	2953	-18.19	-120.92	-245
Uttar Pradesh	144.0	403.3	2801	176	492.98	2801	32.00	89.64	0
Uttarakhand	20.0	26.7	1337	23	30.34	1319	3.00	3.60	-18
West Bengal	2.8	4.0	1429	0.5	0.7	1400	-2.30	-3.30	-29
Others	1.0	1.2	1164	1.03	1.17	1136	0.00	-0.03	-28
INDIA	660.8	1780.8	2695	662.52	1733.6	2617	2	-47	-78

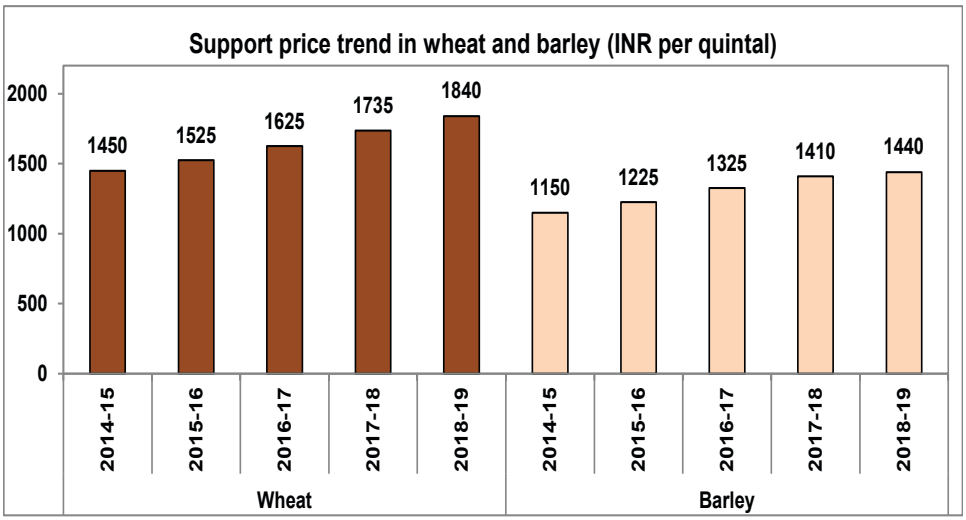
Source: DES, MoA&FW, India.



	Bihar	Haryana	Himachal Pradesh	Madhya Pradesh	Punjab	Rajasthan	Uttar Pradesh	INDIA
Area ('000 Ha)	0.24	-2	0.00	-9	3	-18	32	2
Production ('000 T)	-0.91	-11	0.02	-7	12	-121	90	-47
Yield (kg/ha)	-122	-246	1	114	-80	-245	0	-78

State wise estimates indicate that Rajasthan ranks first in barley production (0.76 mt: 44%), followed by Uttar Pradesh (0.49 mt: 28%) and Madhya Pradesh (0.29 mt: 17%). The aforementioned three states on the whole accounted for about 89 per cent of the total barley output produced in the country. Rajasthan holds the top slot position in terms of barley acreage (0.26 mha: 39%) during 2018-19, a plausible reason for its high share in production as well (44 %). During 2018-19 Rabi season, the average crop productivity in barley was highest in the case of Punjab (3800 kg/ha), followed by Haryana (3204 kg/ha), Rajasthan (2953 kg/ha) and Uttar Pradesh (2801 kg/ha). The above mentioned states registered crop productivity more than the national average (2617 kg/ha).

A wide range of regional variation has been noticed across barley growing states in terms of crop acreage, output and yield levels. Yield decline was observed in a majority of the states and it was highest in the case of Haryana and Rajasthan to the tune of 245 kg/ha. Jammu & Kashmir and Madhya Pradesh are the only two states to show a considerable higher yield levels during the current season in comparison to the recent past. The maximum positive growth in yield was noticed in Madhya Pradesh (+114 kg/ha: +5%). The crop acreage has witnessed an increase in states like Bihar, Jammu & Kashmir, Punjab, Uttar Pradesh and Uttarakhand. States like Chhattisgarh, Haryana, Rajasthan and West Bengal have exhibited a negative change in all the three variables *viz*., area, production and yield of barley, which is a serious concern for researchers. Shockingly, Rajasthan a leader in barley production has witnessed a fall in crop output to the tune of 1.21 lakh tonnes (-13.80%), which is attributed to both fall in crop acreage as well as yield decline.

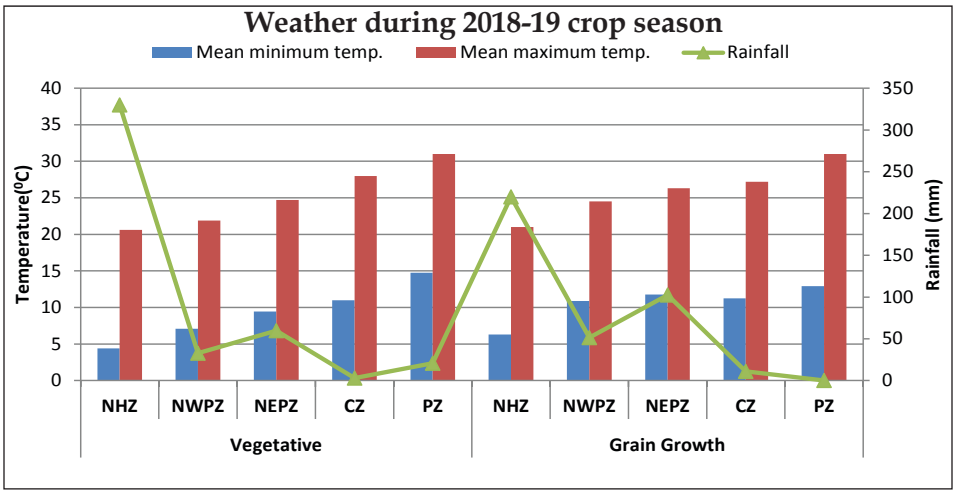


Price Scenario for Wheat and Barley

Trend in the support price for wheat and barley (in nominal terms) indicated a positive change over time. Government's policy decision on increasing the wheat procurement price by 6.1 per cent and barley by 2.1 per cent in comparison to past year price helped farmers to take prior sowing decision. However, the magnitude of change in the support prices had a diverse impact on both the crops acreage. The area under wheat has declined marginally (-0.09 mha) whereas, barley acreage has increased slightly (+0.02 lakh ha) owing to increase in the support price. It is also clear from the quinquennial data that the support price difference between wheat and barley hover around ₹ 400 - ₹ 300 per quintal and the divergence keeps on increasing in the recent past.

Weather Scenario (2018-19)

Meteorological data was received from 55 centres across NHZ (7), NWPZ (12), NEPZ (12), CZ (15) and PZ (9). The mean minimum temperature and mean maximum temperature was 10.9^{0}C and 24.5^{0}C in NWPZ and 11.7^{0}C and 26.3^{0}C in NEPZ during grain filling period. The mean maximum temperatures for crop growth period were below 30^{0}C in all wheat growing zones. The mean minimum temperature was highest (12.9^{0}C) in PZ, followed by NEPZ (11.7^{0}C) and CZ (11.2^{0}C) during grain growth. Compared to weather observed during grain growth phase of the 2017-18 crop season, both the mean minimum and the maximum temperatures were lower in all zones except a small increase in maximum temperature in



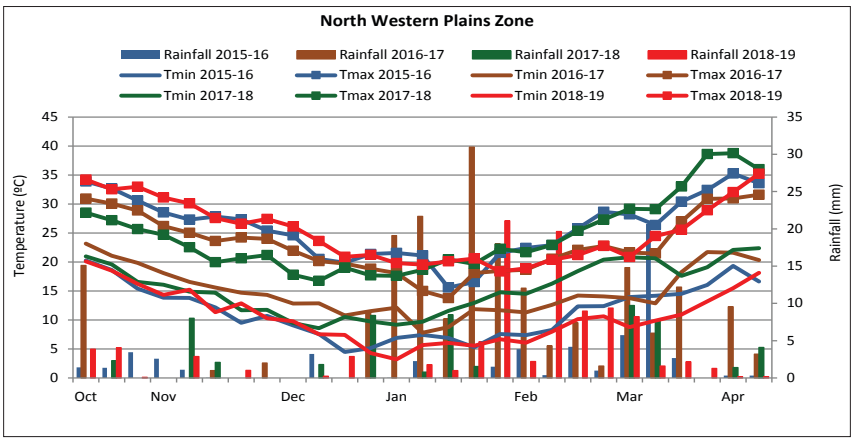
PZ. The mean minimum temperature was lower by 0.9^{0}C in NHZ, 2.9^{0}C in NWPZ, 3.4^{0}C in NEPZ and 1.3^{0}C in PZ. The mean maximum temperature was lower by 2.0^{0}C in NHZ, 1.8^{0}C in NWPZ, 3.9^{0}C in NEPZ, 4.7^{0}C in CZ and increased by 1.3^{0}C in PZ during grain growth period.

All the zones received rainfall during the crop season. Maximum rainfall of 550 mm was recorded in NHZ, followed by 162 mm in NEPZ. NWPZ received 84 mm rainfall, CZ and PZ received 14 and 21 mm rainfall respectively during the crop seaon. Compared to previous crop season, CZ and PZ received less rainfall, whereas, NHZ and NWPZ received relatively more rain during current crop season. There was almost no rainfall in PZ during grain growth period but a good spell of rainfall occurred before wheat sowing and during vegetative period.

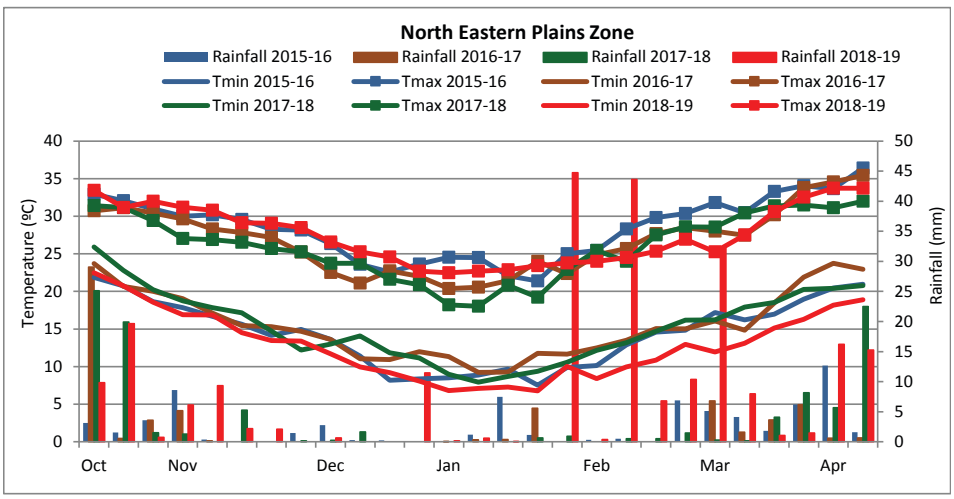
The weekly average weather data of cropping duration for all four major wheat growing zones (NWPZ, NEPZ, CZ and PZ) were compared with previous 3 years (2015-16, 2016-17, 2017-18) and the trend of minimum temperature, maximum temperature and rainfall are discussed below:

In NWPZ, the weekly average minimum temperature was lower than all three previous crop seasons and there was 4-5^{0}C decrease in minimum temperature was observed during 2018-19 crop season. The weekly average maximum temperature was 1-2^{0}C higher compared to 2016-17 & 2017-18 crop seasons but lower than 2015-16 crop seasons. Most of the grain filling period remained cooler and >30^{0}C temperature was observed only during 13-14th week during grain filling. The rainfall received was

lower than 2016-17 crop seasons and was higher than 2015-16 and 2017-18 crop seasons.

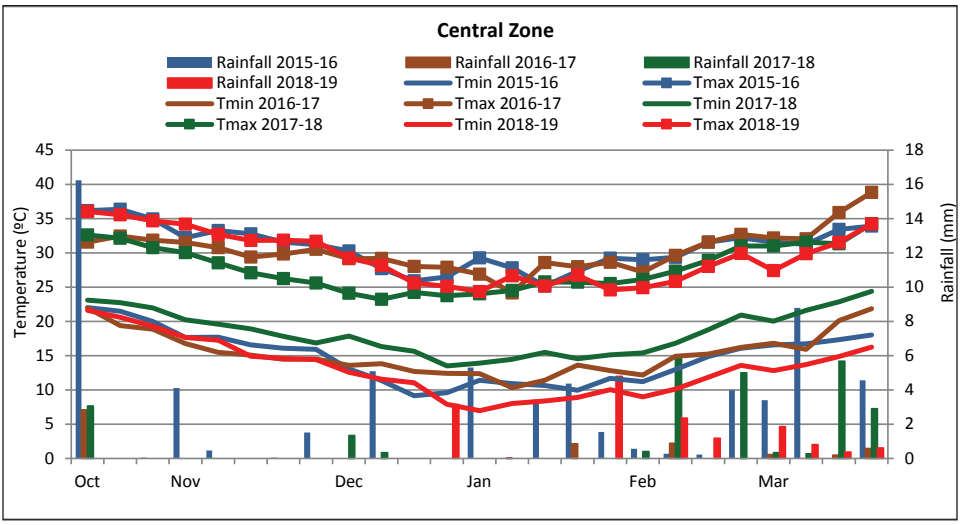


In NEPZ, the weekly average minimum temperature remained 2-3^{0}C lower compared to other previous crop seasons and the maximum temperature was 1^{0}C higher than 2016-17 and 2017-18 crop seasons and was lower than 2015-16 crop seasons. The temperature >30^{0}C was observed from last week of March to April. The rainfall received was higher than all three previous crop season.

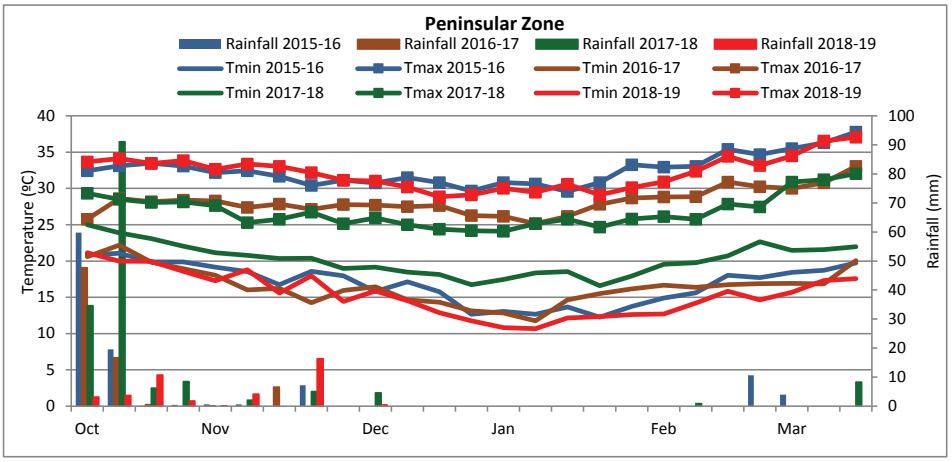


In CZ, the weekly average minimum temperature was lower than all three previous crop seasons. The maximum temperature was lower than 2015-16 and 2016-17 crop seasons and was 2^{0}C higher than 2017-18 crop season. The weekly average temperature >30^{0}C was observed in 11th and 12th week

of grain filling. The rainfall was lower than 2015-16 & 2017-18 crop seasons and was higher than 2016-17 crop season.



In PZ, the weekly average trend of minimum temperature was lower than all three previous crop seasons. The mean maximum temperature was lower than 2015-16 crop season but was higher than 2016-17 and 2017-18 crop seasons. The weekly average temperature >30^{0}C was observed from 5th to 12th week during grain filling. The rainfall received was lower than all three previous crop seasons.



Major Research Achievements

Crop Improvement

Development and release of new wheat varieties for different zones

Central released varieties

During the year 2018-19, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops (CVRC) recommended the release of six bread wheat namely PBW752, PBW757, HD3226, HD3237, HI1620 and DBW 187 for different production conditions in various zones.

Wheat varieties released by CVRC during 2018-19

Variety	Area and Production Condition (q/ha)	Grain yield (q/ha)		Special feature
		Av.	Pot.	
PBW752	NWPZ LS IR	49.7	65.4	High level of resistance to yellow and brown rust
PBW757	NWPZ VLS IR	36.7	44.9	High degree of resistance against yellow and brown rusts, Good chapati quality
HD3226	NWPZ TS IR	57.5	79.6	Resistance to yellow and brown rusts, high wet gluten content.
HD3237	NWPZ TS RI	48.4	63.1	Resistance to yellow and brown rust, less reduction in yield under no irrigation, good chapati quality
HI1620	NWPZ TS RI	49.1	61.8	Resistance to yellow and brown rust.
DBW187 (Karan Vandana)	NEPZ TS IR	48.8	64.7	Resistance to yellow and brown rust, good biscuit spread factor, High Fe content

State released varieties

Eleven wheat varieties (Sabour AAIW10, AAIW9, UP2844, UP2855, UP2865, VL Gehun967, VL Gehun2014, VL Gehun3004, JAUW584, CG1018 and Unnat PBW550) for 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.

Registration of new genetic stocks

During the year 2018-19, twenty one genetic stocks of wheat have been registered with ICAR-NBPGR, New Delhi for novel traits (disease resistance, chlorophyll deficient mutation, heat tolerance, drought tolerance

Wheat varieties released by SVRC during 2018-19

Variety	Developed by	Area and Production condition	Av. Grain yield (q/ha)	Special feature
AAIW10	SHUATS, Allahabad	UP TS IR	43.07	Resistance to brown rust, leaf blight, Karnal bunt
AAIW9	SHUATS, Allahabad	UP LS IR	38.37	Resistance to brown rust, leaf blight, Karnal bunt
UP2844	GBPUA&T, Pantnagar	Uttarakhand (Plains) LS IR	42.04	Resistance to yellow and brown rust
UP2855	GBPUA&T, Pantnagar	Uttarakhand (Plains) TS IR	52.52	Resistance to leaf rust
UP2865	GBPUA&T, Pantnagar	Uttarakhand (Plains) LS IR	45.82	Resistance to leaf rust
VL Gehun967	VPKAS, Almora	Uttrarakhand (Hills) TS, RF (Organic Cultivation)	19.86	Highly resistant to yellow and brown rust
VL Gehun2014	VPKAS, Almora	Uttarakhand (Plains) TS IR	52.06	Highly resistant to yellow and brown rust
VL Gehun3004	VPKAS, Almora	Uttarakhand (Plains) LS IR	43.88	Highly resistant to yellow and brown rust
JAUW584	SKUAST, Jammu	Jammu region of J&K TS IR	37.6	Resistance to yellow and brown rusts
CHHATTISGARH AMBER WHEAT (CG1018)	IGKVV, RS, Bilaspur	Chhattisgarh Restricted TS RI	35.09	Resistant to brown and black rust
Unnat PBW550	PAU, Ludhiana	Punjab TS IR	60.4	Highly resistant to yellow and brown rust

and quality). The genetic resources unit of the ICAR-IIWBR, Karnal multiplies the seed of these registered genetic stock and supplies to breeder across the country for use wheat improvement.

Genetic stocks registered during 2018-19

Name	Registration no.	National ID	Developed by	Trait
DBW-EMS98	INGR 18004	IC0625990	ICAR-IIWBR, Karnal	Chlorophyll deficient mutant
PHS1108	INGR 18005	IC0624499		High protein & manganese with bold seeds
DBW129	INGR 18006	IC0624497		Multiple disease and pest resistance
DBW246	INGR 18007	IC0625998		Highly resistant to yellow rust.
HTW9	INGR 18009	IC0625994		Heat tolerance.
DBW218	INGR 18010	IC0625997		High sedimentation value
QLD49	INGR 18016	IC0626288		Soft grain (biscuit making).
QLD46	INGR 18017	IC0626289		High grain protein content.
DDW32	INGR 18018	IC0626290		Loose smut resistance
QLD84	INGR 19010	IC0628572		Soft grain (hardness index=18)
QLD11	INGR 19011	IC0628573		High protein content (14.8%)
HTW63	INGR 19032	IC36761A		Drought tolerance.
IC0624570	INGR 18008	IC0624570	BHU,Varanasi	Spot blotch resistance, early maturity.
EC531185	INGR 18011	EC531185	ICAR-NBPGR, New Delhi	Drought tolerant with low DSI (<0.5)
EC339604	INGR 18012	EC339604		Resistant to leaf rust.
IC252459	INGR 18013	IC0252459		Resistant to stripe and leaf rust
IC564121	INGR 18014	IC0564121		Resistant to spot blotch
IC443669	INGR 18015	IC0443669		Resistant to spot blotch
IC536365	INGR 19007	IC0536365	ICAR-IARI, RS, Wellington,	Resistant to all three rusts
EC574482	INGR 19008	EC574482		Stripe rust *(Yr5 &Yr15)* leaf rust *(Lr50)* and 3 minor APR genes
HI8774	INGR 19009	IC0628570	IARI RS, Indore	Resistant to stripe rust, Karnal bunt and powdery mildew.

Registration of Plant Varieties with PPV&FRA

Four wheat varieties namely HS490, MPO 1215, HW1098, and CoW2 ere registered with the PPV&FRA vide registration number 71, 76, 176 and 178 of 2018, respectively. Registration proposals of DBW168 and DBW173 were submitted to the PPV&FRA, New Delhi for seeking protection under PPV&FRA, 2001 in extant and new category, respectively.

Significant results from coordinated yield trials

Conduction of coordinated trials

The wheat coordinated varietal evaluation programme entails a huge multilocation testing programme which is undertaken with the cooperation of 29 funded and 95 voluntary centres spread across five wheat growing zones in the country.

Funded and voluntary centres conducting coordinated trials

Zone	Funded centres	Voluntary centres, including ICAR centres
NWPZ	5	22
NEPZ	8	24
CZ	8	24
PZ	4	17
NHZ	4	8
Total	29	95

A total of 24 series of trials comprising AVTs, NIVTs, IVTs and special trials were laid out in the different zones under major production conditions *viz.* timely sown irrigated, late sown irrigated, timely sown restricted irrigation, early sown and very late condition during the crop season 2018-19. In all, 318 test entries were evaluated along with a total of 67 check varieties in different trials. A total of 436 trial sets were supplied to 124 centres out of which 423 trials were actually conducted. The non-conduction of the coordinated trials was mainly at voluntary centres. The percent conduction of trials was 100% in NEPZ and PZ followed by NWPZ (97.4%), NHZ (97.1%) and CZ (91.9%).

Breakup of yield trials during 2018-19

Zone	Proposed	Conducted	Reported	Not Reported
NHZ	34	33	31	LSM (1), RMT (1)
NWPZ	117	114	104	HCV (3), RMT (5), LSM (2)
NEPZ	93	93	75	DNR (1), LSM (6), TF (1), RMT (9), LSM&HCV(1)
CZ	111	102	78	DNR (8), LS (3), LSM (3), RMT (8), HCV (2)
PZ	81	81	62	DNR (3), LSM (4), RMT (8), LS (3), HCV(1)
Total	436	423	350	73 (RMT - 31)

Percent success in trial conduction and reporting during 2018-19

Zone	% conduction of proposed trials	% reporting of conducted trials
NHZ	97.1	93.9
NWPZ	97.4	91.2
NEPZ	100.0	80.6
CZ	91.9	76.5
PZ	100.0	76.5
Total	97.0	82.7

Amongst the 423 trials conducted, the data of 350 trials were found qualifying for reporting based on set norms for disease resistance and yield performance. As many as 73 trials were not reported this year.

Varieties in the final year evaluation in AVTs

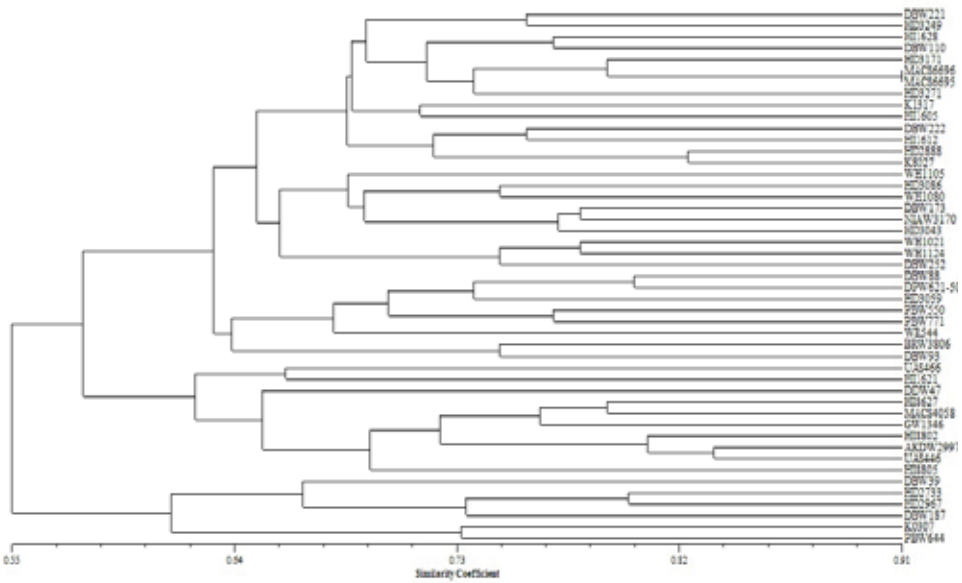
During the year under report, there were 19 varieties in the final year of yield evaluation in various AVTs and SPL trials in the different zones. The proposal for identification of these varieties would be placed for consideration by the Varietal Identification Committee.

Marker assisted gene prospecting in AVT entries of wheat

Varieties in final year of evaluation in AVTs during 2018-19

Trial	Final year entries
North Western Plains Zone	
AVT-IR-TS-TAS	DBW221, DBW222
AVT-IR-LS-TAS	PBW771
AVT-RI-TS-TAS	BRW3806, NIAW3170, HI1628
North Eastern Plains Zone	
AVT-IR-TS-TAS	HD3249
AVT-RI-TS-TAS	DBW252
Central Zone	
AVT-RI-TS-TAD	UAS466(d), DDW47(d)
Peninsular Zone	
AVT-RI-TS-TAD	MACS6696, MACS6695, NIAW3170 MACS4058(d), GW1346(d), HI8805(d), HI8802(d)
SPL Trials	
SPL-VLS	HD3271, HI1621

The AVT final year entries along with checks were screened with available molecular markers, linked to the gene(s) of waxiness (*WxB1*), abiotic (*drought*) stress related (*DREB*), vivipary (*Vp1B3*), leaf rust resistance (*Lr*), Photoperiod response (*Ppd1*) and vernalization (*Vrn*). The dendrogram showed genetic relatedness among genotypes ranging from 0.58 to 0.9. There were two distinct clusters one having predominantly the durum wheat varieties and the other primarily for bread wheat which gets reflected in the dendrogram based on genetic similarity.



Dendrogram showing relative diversity in AVT entries based on molecular markers

Most promising varieties in AVTs

Zone	Late sown, Irrigated	Timely sown, Restricted irrigation
CZ	CG1029	-
PZ	HI1633	NIDW1149 (d)

Promising varieties in NIVTs

Among the total 217 new entries evaluated for their performance in 8 NIVTs, 33 entries (26 bread wheat & 07 durum) were found promising on the basis of high yielding ability and disease resistance. In all, 11 entries were promising in NWPZ, one in NEPZ, 9 in CZ and 12 in PZ under different cultural conditions at the zonal level.

Most promising entries in NIVTs

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Restricted irrigation
NWPZ	PBW803	PBW811, PBW812, PBW813, DBW290, DBW291, HD3332, HD3334, JKW261, WH1264	DBW296
NEPZ	PBW804	-	-
CZ	GW513, HI1636, HI1637, MACS6747, MP1361, TAW155	-	MPO1357(d), UAS 472(d),HI8823 (d)
PZ	WHD964 (d), HI8818(d)	UAS3008, HI1641, HI1642, HI1646,MACS6752, MACS6749, GW519	MP1358, MACS4087(d), UAS472 (d)

Report on preparatory screening against wheat blast disease

As a part of anticipatory breeding against wheat blast disease, AICRP on Wheat and Barley sent a set of 100 wheat genotypes (released varieties, AVT and NIVT entries) for screening against wheat blast disease at Jessore (Bangladesh) and Bolivia during 2017-18 and same set of 100 genotypes was sent to Jessore (Bangladesh) during 2018-19 for confirmation. The genotypes BRW3806, DBW173, HD2967, DBW233 and DBW187 were found resistant. Also, another set of 353 lines (checks, AVT, NIVT and registered genetic stocks) was sent for screening against wheat blast at Jessore (Bangladesh) during 2018-19. About 27 genotypes namely PBW820, WH1256, WH1258, HUW835, UP3029, DBW287, JKW260, KRL429, UAS3006, MP3522, PBW810, TAW155, NWS2118, HD3334, JKW261, HD3344, MP1362, UP3036, UP3037, K1810, HUW838, MP1358, UAS3010, DBW301, DBW187, DBW233, and HD3043 were found highly resistant.

Monitoring of coordinated trials and nurseries

Multidisciplinary teams were constituted to monitor trial conducting centres in all zones. Out of the total 124 trial conducting centres, 103 centres were monitored during this crop season. The general comments of the members of the zonal teams on the genetic purity of test genotypes would be taken into account for promotion, retention / dropping of entries during the group meeting at the ensuing workshop. The monitoring teams recommended the rejection of 31 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 and recommended for rejection. However commonly appearing entries in the recommendation of different teams were dropped from further testing.

Entries dropped from further testing

Trial	Entry
Central Zone (AVTIR-TS)	CZ-TS104 (HD3343M)
Central Zone (AVT-IR-LS)	CZ-LS206 (UAS3002)
NIVT 1A	N114 (WH12557)
NIVT 1B	N202 (HD3326), N203 (HUW834)
NIVT 2	N314(RVW4265), N327(UP3032), N328 (Raj4542), N329(UAS3005)
NIVT 3B	N525(TAW154)
NIVT 5A	N720 (UP3036), N724 (HD3335)
NIVT 5B	N811 (UAS3009), N814 (CG1033)

Seed production

An indent of 20321.78q breeder seed of 141 wheat varieties was received from DAC&FW for production during 2018-19. The highest indented varieties included HD 2967 (2972.88q), HD 3086 (1936.30q), PBW 723 (1569.40), RAJ 4238 (955q), PBW 725 (746.20q), HI 8713 (462.20q), GW 366 (445q) and HI 1544 (398.80q).

Top indented varieties in breeder seed chain during 2018-19

Variety	Year of release	Breeder seed (q)	
		DAC Indent / Allocation	Production
HD 2967	2011	2972.88	4060.08
HD 3086 (Pusa Gautami)	2014	1936.30	1960.00
PBW 723	2017	1569.40	1404.40
RAJ 4238	2013	955.00	1195.00
PBW 725	2015	746.20	748.00
HI 8713 (Pusa Mangal)	2013	462.20	520.00
GW 366	2007	445.00	647.55
HI 1544 (Purna)	2008	398.80	886.50

Breeder Seed Production: Total production of breeder seed during the year was 28361.72q with a surplus production of 8710.87q over the allocated quantity (19650.85q). JNKVV, Jabalpur produced highest quantity of breeder seed (2676.98q), followed by PAU, Ludhiana (2560.40q) and IIWBR Karnal (2327q). The highest quantity of breeder seed was produced for HD 2967 (4060.08q), followed by HD 3086 (1960q), PBW 723 (1404.40q), MP 3288 (1398.84q), Raj 4238 (1192q), HI 1544 (886.50q), Raj4079 (860.50q) *etc.*

Nucleus Seed Production: Against an allocation of 766.30q nucleus seed of 141 wheat varieties, 1153.67q nucleus seed was produced. IARI Indore produced maximum quantity (194.30q) of nucleus seed, followed by PAU Ludhiana (116.75q), MAF (AU) Kota (110.86) and IARI New Delhi (91.40q).

Test stock multiplication: NSC reported to produce 909.50q test stock multiplication of 5 newly identified wheat varieties *viz.*, HD 3226 (204.5q), HD 3237 (86.4q), HI 1620 (266.60q), PBW 752 (261.0q) and DBW 187 (91.0q)

Evaluation of National and International Nurseries/Trials

National nurseries

During 2018-19, eight nurseries including one segregating stock nursery were constituted at the institute and supplied to different co-operators located across various zones in the country for evaluation and utilization.

Nursery	Entries+ Checks	# centre
National Genetic Stock Nursery (NGSN)	80+3	34
Short Duration Screening Nursery (SDSN)	44+6	17
Drought Tolerance Screening Nursery (DTSN)	19+6	15
Salinity-alkalinity Tolerance Screening Nursery (SAT/ALK SN)	26+2	9
Quality Component & Wheat Biofortification Nursery (QCWBN)	45+7	13
Elite International Germplasm Nursery (EIGN)	108+4	27
National Durum Screening Nursery (NDSN)	54+3	13
Segregating Stock Nursery (SSN)	160 F2/F3	20

International nurseries and trials

Sets of seven trials and seven nurseries comprising a total of 1539 lines (1312 bread wheat and 227 lines of durum wheat) were received from CIMMYT Mexico and evaluated at various wheat breeding centres. Based on yield per se and field screening for multiple diseases under different agro-climatic conditions, promising lines were identified for various zones as well as across the zones. One set of each of CIMMYT nursery/ trial that was planted at IIWBR, Karnal for comprehensive evaluation and seed multiplication also facilitated *in-situ* selection by a large number of wheat breeders/pathologist, who participated and made selections during wheat field day organized on March 29th, 2019 at Karnal.

Physiological studies on heat stress tolerance

The multilocation heat tolerance trial (MLHT) is conducted to identify heat tolerant genotypes among the AVT genotypes. Two trials MLHT1 and MLHT2 (each with 16 entries for CZ and PZ trial and 25 entries for NWPZ and NEPZ trial) were conducted during 2018-19.

HSI of genotypes in MLHT2 across locations

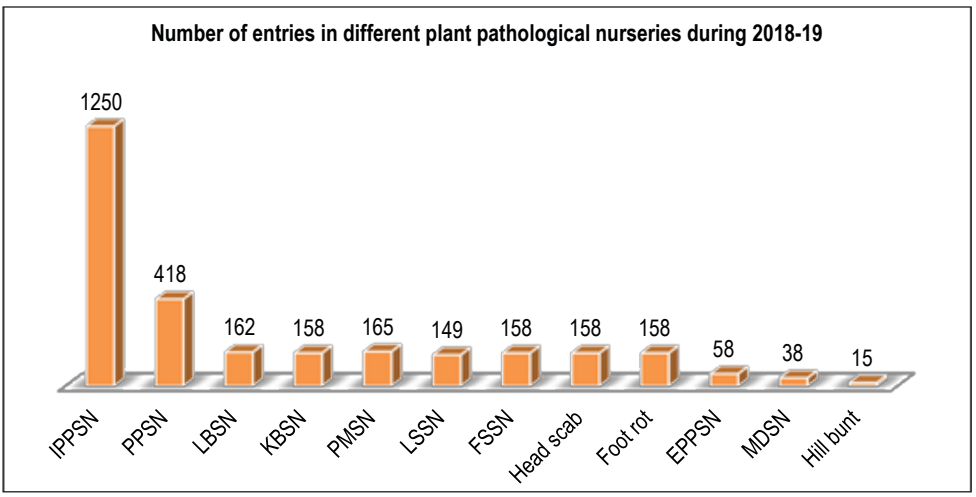
Zone	Genotypes
CZ&PZ	HI1625(0.54),AKAW4924(0.66),RWP 2017-21(0.93), GW492(0.96), GW491(0.98), MP1338(0.98)
NWPZ& NEPZ	HD3249(0.84), PBW771(0.88), PBW762(0.89), DBW221(0.91), K1601(0.91), BRW3792(0.95), DBW233(0.97), WH1218(0.97), PBW769(0.99)

Crop Protection

Crop protection programme aim to minimize losses caused by biotic stresses through strict surveillance, identification of resistance sources and development of management strategies.

Host resistance

Advance breeding material was evaluated against disease and insect pests to support the breeding programme at various hot spot locations and under artificially inoculated conditions. The major nurseries were: Initial Plant Pathological Nursery (IPPSN), Plant Pathological screening nursery (PPSN), Elite PPSN, Multiple Disease Screening Nursery (MDSN), Multiple Pest Screening Nursery (MPSN), and disease / insect pest specific nurseries.



Constitution of different plant pathological nurseries during 2018-19

Entries and check varieties identified resistant in PPSN:

Rust resistance materials in AVT entries (2018-19) with ACI upto 10.0 are given below:

Stem, Leaf and Stripe rusts

HPW467, PBW820[M], PBW821[M], PBW771[*], HD3249[*#Q], HD3277, HI8713(d)(C), NIDW1158(d), HI8811(d), HI8812(d), GW1348(d), PBW822[B], DDW48(d), DDW47(d)[*Q], HI8808(d), HI8807(d), PBW823[B], UAS428(d)(C), MACS3949(d)(C), HI 8805(d)[*], UAS446(d)(C), NIDW 1149(d), HI 8802(d)[*], WH1270, DBW303 and DBW302

Leaf and Stripe rusts

NW7049, PBW752 (I)(C), PBW781, DBW187(I)(C), WH1239, HI1612(C), HI8737(d)(C), WHD 963 (d), AKDW2997-16(d)(C), DBW301, UP3043, UP3042 , WH1223, NW 7060, HD3271 and PBW 797

Leaf and Stem rusts

VL907(C), VL892(C), PBW550(C), HD2967(C), DPW621-50(C), DBW173(C), HI1620(I)(C), HI1628*, NIAW3170*, DBW39(C), HD2888(C), K8027(C), HI1544(C), HI8627(d)(C), MP3288(C), DBW277, HD2864(C), MP4010(C), CG1029, HI1633, HI1634, MACS6222(C), DDW 48 (d), GW509, HD3090(C), NIAW3170* , GW1346(d)*, MACS4058(d)*, DDK1029(C), MACS5052, DDK1056, HW1098(C), MACS5053, DDK1057, DBW304, PBW825, PBW757(C) and DBW14(C)

Stem and Stripe rusts

HS507(C), VL3020, VL3021, HD3226(I)(C), PBW796, WH1142 C), HD3317, WH1254 and HI1621

Identification of multiple diseases resistant entries

Based on rigorous screening under Multiple Diseases Screening Nursery (MDSN) at multilocations the following genotypes have been identified as conformed source of resistance for multiple diseases:

A. Resistant to stem, leaf and stripe rusts +

- **Resistant to all three rusts + PM + FS + KB:** PBW777, TL 3011(T), TL 3012(T), TL 3013(T), TL 3014(T), TL 3015(T)
- **Resistant to all three rusts + FS + KB:** HS611, PBW778, B662, HG 110
- **Resistant to all three rusts + FS:** HI 8791(d)
- **Resistant to all three rusts + PM + FS:** VL3014
- **Resistant to all three rusts + LB + FS + FHS:** HS 645
- **Resistant to all three rusts + LB +PM + FS + KB:** UAS 462(d)

B. Resistant to Stem and Leaf rust +

- **Resistant to Stem and Leaf rust + FS + KB:** HI1620, DDK 1053(dic.), HS 644, MACS 5047, MACS 5049, WH 1232, IWP 5019, Line 1172
- **Resistant to Stem and Leaf rust + LB + PM + FS + KB:** DDK 1052(dic.)
- **Resistant to Stem and Leaf rust + PM + FS + KB:** HS 646
- **Resistant to Stem and Leaf rust + KB:** VL3013

C. Resistant to leaf and stripe rust +

- **Resistant to leaf and stripe rust + PM + FS + KB:** HPW439, PBW780, DBW246
- **Resistant to leaf and stripe rust + LB + FS + KB:** HD3271
- **Resistant to leaf and stripe rust + FS + KB:** HI1619, KRL370, DBW251
- **Resistant to leaf and stripe rust + KB:** HI1612
- **Resistant to leaf and stripe rust + FS:** HS468, WH1233

D. Resistant to LB +

- **Resistant to LB + PM + FS + KB + FHS:** VL1013

Pathotype distribution of *Puccinia* species on wheat and barley

More than 600 samples of three rusts of wheat, yellow and black rusts of barley were analyzed from thirteen Indian states and Nepal during 2018-19.

Predominant pathotypes of *Puccinia* on wheat in India

Wheat Rusts	Predominant pathotypes
Black	79G31(11), 123R15 (15-1) and 62G29(40A)
Brown	121R60-1(77-9), 121R60-1,7 (77-13) and 121R63-1(77-5)
Yellow	46S119 and 110S119

Yellow rust of wheat and barley (Puccinia striiformis)

During this crop year, 201 samples of yellow rust of wheat and barley were pathotyped from eight Indian states and Nepal. Unusually yellow rust was observed on Lok1, Sujata and some wheat material of some seed company at Indore in Madhya Pradesh. There had been no occurrence of wheat yellow rust from Madhya Pradesh earlier. Over the years diversity of pathotypes has decreased. Six pathotypes (46S119, 110S119, 238S119, 110S84, P and T) of wheat stripe rust pathogen were identified. They were avirulent to *Yr5, Yr10, Yr15,* and *YrSp*. The frequency of pathotype 46S119 (virulent on *Yr2, Yr3, Yr4, Yr6, Yr7, Yr8, Yr9, Yr17, Yr18, Yr19, Yr21, Yr22, Yr23, Yr25, YrA*) was maximum (47.3 %) in this cropping season. Pathotype 110S119, first identified in 2013-14, was present in 34.3 % samples. Remaining 4 pathotypes were observed in 13.3% samples only. Presence of barley yellow rust was negligible during this year. The barley yellow rust pathotypes 57 (0S0) and M (1S0) were observed in five and one samples, respectively.

Black rust of wheat (Puccinia graminis f. sp. tritici)

Eight pathotypes of black rust of wheat and barley were identified from the analyses of 134 samples, received/collected from five Indian states and Nepal. Population analyzed during the year has avirulence to *Sr26, 27, 31, 32, 35, 39, 40, 43, Tt3* and *Tmp*. Maximum number of samples was received from Karnataka, followed by Tamil Nadu. Pathotype 11 (79G31), virulent on *Sr2, Sr5, Sr6, Sr7b Sr9a, Sr9b, Sr9c, Sr9d, Sr9f, Sr9g, Sr10, Sr13, Sr14, Sr15, Sr16, Sr17, Sr18, Sr19, Sr20, Sr21, Sr28, Sr29, Sr30, Sr34, Sr36, Sr38, SrMcN* was recorded in 50% of the samples, which was followed by 15-1 *(22.3 %)* and 40A (15.6 %). Other pathotypes were observed in few samples only. Diversity of black rust pathotypes was maximum in samples from Karnataka. Pathotypes 40A and 11 were detected in nine barley samples received from Tamil Nadu and Karnataka.

Brown rust of wheat (Puccinia triticina)

Twenty-three pathotypes of *P. triticina* were identified in 292 samples analyzed from 11 states of India and Nepal. Indian population of *P. triticina* showed resistant infection type on *Lr24, Lr25, Lr29, Lr32, Lr39, Lr42, Lr45* and *Lr47.* Among *12, 77, 104* and *162* group of pathotype, 77 was the most predominant and was ascribed to 88.7% samples whereas remaining groups were attributed to 11.3% samples. Pathotype 77-9 (121R60-1) virulent on *Lr1, Lr3, Lr10, Lr11, Lr12, Lr13, Lr14a, Lr14b, Lr14ab, Lr15, Lr16, Lr17a, Lr17b, Lr18, Lr20, Lr21, Lr22a, Lr22b, Lr23, Lr26, Lr27+31, Lr30, Lr33, Lr34, Lr35, Lr36, Lr37, Lr38, Lr40, Lr44, Lr46, Lr48, Lr49, Lr67* was most frequent and identified in 149 rust samples (51.1 %). It was followed by pathotypes 77-13(121R60-1,7) in 20.2 % and 77-5 (121R63-1) in 15.1 % rust samples. The diversity of *P. triticina* was comparatively higher in Haryana, Karnataka and Himachal Pradesh. The pathotype 77-9 was most frequent in all the states except Himachal Pradesh and Punjab.

Rust resistance in wheat material

To identify rust resistant lines and characterize rust resistance genes in wheat, 158 advanced accessions (AVT I&II) were evaluated at seedling stage using an array of pathotypes of *Puccinia graminis* f. sp. tritici (black rust), *P. triticina* (brown rust) and *P. striiformisf. sp.* tritici (yellow rust) possessing different avirulence/virulence structures. Four lines, PBW821, PBW822, PBW823, and PBW757 were resistant to all the rusts. Rust resistance to all the pathotypes of black, brown and yellow rust pathogens

was observed in four entries (PBW821, PBW822, PBW823 and PBW757) of advanced wheat material. Four lines, CG1029, HD2864, K8027 and MACS6222 were found resistant to brown and black rusts. Entries NIDW1158, PBW752 and PBW781 were resistant to yellow rust only. Twelve lines (DBW110, DBW303, HD3226, HD3237, HD3277, HD3298, HI1628, NW7049, RAJ4529, PBW825, WH1105 and WH1223) showed resistance to all the pathotypes of black rust pathogen only. Fourteen entries (DDW47, DDW48, DDK1057, HD3090, HI1633, HI1634, HS562, MACS3949, PBW550, PBW797, PBW820, PBW824, UAS446, UAS466) were resistant to all pathotypes of brown rust pathogen only, whereas, five entries which possessed *Lr24*, were also resistant to brown rust. All the lines carrying *Sr31*, were resistant to black rust.

Rust resistance in advanced wheat material (AVT 2018-19)

Rusts	No. of lines	Wheat lines
Brown, Black and Yellow	4	PBW821, PBW822, PBW823, PBW757*
Brown & Black	4	CG1029, HD2864, K8027*, MACS6222
Brown	14	DDW47, DDW48, DDK1057, HD3090, HI1633, HI1634, HS562*, MACS3949, PBW550, PBW797, PBW820, PBW824, UAS446, UAS466*
Black	12	DBW110, DBW303, HD3226, HD3237, HD3277, HD3298*, HI1628, NW7049, RAJ4529, PBW825, WH1105, WH1223*
Yellow	3	NIDW1158, PBW752, PBW781

*represents variable reaction in different years

Rust resistance genes in AVT lines

Wheat rust resistance genes (*Lr, Sr, Yr*) were characterized using gene matching technique. Rust resistance genes were characterized only in the lines where differential host-pathogen interaction was present. In addition, linked characters, morphological markers, characteristic infection types and pedigree also formed the basis for postulating rust resistance genes in absence of clear host-pathogen differential reactions.

Yr **genes:** In advanced wheat material, 4 *Yr*-genes (*Yr9, 2, 18* and *A*) were characterized in 91 entries. Among these, *Yr2* was characterized in 57 lines. *Yr9*, alone or in combination, was postulated in 25 lines. *YrA* was characterized in 09 lines. Gene combinations *Yr9+A+* and *Yr9+18+* were inferred in 03 and 01 lines, respectively.

Diversity for rust resistance in AVT lines

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Yellow	91	Four: *Yr2, 9, A, 18*
Brown	119	Eleven: *Lr1, Lr2a, Lr3, Lr10, Lr13, Lr18, Lr19, Lr23, Lr24, Lr26 and Lr34*
Black	117	Fourteen : *Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr25, Sr28, Sr30* and *Sr31*

Lr **genes:** Eleven *Lr*-genes (*Lr1, Lr2a, Lr3, Lr10, Lr13, Lr18, Lr19, Lr23, Lr24, Lr26* and *Lr34*) were characterized in 119 lines. Genes were postulated alone or in combination. *Lr13* and *Lr23* were the most common resistance genes postulated in advanced wheat material. Both were characterized either alone or in combination, were found in 47 lines (39.5 %) each followed by *Lr10* in 34 lines. Resistance gene *Lr26* (linked with *Sr31* and *Yr9*) was postulated in 25 entries. *Lr13* is known to confer high temperature resistance. Therefore, in most wheat growing areas in India, lines possessing *Lr13* will show less terminal disease severity as the temperature rises towards the maturity. Brown rust effective resistance gene *Lr24* (linked with *Sr24*), was postulated in GW509, HD2888, HI1544, MP3288 and MP4010. Another effective gene *Lr19* was characterized in WH1254. Other brown rust resistance genes *Lr3, Lr2a, Lr18 and Lr34* were characterized only in four, two, two and one entries, respectively.

***Sr* genes:** Fourteen *Sr* genes (*Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr25, Sr28, Sr30* and *Sr31*) were characterized in 125 lines. Genes were postulated alone or in combinations. *Sr2*, whose postulation is based on characteristic micro-flecking, was postulated in 81 lines (64.5%), followed by *Sr*11 in 34 lines. *Sr31* is linked with *Lr26* and *Yr9* was postulated in 25 lines. Entries DBW252 and KRL19 possessed a combination of four genes.

Race specific Adult Plant Resistance (APR) in AVT material

To identify race specific adult plant rust resistance in wheat material, 158 lines of AVT were evaluated for identifying adult plant resistance. Four pathotypes, two each of yellow and brown rust pathogens, were used in the study. Optimum conditions for infection of rust and growth of wheat material were provided. Entry VL3021 showed APR to both the pathotypes of yellow and brown rust pathogens.

Sixteen entries (DBW277, DBW39(C), DBW49(D), HD3237(C)(I), HI1612(C), HPW468, MACS4058(D), MACS6222(C), MACS6696, PBW796, PBW797, UP3043, VL3019, WH1223) of advanced wheat material were

observed to carry APR to both the pathotypes of yellow rust pathogen. Fourteen entries possessed APR to pathotype 46S119 and fifteen to 110S119. Eight entries of AVT (DBW39, DBW110, HD2733, HI1612, GW1346, HPW467, K1317, and VL3021) were resistant to both pathotypes (77-9 and 104-2) of brown rust pathogen at adult plant stage. Nine entries of AVT showed APR to pathotype 77-9 and twenty entries to pathotype 104-2.

Rust resistance in EBDSN and NBDSN lines at seedling stage

A total of 284 lines of NBDSN and EBDSN were screened against 17 pathotype of *P. graminis* tritici (Black/Stem rust of barley), *P. hordei* (Leaf/brown rust of barley) and *P. striiformis hordei* (Stripe/yellow rust of barley) under controlled conditions of temperature and light. None of the barley lines possessed resistance to all the rusts.

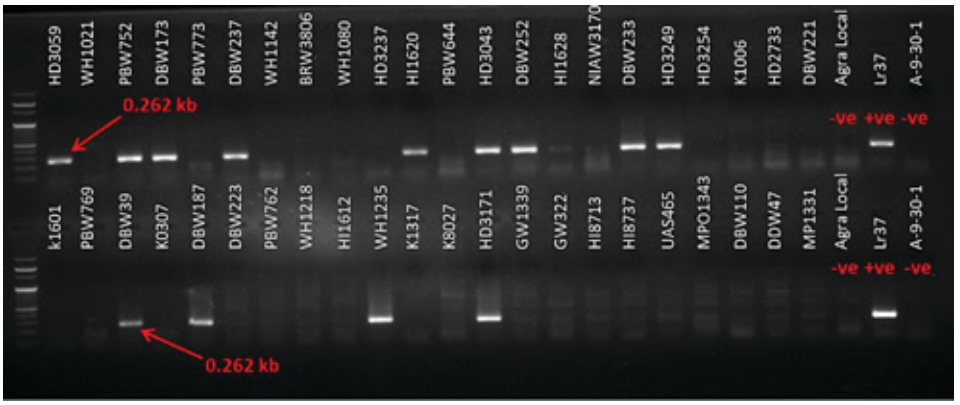
NBDSN: Fifty lines conferred resistance to one or more rusts of barley in NBDSN. Three lines (BH1024, KB1762 and RD3008) were resistant to brown and black rusts. BHS474, HBL845, HBL863, RD2786(C), RD2991 and RD3003 possessed resistance to brown & yellow rusts whereas DWRB182, HBL812 to black & yellow rusts of barley. Yellow rust resistance was observed in 25 lines and brown rust in 14 lines.

EBDSN: Thirty seven of the 59 lines of EBDSN were resistant to one or more rusts of barley. HBL814 was resistant to black & yellow rusts whereas RD2786, RD2972, RD2973, RD2875, RD2976 were resistant to brown & yellow rusts. In addition 23 barley lines conferred resistance to yellow rust whereas 8 lines to brown rust.

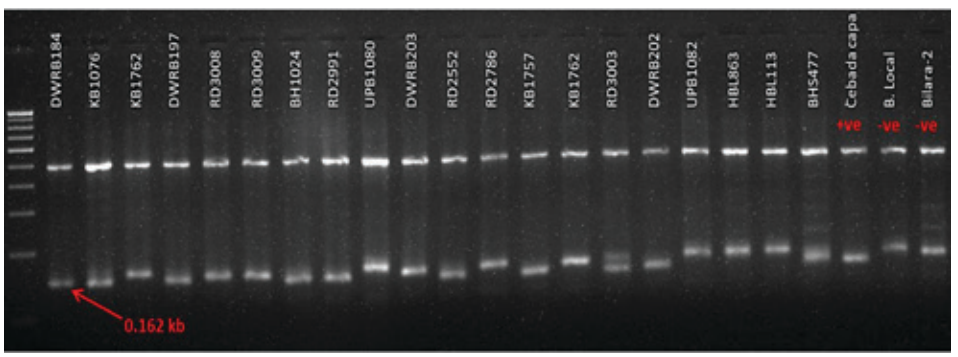
Screening of wheat and barley lines using resistance gene specific markers

Lr34/Sr57/Yr18 was confirmed in five AVT entries (UP3016, HI1625, PBW770, PBW757, and HI1624) out of twenty lines screened. Among the 44 lines, marker linked to *Lr37/Sr38/Yr17* was confirmed in thirteen AVT lines (HD3059, PBW752, BW173, DBW237, HI1620, HD3043, DBW252, DBW233, HD3249, DBW39, DBW187, WH1235 and HD3171). *Lr67/Sr55/Yr*46 was present only in K8027 out of 42 AVT lines.

Rph7 confers resistance to the Indian population of barley leaf rust. To ascertain the presence of *Rph7* in barley lines, all the 20 leaf rust resistant lines were screened with gene specific marker. Presence of *Rph7* was confirmed in thirteen NBDSN 2018-19 lines (DWRB184, KB1762, DWRB197, RD3008, RD3009, BH1024, RD2991, DWRB203, RD2552, KB1757, RD3003, DWRB202, BHS477).



Presence of leaf rust resistance gene *Lr37* in AVT lines



Presence of barley leaf rust resistance gene *Rph7* in NBDSN lines 2018-19

Maintenance and supply of nucleus inoculum of rust pathogens

National repository of more than 145 pathotypes of different rust pathogens of wheat, barley, oat and linseed was maintained in live culture as well as cryo-preserved. For the smooth conduct of wheat and barley rust research, nucleus/bulk inocula of different pathotypes of wheat and barley rust pathogens was supplied to more than 45 scientists/centres engaged on wheat rust research elsewhere in India.

Disease incidence in WDMN/SAARC wheat disease monitoring nursery

The 51st wheat disease monitoring nursery was conducted at 41 locations covering all the major wheat growing areas in the country, especially those situated near the bordering areas to the neighboring countries. The occurrence of wheat blast and *Sr31* virulences (*Ug99* type of pathotypes) of black rust were not reported from any of the locations where WDMN was planted. Yellow rust was observed on few entries at some locations of

Northern Hills Zone (NHZ) and North Western Plains Zone (NWPZ) except Shimla, Abohar and Ropar. It was also observed at Kanpur in North Eastern Plains Zone (NEPZ). Brown rust was reported from nine locations of NHZ and NWPZ. Black rust was observed at Powarkheda only in Central Zone (CZ), Dharwad and Wellington in Peninsular Zone (PZ). SAARC wheat disease monitoring nursery was conducted, by the station in collaboration with CIMMYT, Delhi, at 29 locations across the six SAARC countries, with the objectives similar to the wheat disease monitoring nursery (WDMN) in India. Information on wheat diseases in SAARC Wheat Disease Monitoring Nursery has been received from all the locations in India. Yellow rust was observed at all the SAARC nursery locations in India except at Abohar, Deenanagar, Faizabad and Wellington. Brown rust was observed at all the SAARC nursery locations except at Dhaulakuan, Ludhiana, Ropar, Abohar and Deenanagar. Black rust was observed only at Wellington.

Utilization of resistance sources

The total 16 entries with confirmed sources of multiple disease and insect pest resistance were shared with 27 breeding centers across different agro-climatic zones of country for their utilization in breeding for resistance to biotic stresses. All 16 entries were utilized in the range of 7.4 – 48.1% by the breeding centres. The most utilized entries at many centres were HS626, DBW179, WH1310 and HS627. Out of these, Faizabad centre, utilized a maximum 13 entries in their breeding programme followed by Niphad centre.

Survey and surveillance for diseases

Crop health was rigorously monitored during the crop season 2018-19 with a major emphasis on occurrence of yellow rust in NWPZ and surveillance for wheat blast. The extensive surveys were conducted by the wheat crop protection scientists of different cooperating centres including ICAR-IIWBR Karnal and information was shared through the *"Wheat Crop Health Newsletter"*, Vol. 24 (Issues 1 to 5) which was issued during the crop season and also uploaded on ICAR-IIWBR website (www.iiwbr.org). The first report of stripe rust was observed from village Fatehgarh Viran of block Chamkour Sahib of district Roopnagar on 14.1.2019. The yellow rust could not make any dent on wheat production and was very well managed. So far, the exotic diseases and pathotypes like *Ug99* race of stem rust and wheat blast were not reported from any part of the country. The overall crop health status was excellent in the country.

Strategy Planning Meetings

For successful and timely implementation of crop protection technologies first strategy planning meeting on "Evolving strategies for enhancing wheat production with special reference to management of wheat rust and Karnal bunt" was held on 22.10.2018 under the Chairmanship of Secretary, DAC&FW in New Delhi and attended by officials of DAC&FW, ICAR and Director Agriculture of different states. The second strategy planning meeting was also conducted on "Preparedness on occurrence of blast disease on wheat" on 31.8.2018 in Kolkata under Chairmanship of Agriculture Commissioner, GOI. It was attended by Director, Agriculture, Govt. of West Bengal, ADG (PP&B), Director, ICAR-IIWBR and other higher officials of Govt. of West Bengal, ICAR and SAUs.

Advisory for stripe rust management: Advisory for stripe rust management was issued time to time *i.e.* in December, January and February for northern states. Awareness among farmers for stripe rust management was created through mobile, internet, toll free number, newspapers, discussions and delivering lectures in farmers training programmes.

Preparedness to wheat blast: Surveys were conducted in North and South West Bengal near Indo-Bangladesh border by the team of scientist from ICAR-IIWBR, Karnal, UBKV, Cooch Behar, West Bengal and BCKV, Kalyani, Nadia, West Bengal and no wheat blast was observed. To check entry of blast from Bangladesh, strict quarantine has been observed and wheat holiday in Murshidabad and Nadia district as well as No wheat zone in 5 Km along Bangladesh border was implemented. For identification of wheat blast resistant sources, a total of 353 Indian wheat varieties and advance breeding material were screened at Jessore, Bangladesh through CIMMYT and out of these 26 were found free from blast infection and 31 showed resistance against wheat blast under artificially inoculated conditions. The varieties showing resistance are DBW187, DBW173, HD2967, HD3043 etc. which should be deployed in the disease prone areas. Anticipatory breeding programme has been initiated for faster breeding of blast resistant cultivars. During the current year 30 fresh crosses were made involving resistant donors.

Brain storming session on blast proofing in agriculture: A brain storming session on blast proofing in agriculture was jointly organized by ICAR-IIWBR, Indian Phytopathological Society, Indian Society of

Plant Pathologists and Society for Advancement of Wheat and Barley Research at ICAR-IIWBR Karnal on 8th August, 2018. It was attended by around 100 delegates from all over India.

Post harvest surveys for Karnal bunt

A total of 7321 grain samples collected from various mandies in different zones were analyzed at cooperating centres. Overall 32.02% samples were found infected. The samples from Haryana showed maximum infection (56.69%), followed by Jammu (54.85%) and Punjab (45.18%). Among different states from where samples were taken, those from Madhya Pradesh, Gujarat, Maharashtra and Karnataka were found free from Karnal bunt infection.

Survey and surveillance for insect pests

- The aphid incidence was above economic threshold level in some places in Punjab *viz.* village Mullanpur & Jagraon (Ludhiana), Ajitwal & Dagru (Moga) and Salabatpura (Bhatinda) during the second and third week of March. Minor incidence of pink stem borer (3-5 %) was also observed in one patch of 0.5 acre in farmers field in village Farwahi (Barnala). The incidence of armyworm was observed in patches and damage varied from 1-5 per cent except one field in village Kheri Malan where it was 15-20 per cent.
- In Vijapur, the incidence of aphids was low to moderate during ear head stage of the crop. The population of *H. armigera*, pink stem borer and surface grasshopper were very low. The appearance of minor pests like spodoptera, thrips, shoot fly, brown mite, jassids and cut worm were in occasional and in negligible form.
- In Rajasthan, survey of wheat and barley fields in Jaipur indicated moderate infestation of termite, mite *H. armigera* and pink stem borer. Besides, the cutworm population was observed in Tank bed condition of Tonk districts.
- Moderate to severe incidence of wheat aphid and pink stem borer was observed in villages Ladwa, Yamunanagar; Kunjpura, Subhari, Racina and Hajwana of Karnal. The grubs and adults of coccinellid beetles were seen frequently in fields infested with aphids.
- Heavy incidence of aphids was recorded in Nasik district. The Coccinellid predatory grubs and beetles feeding on the aphid and spyrphid fly infested fields were also observed. The incidence of Jassids and stem borer were recorded in medium intensity.

Host plant resistance against insect pests

Shoot fly: Amongst 158 AVT entries tested at five locations during 2018-19, 113 entries showed average shoot fly infestation below 10%. The lowest infestation of shoot fly *i.e.* 5.04 % was recorded in entry HI1628.

Brown wheat mite: Out of 158 AVT entries, two entries *viz.*, PBW821M and MACS6478(C) recorded the minimum mite population of 7/10 cm^2 area at Ludhiana while entry HI8627(d)(C) recorded the minimum mite population of 9.33/10 cm^2 at Durgapura.

Foliar aphid: None of AVT entry found resistant across all the four locations, whereas, three entries *viz.* GW1348 (d), DBW93 (C) and UP3043 at Ludhiana and six entries DBW93 (C),UP3043, HD3086 (C),WH1223, KRL19 (C) and PBW757 (C) at Karnal showed moderate level of resistance to foliar aphid. However, at Kharibari, one entry UP3042 was found to be resistant (grade 2) and three entries *viz.*, DBW304, DBW302 and PBW825 were found to be moderately resistant.

Root aphid: Out of total 158 entries, eight entries *viz.* PBW752(I)(C), WH1124(C), BRW3806, NIDW1158(d), GW322(C), UAS466(d), AKDW2997-16(d) (C) and HI1621 showed the moderately resistance reaction at Ludhiana.

Screening against multiple pests: The average minimum score (6.01%) for shoot fly was observed in entry HI1612 and the maximum score of 15.26% was recorded for GW173 (C). The lowest population of 10 brown wheat mites/ 10 cm^2 area was recorded for DBW251 at Ludhiana while entry HI8791(d) had lowest population of 10.66 mites/ 10 cm^2. Based on average score of four locations, two entries DBW251 and PBW780 showed moderately resistance to foliar aphid. At Ludhiana, one entry B622 was found to be moderately resistant (grade 3) to root aphid.

Integrated pest management

- Amongst the different tested monitoring traps *viz.*, sticky-traps and tray-traps, the efficiency of yellow sticky traps was comparatively more than tray traps.
- Foliar application of imidacloprid 17.8 SL @ 100 ml/ha, acetamiprid 20 SP@ 100 g/ha and quinalphos 25EC @400 ml/ha was more effective in checking aphid population.

- The integrated pest modules tested against major pests of wheat *viz.*, foliar aphids, shootfly and termites, and pink stem borer revealed comparatively lower pest population in IPM module treatment as compared to Farmer practice (FP). However, in FP treatment the population of natural enemies was little higher than IPM treatment.
- Impact of three different doses (low, medium & high) of nitrogen application on population abundance of foliar aphid was investigated in wheat. Treatments with higher doses of nitrogen *i.e.* 150 & 225 kg/ha had highest number of aphids as compared to lower doses of nitrogen.
- Population dynamics of foliar studies on wheat and barley crops revealed comparatively higher population of aphid on barley as compared to wheat crop. The coccinellid beetle appeared after the peak period of aphid infestation on wheat and barley crop.

Stored grain pest management

Efficacy of various plant materials as seed protectant was evaluated against grain weevil (*Sitophilus oryzae*) and it was found that seed treatment with Vekhand powder and its combinations with Neem leaves, Jungli Imli and Gulwel powder proved to be significantly effective in controlling the population of grain weevil as compared to rest of the treatments.

Resistance against *Heterodera avenae:* One hundred fifty eight entries of AVT were screened for resistance against *H. avenae* (CCN) under sick plot conditions at three locations *viz.* Ludhiana, Durgapura and Hisar. None of the entries showed resistance across all the locations. Out of these, three had been found resistant [HI1628, NIAW3170 and K8027(C)] and four showed moderately resistance reaction *viz.*, HS652, HD2967(C), HI8812(d) and HI8807(d) at Durgapura, whereas only six entries namely HS673, DPW621-50(C), K0307(C), PBW822, DDW47(d) and HW1098(C) have shown moderately resistant reaction at Ludhiana.

Training of wheat health management

A training programme on "Disease surveillance and adoption of new wheat and barley varieties for better productivity and resistance" was conducted on 31.10.2018 at BCKV Kalyani (West Bengal). Around 60 farmers and state government officials participated.

Resource Management

The Resource Management group of the "All India Co-ordinated Research Project on Wheat and Barley", 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.

Varietal evaluation in different wheat growing zones

In all, 62 trials were proposed, of which 58 were conducted. Out of the conducted trials, four trials were rejected due to low yield and/or high CV and improper data reporting. The overall conduct of trial was 93.5 percent with a success and rejection rate of 93.1 percent and 6.9 percent, respectively.

Zone-wise details of the coordinated varietal evaluation trials

Trial Series	Locations	Trials conducted	Trials not conducted		Rejected	
			Number	Centres	Number	Centres
North Western Plains Zone						
IR-TS--DOS	10	10	-	-	-	-
RIR-TS-TAS	10	10	-	-	-	-
IR-ES-HYT	07	05	02	Delhi, Ladowal (BISA)	-	-
Total	27	25	02	-	-	-
North Eastern Plains Zone						
IR-TS--DOS	11	11	-	-	-	-
RIR-TS-TAS	11	11	-	-	-	-
Total	22	22	-		-	
Central Zone						
RIR-TS-TAD	08	08	-	-	03	Jabalpur, Junangarh, Vijapur
Total	08	08	-	-	03	-
Peninsular Zone						
RIR-TS-TAS	05	03	02	Akola, Washim	01	Niphad
Total	05	03	02		01	
Total Trials	**62**	**58**	**04**		**04**	

In NWPZ, out of 27 proposed trials, 25 were conducted successfully. In NEPZ, all the 12 proposed trials were conducted. In CZ, 16 out of 20 trials were conducted successfully. In PZ, out of 20 proposed 18 were conducted.

In PZ, one trial was rejected by the monitoring team; two were rejected due to high CV and one due to incomplete set at Dharwad. Akola centre did not conduct RIR-TS-TAS trial.

In NWPZ, out of five test entries in the AVT II timely sown condition, only three genotypes namely, DBW222, PBW771, and HD3271 were significantly superior to the best check (PBW752) with a yield gain of 3.46, 2.08 and 1.71 percent respectively. Whereas, in restricted irrigation trial in NWPZ, out of 3 test entries *viz.* BRW3806, HI1628 and NIAW3170, only one test entry BRW3806 was found numerically better than the best check HI1620 with a yield gain of 1.25%. In early sown high yield trial, out of the 13 test entries, one entry DBW187 was significantly superior to the best check HD3086 with an yield gain of 5.80 percent whereas four test entries *i.e.* WH1254, WH1270, UP3043, DBW303 were numerically better with an yield gain of 0.15 to 2.07 percent.

In NEPZ, three genotypes namely HD3249, HD3271 and HI1681 were

Performance of new genotypes in various agro-climatic zones

Zone wise trial	Test entries	Entry sowing superiority		Best check	Yield gain, %	Locations
		Numerical	Significant			
North Western Plains Zone						
IR-TS--DOS	DBW221, DBW222, PBW771, HD3271, HI1621	- -	DBW222, PBW771, HD3271	PBW752(I) PBW752(I) PBW752(I)	3.46 2.08 1.71	10 10 10
RIR-TS-TAS	BRW3806, HI1628, NIAW3170	BRW3806		HI1620	1.25	10
IR-ES-HYT	HD3317, WH1254, DBW301, WH1270, PBW824, UP3043, DBW187, DBW303, DBW304, UP3042, DBW302, PBW825, HD3347	WH1254, WH 1270 UP3043 DBW303	DBW187	HD3086	5.80 1.00 0.15 2.07 1.90	05
North Eastern Plains Zone						
IR-TS--DOS	HD 3249, HD3271, HI1681	-	HD3249	DBW187	3.79	11
RIR-TS-TAS	DBW 252	-		K1317	-	11
Central Zone						
RIR-TS-TAD	DDW 47, UAS 466	-	-	DBW110	-	05
Peninsular Zone						
RIR-TS-TAS	MACS6695, MACS 6696, NIAW3170, MACS4059(d), GW 1346(d), HI8802(d), HI 8805(d)	- - NIAW3170	MACS6695, MACS 6696	HI1605 HI1605 HI1605	8.46 5.72 1.63	02

tested and only HD3249 was found significantly superior to the best check DBW187 with a yield gain of 3.79% for irrigated timely sown conditions. Whereas in restricted irrigation trial one test entry namely DBW252 was evaluated and was found inferior to best check variety K1317.

In CZ, two durum test entries namely DDW47 and UAS466 were evaluated and none was found significantly superior to the best check DBW110.

Zone-wise details of the special agronomic trials

Trial Series	Locations	Trials conducted	Trials not conducted	
			Number	Centres
Northern Hill Zone				
SPL-2: Role of PSB	02	02	-	-
SPL-3: Enhancing Zn in wheat grain	03	03	01	Shimla
SPL-6 Varieties at date of sowing	05	02	03	Almora, Khudwani, Shimla
SPL-7 :Precision nutrient management	04	04	-	-
Total	14	11	03	
North Western Plains Zone				
SPL-1:Early sown high yielding trial	07	05	02	Delhi, Ladowal (BISA)
SPL-2: Role of PSB	02	02	-	
SPL-6 Varieties at date of sowing	10	07	03	Agra, Delhi, Sriganganagar
SPL-7 :Precision nutrient management	04	04	-	-
Total	23	18	05	
North Eastern Plains Zone				
SPL-2: Role of PSB	01	01	-	-
SPL-5: Precision nitrogen management	02	02	-	-
SPL-6 Varieties at date of sowing	11	08	03	IARI Pusa, Kanpur, CAU Pusa
SPL-7 :Precision nutrient management	01	01	-	-
Total	15	12	03	
Central Zone				
SPL-6 Varieties at date of sowing	07	06	01	Junagarh
SPL-7 :Precision nutrient management	01	01	-	-
Total	08	07	01	
Peninsular Zone				
SPL-4: Yield maximization of dicoccum	04	03	01	Akola
SPL-5: Precision nitrogen management	02	02	-	-
SPL-6 Varieties at date of sowing	03	03	-	-
SPL-7 :Precision nutrient management	01	01	-	-
Total	10	09	01	
Total Trials	70	57	13	

In PZ, under restricted irrigation conditions seven test entries *viz.* MACS6695, MACS6696, NIAW3170, MACS4059(d), GW1346(d), HI8802(d) and HI8805(d) were evaluated and two test entries were found significantly superior to best check HI1605 with a yield gain of 8.46 and 5.72%, respectively. One test entry NIAW 3170 gave numerically better yield than the best check HI 1605 with a yield gain of 1.63 percent.

In all, 70 special trials were proposed, out of which 57 were conducted and the conduct percentage was 81.4. The maximum numbers of special trials were conducted in NWPZ (18) followed by NEPZ (12), NHZ (11), PZ(09) and CZ (07), respectively.

Production technologies

Various special coordinated trials on optimising phosphorus usage, enhancing Zn content in wheat grain, identifying optimum spacing and seed rate for dicoccum, precision nitrogen management using NDVI sensor, quantifying the yield losses due to delayed sowing, and validation of nutrient expert in wheat were conducted to address the various issues in different wheat growing zones.

Optimizing phosphorus usage in wheat

Phosphorus is a major nutrient element, which plays a key role in realizing crop yield potential. Phosphorus solubilising bacteria makes phosphorus available for crop from the fixed reservoir in the soil and therefore enhancing the phosphorus use efficiency. For exploring the role of phosphorus solubilising bacteria in improving phosphorus usage in wheat under wheat based cropping systems field trials were conducted across the wheat growing zones.

In NHZ, this trial was conducted at Bajaura and Malan centres. The results revealed significant effect of phosphorus solubilising bacteria with phosphorus fertilizer at 30 and 60 kg/ha. The highest yield was obtained in 60 kg/ha phosphorus + PSB treatment.
In NWPZ, the trial was conducted at Ludhiana and Karnal. The maximum wheat grain yield (60.0 q/ha) was obtained at recommended dose of P application. Additional application of PSB did not increase any yield across the P (0, 30 60) levels.

In NEPZ, this experiment was conducted at Shillongani only. Maximum wheat grain yield (47.66 q/ha) was obtained at recommended dose of P application (60 kg/ha) without PSB inoculation. The addition of PSB significantly increased the yield in comparison to treatments where no P or 30 kg P_2O_5/ha was applied.

Agronomic management for enhancing Zinc in wheat grain in NHZ

To enhance zinc content in wheat grain in NHZ, a special coordinated trial was conducted at three locations in NHZ (Bajuara, Khudwani and Malan). The results revealed that lowest wheat productivity was recorded when no zinc was applied which was significantly lower than all the zinc application treatments except where only foliar spray of 0.5% hepta hydrate zinc was done twice. The highest yield was obtained in Zn application in soil (37.5 kg $ZnSO_4$/ha) + Foliar Zn application (0.5% $ZnSO_4$ heptahydrate) at heading and early milk stage (47.24 q/ha), followed by Zn application in soil (25 kg Zinc sulphate/ha) + Foliar Zn application (0.5% $ZnSO_4$ heptahydrate) at heading and early milk stage (45.79 q/ha).

Yield maximization in dicoccum wheat through spacing and seed rates

This trial was conducted at three locations in PZ (Dharwad, Niphad and Pune) to evaluate the effect of spacing and seed rate on productivity of dicoccum wheat. The results revealed that among various seed rates there were no significant differences in yield, whereas, significant differences were observed only for line spacing treatments. The highest yield was obtained in line sowing at 20 cm with seed rate of 125 kg/ha (45.38 q/ha), followed by 20 cm line spacing with seed rate of 100 kg/ha (44.35 q/ha) and these were at par.

Precision nitrogen management in irrigated wheat using NDVI sensor

This experiment was conducted to improve nitrogen use efficiency in wheat by need based nitrogen application using NDVI sensor at Coochbehar and Ranchi centres in NEPZ and Dharwad and Pune in PZ.

The results of NEPZ revealed significant effect of precision nitrogen management using need based application using remote sensing based GreenSeeker on grain yield. The maximum yield (51.98 q/ha) was recorded for the treatment 30 kg N/ha basal +60 kg N/ha CRI and rest using Green Seeker twice at 40-45 DAS and 60-65 DAS, followed by treatment where

75 kg N basal +37.5 kg N/ha at CRI and 37.5 kg N/ha at tillering stage (48.68 q/ha) and Rich Plot-90 kg N/ha basal+90 at CRI (48.35 q/ha) and these treatments were statistically at par.
In PZ also this trial was conducted at two locations (Dharwad and Pune). The results revealed that there was significant difference in grain yield due to different N application treatments. The maximum grain yield was recorded for the treatment rich Plot-90 kg N/ha basal+90 at CRI (56.02 q/ha) followed by 75 kg basal +37.5 kg N/ha at CRI and tillering (55.22 q/ha) and these treatments were statistically at par.

Performance of varieties at different dates of sowing under changing climate

In this trial, six varieties (HS562, HD2967, HD3086, HI1544, MACS6222 and WR544) were evaluated at different sowing time from 5th November to 5th January in all the five wheat growing zones.

In NHZ, the trial was conducted at two centres (Bajaura and Malan). The results revealed that 5th November sown wheat produced the maximum (46.89 q/ha) and significantly higher yield as compared to other dates of sowing. The delay in wheat sowing from 5th November to 5th January decreased grain yield significantly from 46.89 q/ha to 28.32 q/ha with the reduction of 39.6%. On mean basis across sowing time, variety HS562 produced the maximum and significantly higher yield (44.62 q/ha) followed by MACS6222 (40.54 q/ha) and HD3086 (38.98 q/ha). The genotypes HD3086 and MACS6222 were at par.

In NWPZ, this trial was conducted at 7 locations (Durgapura, Gurdaspur, Hisar, Jammu, Karnal, Ludhiana, and Pantnagar). The results showed that 5th November sowing recorded significantly higher grain yield (59.37 q/ha) than all other dates. There was significant successive reduction of 11.1, 28.6, and 62.7 percent by delaying the sowing to 25th November, 15th December and 5th January, respectively. Variety HS562 produced the maximum grain yield (50.43 q/ha), followed by HD3086 (49.82 q/ha) and lowest was by WR544 (42.32 q/ha).

In NEPZ, this trial was conducted at eight centres (Burdwan, Coochbehar, Faizabad, Kalyani, Ranchi, Sabour, Shillongani and Varanasi). The results showed that 25th November sown wheat produced the maximum yield

(45.63 q/ha) which was significantly superior to other dates of sowing. The delay in wheat sowing from 25th November to 5th January decreased grain yield by 43 percent, whereas the reduction in yield was 17 percent in 15th December sowing. On mean basis across sowing time, variety MACS6222 produced the maximum and significantly higher yield (39.97 q/ha), which was at par with HD2967 (39.48 q/ha) and HD3086 (39.68 q/ha).

In CZ, this trial was conducted at six locations (Bilaspur, Gwalior, Indore, Jabalpur, Powarkheda and Udaipur). The results showed that 5th November sowing produced maximum (49.68 q/ha) and significantly higher grain yield than all other sowing dates. There was significant successive reduction of 4.51, 18.67 and 33.57% by delaying the sowing to 25thNovember, 15th December and 5th January, respectively, as compared to 5th November sowing. Variety HI1544 produced maximum grain yield (46.68 q/ha), followed by MACS6222 (44.88 q/ha) and the lowest by WR544 (39.00 q/ha).

In PZ, the trial was conducted at three centres (Dharwad, Niphad, and Pune). The results revealed that there was a significant difference in grain yield among varieties, sowing time and their interactions. The highest yield was obtained in the 5th Nov sowing time and yield declined with delay in sowing. Among varieties, the top yielder was HI1544 with an average yield of 36.68 q/ha followed by HS562 (35.23 q/ha) and MACS6222 (35.18 q/ha).

Precision nutrient management and validation of nutrient expert in wheat

This experiment was conducted with seven fertilizer treatments *viz.* control, recommended dose of fertilizers (RDF), 150% RDF, 150% PK, 150% NK, 150% NP and nutrient expert at four locations (Almora, Bajaura, Khudwani and Malan) in NHZ, four location in NWPZ (Hisar, Karnal, Ludhiana, Pantnagar), one location each in NEPZ (Varanasi), CZ (Udaipur) and PZ (Dharwad).

In NHZ, 150% RDF recorded maximum grain yield (44.74 q/ha) which was followed by Nutrient expert treatment (44.25 q/ha) and both the treatments were found at par. The 150% RDF application produced almost 11.82% higher grain yield than recommended dose of fertilizer (RDF) application. The 150% PK application produced 20.53 q/ha yield

indicating that the omission of only nitrogen drastically reduced the productivity but omission of phosphorous and potash had marginal effect.

In NWPZ, the results revealed that 150% RDF recorded the highest grain yield (60.7 q/ha) and was significantly higher than recommended fertilizer but was at par with nutrient expert treatments. The 150% RDF application produced 8.98% higher grain yield than recommended dose of fertiliser (RDF) application. The lowest yield was recorded in control treatment (26.1 q/ha).

In NEPZ, the results revealed that nutrient expert recorded maximum and significantly higher grain yield (55.32 q/ha). This was followed by 150% RDF, 150% NP and NK applications. Application of 150% RDF produced almost 15.4% higher grain yield than recommended dose of fertilizer (RDF) application. The lowest yield was recorded in control plots and over control, the 150% PK application produced yield increase of about10 q/ha.

In CZ, the highest yield of 53.72 q/ha was obtained in treatment where fertilizer application was done using nutrient expert closely followed by 150% RDF (52.02 q/ha). The fertilizer application using nutrient expert was 170.65 nitrogen, 89.76 kg/ha phosphorus and 76.04 kg/ha potash. The yield gain in nutrient expert was 15.83% as compared to recommended fertilizer application.

At Dharwad centre in PZ, the highest yield was obtained under 150% RDF with a yield level of 45.91 q/ha followed by Nutrient Expert treatment (43.85 q/ha) and recommended dose of NPK (42.38 q/ha) and all these treatments were statistically at par. The yield obtained in nutrient expert treatment was much below the targeted yield of 6t/ha.

Wheat Quality

Zone wise variability in wheat quality and grain nutrition parameters has been recorded. During 2018-19, 126 AVTs, 244 NIVTs, 37 SPL, 52 QCSN, and 68 preliminary QCSN were analyzed from different zones and growing conditions. Promising genotypes showing superiority in various quality traits including Fe and Zn content and product quality have been identified. All the 2nd year AVT entries including checks were subjected to baking evaluation for chapati, bread, biscuit and gluten content.

Promising *T.aestivum* genotypes for Chapati and Bread

Category		Genotypes
Chapati (Score>8.0)	Checks	HD2967, HD3086 (NWPZ-HYPT), HD2967, K0307 (NEPZ-ITS), , PBW757 (NWPZ & NEPZ, SPL-VLS)
	Entries	PBW 771 (NWPZ-ILS), DBW301, PBW824 (NWPZ-HYPT),
Bread (Loaf>600 ml)	Check	HD3226, WH1105 (NWPZ-ITS), , WH1080 (NWPZ-RITS) DBW93 (PZ-RITS)
	Entries	DBW221, DBW222 (NWPZ-ITS), , BRW 3806*# (NWPZ-RITS), NIAW 3170* (NWPZ & PZ-RITS), HI1621* (SPL-VLS), WH1254, DBW303 (HYPT)
Biscuit (SF>10.0)	Check	NIL
	Entries	NIAW 3170* (NWPZ & PZ-RITS)

Promising genotypes for various quality traits

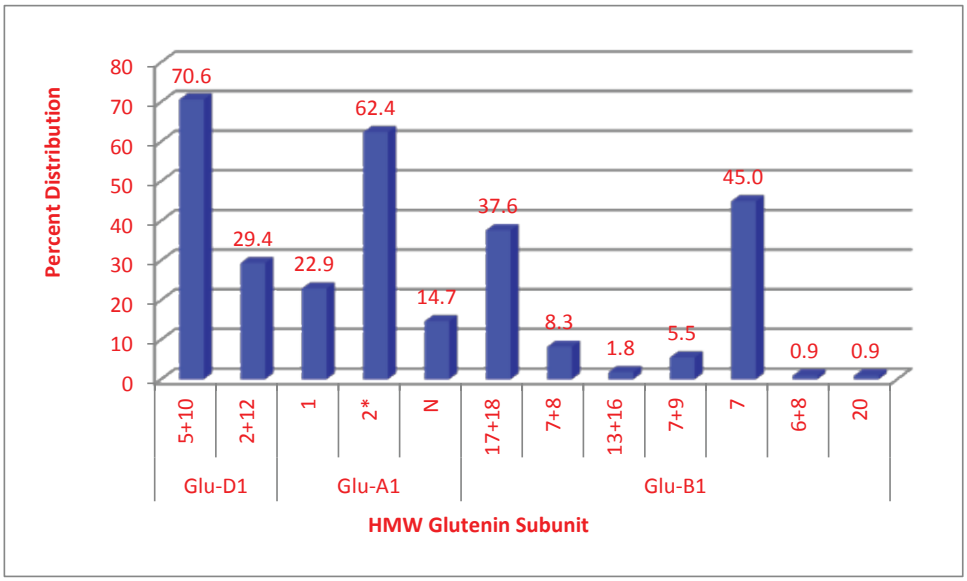
In addition, promising genotypes of both *T. aestivum* and *T. durum* were identified for individual quality parameters like, test weight, protein, grain hardness index sedimentation value, moisture, phenol test, wet gluten, dry gluten, gluten index, high molecular weight glutenin subunits (HMWGS), yellow pigment, iron and zinc content. On an average grain protein content was in lower range. There were entries in NWPZ and CZ having soft grain characteristics and thus suitable for biscuit making quality. Fe and Zn contents were comparatively lower in entries from NEPZ and higher from NHZ.

Promising genotypes for various quality parameters (AVTs)

Parameter	Value	Genotypes
		T. aestivum
Protein	≥12.5%	**NHZ :** VL3019, **NWPZ:** HD 3226 **CZ :** HD2932, MP3336, MP4010, UAS3002, DBW110, MP3288 , DBW 277 **PZ :** PBW 823, DBW 93
Sedimentation value	> 65 ml	**NHZ :** HS 673 **NWPZ :** HD 3226, PBW 752, DBW 173 **NEPZ :** HD 3249, DBW 187, PBW 781, DBW 257, HI 1612 **CZ :** DBW 110, MP 3288, DBW 277
Hardness Index	< 35	**NHZ :** HS 490 **NWPZ :** NIAW 3170
Iron	≥40ppm	**NHZ :** HS 507, VL 907, HS 562, HPW 468, HS 673, UP 3041, VL 3019 **NWPZ :** HD 3086, DBW 173, **NEPZ :** HD 3249, DBW 187, K 0307, DBW 25, 7 HD 2888 **CZ :** HI 1544, CG 1029, HI 1634, MP 4010, HD 3345, DBW 277 **PZ :** PBW 823, Raj 4083, HD 3090, GW 509, HI 1633, MP 3170, DBW 93, HI 1605
Zinc	≥40ppm	**NHZ :** HS 673, UP 3041, VL 3019 **NWPZ :** WH 1105, PBW 550, PBW 771, PBW 752, DBW 173, WH 1021, HD 3043 **NEPZ :** HD 2888 **CZ :** PBW 822, HD 3345, MP 4010, **PZ :** PBW 823, GW 509,
		T. durum
Protein	>13.0%	**CZ :** UAS 466, DDW 47, HI 8627
Sedimentation value	≥40ml	**CZ :** HD 8737, DDW 49, UAS 466 **PZ :** MACS 3949, DDW 49, DDW 48, WHD 963
Yellow Pigment	>7.0ppm	**CZ :** DDW 47
Iron	≥40ppm	**CZ :** HI 8737, DDW 49, HI 8812, HI 8808, HI 8807, DDW 47, HI 8627 **PZ :** UAS 428, MACS 3949, DDW 49,WHD 963, HI 8807, HI 8802, NIDW 1149
Zinc	≥40ppm	**CZ :** HI 8737, HI 8812, DDW 49, HI 8627 **PZ :** DDW 48, HI 8807, HI 8802

Distribution of HMW glutenin subunits in different trials

One hundred and nine (109) AVT, IVT and special trial entries including checks were evaluated for High Molecular Weight Glutenin subunits (HMWs) encoded by *Glu-A1*, *Glu-B1* and *Glu-D1* loci. Subunits 5+10 and 2+12 were present in 70.6 % and 29.4 % of the total entries, whereas entries having 1, 2* and N subunits were 22.9 %, 62.4 % and 14.7 %, respectively. Entries with subunits 7, 7+8, 7+9, 17+18, 6+8, 20 and 13+16 were 45.0, 8.3, 5.5, 37.6, 0.9, 0.9 and 1.8% respectively.



Quality Component & Wheat Biofortification Nursery (QCWBN)

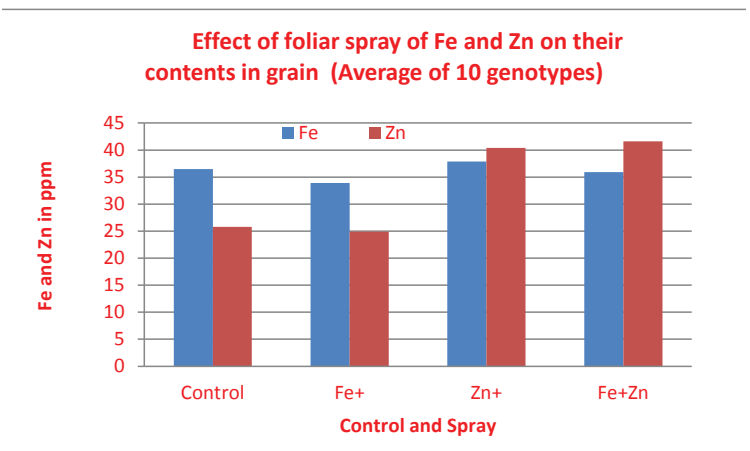
In 2018-19, the QCSN and biofortification nurseries were combined to constitute a single nursery QCWBN to select useful donors for quality traits and micronutrient content. The nursery was comprised of 52 entries including 7 checks namely UP2672, MACS6222, HD2967, WB2, HD3086, GW322 and HS490 and was evaluated at 12 locations. Grain quality analysis was done at ICAR-IIBWR, Karnal. Samples from 12 centres were analyzed for 4 parameters namely grain protein content at 12% grain moisture level, hectolitre weight, sedimentation value, grain appearance score. In addition, the samples from 4 centres representing one centre from each zone were analysed for grain hardness index also. Iron and zinc analysis was conducted of the hand threshed samples provided by six centres only. GW20171-596 and UP2994 recorded highest grain protein content of 14.6% and 13.8% respectively. HD3304, HD3241 recorded highest sedimentation value (75) followed by HD3215(73). QLD112 was the softest genotype with grain hardness index of 15 followed by QLD110(43). UP2994 recorded highest Iron content of 49.0 ppm followed by BWL7800 with 48.3 ppm. BWL7805 recorded highest Zinc content of 46.9 ppm followed by Raj4541(46.3 ppm).

Promising genotypes identified in QCWBN 2018-19

Component	Genotypes	Range	Best Check
Protein content (%)	GW20171-596, UP2994	13.8 - 14.6	WB2 (13.5)
Sedimentation value (ml)	HD3304, HD3241, HD3215	73 - 75	WB2 (72)
Grain hardness index (soft wheat)	QLD112	15.0	HS 490 (30)
Iron content (ppm)	UP2994, BWL-7800, QBP-17-7	48.1 – 49.0	WB2 (44.8)
Zinc content (ppm)	BWL-7805, Raj-4541, BWL-7800, UP2994	43.5 – 46.9	UP 2672 (39.8)

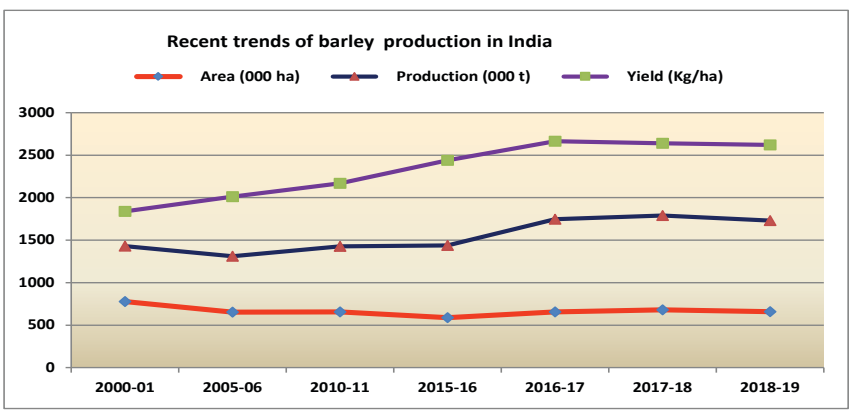
Agronomic biofortification

To complement genetic biofortification efforts, Fe and Zn fertilization is an agronomic biofortification strategy where Fe and Zn containing fertilizers are used for foliar application during early grain filling stage. In this investigation, trials were conducted at IIWBR, Karnal using a set of 10 commercial wheat varieties under field conditions with +Zn and +Fe and control treatments during 2017-18 and 2018-19 crop seasons. The results showed more than 60% increase in Zn content in +Zn treated conditions while no significant change in Fe content was recorded under +Fe treatments. On an average Zn content enhanced from 25.8 ppm to 40.4 ppm from control to +Zn treatment. The activity of Zn in the source (flag leaf and stem) during grain filling could be increased by additional Zn and Fe foliar application. The maximum increase in Zn concentration was about 22 ppm.



Barley Network

According to 3rd advance estimates for *Rabi* 2018-19, nearly 1730 thousand tonnes of barley was produced in 662 thousand ha area with a productivity of 26.17 q/ha. Rajasthan is the largest state having >45% share in production and 40% area followed by Uttar Pradesh. A concern is usually raised at various platforms for barley area decline, however, in last 18 years, the area has stabilized and there has been gain in production and productivity resulting in higher production. Though the MSP of barley (₹1440/-) is much lower than wheat (₹1840/-), but during current season the market price of barley remained higher (>₹1600/q). The monitoring teams surveyed the major barley growing areas during the season and observed that the crop season was by and large a disease free year in major barley growing areas, with some incidence of aphids in the plains and 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 and quality of malt and food purpose barley. Awareness programmes were organized to popularise barley for the health benefits (high antioxidant, higher beta glucan content). Linkages with national and international organizations, industries and farmers were also strengthened. Scientists visited the malting, brewing and food industries to promote the use of malt and food barley in different products. The lack of assured market and procurement system and low minimum support price for barley render the crop unpopular among the farmers.

Crop improvement

Release and identification of new barley varieties

Two barley varieties were released and notified by CVRC for commercial cultivation during 2018.

Sr.No	Variety	Parentage	Zone	Developed by	Production condition	Average Yield (q/ha)
1.	RD2899	RD2592/ RD2035// RD2715	CZ	RARI Durgapura	Irrigated timely sown	42.19
2.	RD2907	RD103/ RD2518// RD2592	NWPZ& NEPZ	RARI Durgapura	Salinity conditions	35.25

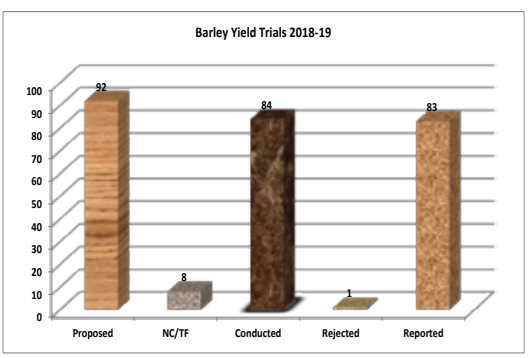
Registration of genetic stocks

Five genetic stocks namely DWRB152, DWRB174, DWRB190, DWRB 191 and DWRB 192 were registered with ICAR-NBPGR for unique traits.

Genetic stock	INGR No.	Year	Trait
DWRB152	18019	2018	Highly resistant to stripe rust at seedling and adult plant stages
DWRB174	18021	2018	Extra early heading coupled with short plant height
DWRB1190	18020	2018	Moderately resistant for spot blotch
DWRB191	19012	2019	High grain zinc content
DWRB192	19013	2019	High grain iron content

Yield evaluation trials

- Out of 92 yield evaluation trials proposed, 84 (91%) trials were conducted. Eight trials were either not conducted/failed or data were not received in time. After the analysis, only 83 trials (90% of proposed, 99% of conducted) were found good for reporting.



- These trials were conducted at 11 main centres and 28 testing centres (including ICAR, SAUs and State Department of Agriculture) during Rabi 2018-19.

- In all 98 test entries contributed by 11 centres, were evaluated against 25 checks in the coordinated yield trials under rainfed (plains and hills), irrigated (plains) and saline soils conditions. The new barley entries include malt, feed or dual purpose types and mostly were hulled type with a few hull-less types in northern hills and plains.

Promising entries in AVT/IVTs during 2018-19

Based upon the promotion criteria *i.e.* significantly superior at 10%, monitoring reports and disease and pest reactions, the entries namely DWRB196, DWRB197, PL906, RD2994, UPB1080, KB1707, DWRB204 and DWRB182 were found suitable for the promotion into advanced varietal evaluation in different trials.

Sr. No.	Trial name	Zone	Entry
1	IVT-MB-TS	NWPZ	DWRB196, DWRB197
2	AVT-MB-TS	NWPZ	DWRB182*
3	IVT/AVT- Hls	CZ	DWRB204
4	IVT-FB	NWPZ	KB1707, PL906, RD2994, UPB1080

*Based on quality parameters

AVT-MB-TS

- The trial was proposed at 8 centres but data of 6 locations were pooled for statistical analysis. The trial comprised of 03 test entries *viz.*, DWRB160, DWRB182 and DWRB184 and 05 check varieties.

- The zonal mean grain yield was 54.82 q/ha and it ranged from 43.83 q/ha (Hisar) to 62.15 q/ha (Durgapura).

- The final year entry DWRB160 ranked first (56.65 q/ha) followed by first year entry DWRB184 (56.59q/ha), whereas the best two row check RD2849 depicted mean grain yield of 56.37 q/ha.

AVT-IR-NEPZ

- The trial comprised of 01 test entry *viz.*, RD2969 and 05 check varieties.

- The zonal mean grain yield was 37.90 q/ha and it ranged from 33.01 q/ha (Varanasi) to 44.72 q/ha (Faizabad).

- The check variety DWRB137 ranked first (41.78 q/ha) and test genotype showed mean grain yield of 36.64 q/ha.

AVT-SST

- The trial comprising of 11 test entries and 05 check varieties was proposed at 7 centres and data of all the locations were considered for pooled analysis. The zonal mean grain yield was 34.09 q/ha, which ranged from 23.76 q/ha (IIWBR, Hisar) to 39.71 q/ha (Vallabhnagar).

- The check variety NDB1445 ranked first (38.49 q/ha), followed by another check RD252 (38.43 q/ha).

IVT-MB-TS

- The trial comprising of 13 test entries and 04 check varieties was proposed at 9 centres and the data of 7 locations were pooled for statistical analysis. The mean grain yield was recorded as 59.04 q/ha, which ranged from 40.65 q/ha (Hisar) to 87.17 q/ha (SG Nagar), suggesting varied genotypic performances across the locations. The two rowed entry DWRB197 ranked first (66.54 q/ha), followed by the six row entry PL908 (65.21 q/ha) and DWRB196 (63.58 q/ha).

IVT-RF-NEPZ

- The trial was proposed at 8 centres in NEPZ and data from all the locations were pooled for compilation.

- The trial comprised of 14 test entries and 2 checks *viz.* K603 and Lakhan.

- The mean grain yield was observed as 30.48 q/ha, which ranged from 22.14 q/ha (Varanasi) to 38.69 q/ha (Faizabad). The check variety K603 ranked first (36.36 q/ha), followed by the entry RD3003 (35.71 q/ha).

IVT-FB-NWPZ/NEPZ/CZ

- In NWPZ, four test entries KB1707, PL906, RD2994 and UPB1080 gave statistically higher grain yield over the best check variety RD2552.

- The zonal mean grain yield across the entries was 48.9 q/ha.

- In NEPZ and CZ, no test entry was found superior over the best check variety.

AVT-DP-NEPZ

- In AVT dual purpose trial NEPZ, check varieties RD2552, and DWRB137 were the highest yielder for grain and forage. The only test entry UPB1074 was inferior to the best check.

AVT/IVT-Hulless-NWPZ/NEPZ/CZ

- In AVT/IVT hulless NWPZ trial, no test entry was superior to the best check Karan 16 having grain yield of 37.8q/ha.

- In NEPZ, no test entry was superior to the best check NDB943 which had grain yield of 36.5q/ha.

- In CZ, three test entries namely, DWRB204, KB1750 and DWRB188 gave significantly superior grain yields over the best check variety NDB 943 (45.7q/ha).

AVT-RF-NHZ

- In NHZ trial, no test entry gave significantly higher grain yield over the best check BHS 400 (27.4 q/ha).

AVT-DP-NHZ

- In dual purpose NHZ trial, test entry VLB 155 was superior in grain yield but in forage yield, check variety BHS 380 was better than the test entry.

Breeder seed production

An indent of 827.85q breeder seed of 29 varieties was received from DAC&FW, Ministry of Agriculture & Farmers Welfare, Govt. of India. The indent included requirement of eight states (Haryana, Himachal Pradesh, Jharkhand, Madhya Pradesh, Rajasthan, Uttar Pradesh, Punjab and Uttarakhand), two public sector agencies (IIFDC and National Seeds Corporation) and one private agency (National Seed Association of India) for the *Rabi* 2018-19. The highest indent was placed by NSAI (330.35q) followed by Rajasthan (210.00q), Uttar Pradesh (130.00q) and National Seed Corporation (85.00q). From variety point of view, the highest indenting varieties were RD2786 (142.00q) followed by RD2794 (97.00), PL426 (83.25q), RD2035 (81.40q) and BH393 (71.20q). A net production of 1421.05q breeder seed was reported, which was surplus (+594.10q).

The nucleus seed 49.72q was produced against the targeted quantity of 36.25q of 27 varieties.

Germplasm evaluation and exchange

The Elite International Barley Germplasm Nursery (EIBGN) was constituted with 45 germplasm lines and six released varieties (BH946, BH959, BHS400, RD2715, DWRB101 and HUB113) as standard checks and was supplied for evaluation to nine cooperating centres. National Barley Genetic Stock Nursery (NBGSN) was constituted with 18 promising entries, received from coordinated centres, and was evaluated at nine locations. In addition, four sets each of the two International trials and nurseries which comprised a total of 347 entries were received from ICARDA during *Rabi* 2018-19. These international trials and nurseries were evaluated along with suitable Indian checks. One set each of these nurseries and trials was sown at ICAR-IIWBR, Karnal, and barley breeders from SAUs and ICAR institutes were given an opportunity to select desirable germplasm during a Field Day organized on 29th March, 2019 at ICAR-IIWBR, Karnal. A total of 241 germplasm lines were selected by the breeders.

International trials and nurseries evaluated during crop season 2018-19

Sr. No.	Trial/Nurseries	Genotypes received from ICARDA	Indian National check	Number of Sets	Locations
1.	IBYT-HI-2019	24	BH946	4	Karnal, Durgapura, Hisar, Ludhiana
2.	6th GSYT-2019	24	K603	4	Karnal, Hisar, Pantnagar, Kanpur
3.	IBON-HI-2019	138	BH946	4	Durgapura, Pantnagar, Ludhiana, Karnal
4.	6th GSBON-2019	161	Lakhan	4	Karnal, Kanpur, Faizabad, Bajaura

Crop protection

- Barley fields were surveyed by different scientists of cooperative centres and no rust was recorded during the survey whereas loose smut, covered smut and bacterial streak were recorded in traces in some fields. Overall barley crop was healthy in all the barley growing areas in India.

- The incidence of insect-pests and their natural enemies was also observed. The aphid population was found to be moderate to high in barley fields at some of the locations. Among natural enemies, coccinellid beetles, chrysoperla and syrphid fly were frequently noticed predating on barley aphids.

- A total 538 entries were screened under various nurseries (IBDSN, NBDSN and EBDSN) for resistance against various diseases, aphid and CCN at different cooperating centers. Of 372 entries evaluated under IBDSN, 19 were found free from yellow rust and 206 entries showed resistant reaction. In case of leaf blight screening, 35 entries were found moderately resistant.

- Out of 107 entries evaluated under NBDSN, 16 entries were found free from yellow rust and 65 entries showed resistant reaction. Among these, 32 entries were found moderately resistant against leaf rust. Among 59 entries screened in EBDSN, 10 entries were found free from yellow rust, whereas 46 have shown resistant reaction. Eleven entries showed moderate level of resistance against leaf blight.

- None of the NBDSN entry was found resistant to all the tested pathotypes of black, brown or yellow rust pathogens. Three entries (BH1024, KB1762, and RD3008) were resistant to brown and black rusts. BHS474, HBL845, HBL863, RD2786(C), RD2991 and RD3003 possessed resistance to brown & yellow rusts whereas DWRB182, HBL812 to black & yellow rusts.

- None of the EBDSN entries was resistant to all the tested pathotypes of black, brown and yellow rusts pathogens. HBL814 was resistant to black & yellow rusts whereas RD2786, RD2972, RD2973, RD2875, RD2976 were resistant to brown & yellow rusts.

- Among different fungicidal treatments, seed treatment (ST) with Vitavax power + Propiconazole @ 0.1% spray and ST with Vitavax power + Tebuconazole (Folicur) @ 0.1% spray found equally effective against foliar blight and significantly superior over control.

- A total 166 entries that includes 107 of NBDSN and 59 of EBDSN, were screened against the Cereal Cyst Nematode (CCN) at three locations *viz.* Durgapura, Ludhiana and Hisar. Most of the entries fall in the category of susceptible or highly susceptible.

- A total of 125 barley NBDSN entries were screened against foliar aphid at three locations (Ludhiana, Kanpur and Karnal) during 2018-19. Majority of the entries at all the locations harboured aphids in different range depending upon their incidence level.

- The entries were found to be in all the category grades *i.e.* 3 to 5. Five entries *viz.*, DWRB182, DWRB184, PL911, RD3005 and HBL 845 were found to be moderately resistant (grade 3). At Ludhiana, seven entries; BH1025, PL909, RD2992, RD2994, BH902 (c), DWRB 123(c) and K508(c) were found moderately resistant (grade 3). None of the entry was found to be in moderately resistant (grade 3) category at Kanpur location.

- A total of eight treatments were tested for their efficacy against foliar aphid in barley. At all locations, it was found that treated plots harboured lower number of aphids as compared to control plots. Treatments of quinalphos 25% EC @100 g a.i/ha and acetamiprid 20 SP @ 20 g a.i/ha were found to be the best among tested treatments.

- The efficacy of bio-pesticides *viz.*, Azadirachtin, Beauveria bassiana and Metarhizium anisopliae was comparatively lower than chemical pesticides at all the locations. Out of three bio-pesticides, Azadirachtin 1000 ppm was comparatively better than Beauveria bassiana and Metarhizium anisopliae.

Resource management

Resource management group conducted experiments for varietal evaluation in AVTs and for updating the package of practices of barley crop in different zones. A total of 47 trials were proposed and conducted. The significant findings are:

- In malt barley AVT trial, the grain yield of test entry DWRB 160 (51.20 q /ha) was statistically at par with the newly released malt barley varieties although BH 946 a six row variety registered significantly higher grain yield (54.46 q /ha). In hulless barley trial, the test entry PL 891 recorded significantly highest grain yield (41.97 q /ha) as compared to the other varieties.

- In special trial of residue management and tillage in NWPZ, maximum grain yield (BH 946, 55.80 q/ha) was realised in zero till sowing with rice residue retention which was significantly higher than other methods of sowing. In NHZ, maximum grain yield (32.24 q/ha) was recorded under zero till sowing with rice residue retention which was at par to conventional tillage sowing with variety BHS 400.

- In seed rate and varieties, grain yield was at par when varieties were sown using seed @ 100 and 125 kg/ha and was significantly more compared to seed @ 75 kg/ha in NHZ. Barley variety BHS 400 registered significantly highest grain yield (42.20 q/ha) as compared to other varieties.

- In NWPZ, all the additives except mulch @ 6 t/ha resulted in significantly higher grain yield as compared to recommended dose of fertilizer, although application of recommended dose of fertilizers coupled with FYM application @ 5 t/ha served the purpose to realize at par yield using all other additives. Grain yield reduced significantly due to delay in sowing. Similar results were observed in NEPZ, also.

- Grain yield in Halauxifen methyl +Florasulam + Carfentrazone + Surfactant, Metsulfuron + Carfentrazone + Surfactant and 2,4-D E + Carfentrazone treatments was significantly superior to other herbicide treatments and weedy check condition. The grain yield reduction due to weeds in weedy check was 25.8 % as compared to weed free conditions in NWPZ. Almost similar results were observed in NEPZ also. All the herbicide treatments controlled the broad leaf weeds very effectively in CZ, which resulted in grain yield statistically at par to weed free condition. In NHZ grain yield was at par in application of Halauxifen methyl + Florasulam + Carfentrazone + Surfactant, Halauxifen-methyl Ester + Florasulam 40.85% WG + Polyglycol 26-2 N, Metsulfuron methyl 20 WG + surfactant, Metsulfuron + Carfentrazone +Surfactant, 2,4-D E + Carfentrazone and weed free condition.

- Application of Pusa Hydrogel @ 2.5 kg/ha and New Hydrogel @ 2.5kg/ha resulted in significantly higher grain yield as compared to control conditions in NWPZ. Highest grain yield (54.62 q/ha) was recorded with three irrigations which was significantly higher than other irrigation levels.

- Application of NPK @ 60:30:40 kg/ha resulted in significantly higher grain yield as compared to application of FYM alone @ 10 t/ha or in combination with NPK @ 30:40:30 kg/ha. BHS400 recorded highest grain yield (37.33 q/ha) as compared to all other varieties.

- Application of recommended doses of fertilizer resulted in significantly higher grain yield (48.0q/ha) as compared to application of FYM alone @ 15 t/ha or combination of FYM @ 10 t/ha and half of the recommended doses of fertilizer in NWPZ. DWRB123 recorded highest grain yield (46.95 q/ha) as compared to all other varieties except RD2849.

- Application of FYM @ 10 t/ha and half of the recommended doses of fertilizer resulted in significantly highest grain yield (42.66 Q/ha) in CZ as compared to application of FYM alone @ 15 t/ha or recommended doses of fertilizer.

Quality evaluation

Malting quality

The Barley Improvement Unit took up the malting quality evaluation of grain samples of Advanced Varietal Trial (AVT) and Initial Varietal Trial (IVT) on malt barley received from various test sites at its central facility. The grain samples (150) were received from six locations (Hisar, Karnal, Ludhiana, Bathinda, Durgapura and Pantnagar). There were 13 test entries in IVT (TS) which were analyzed with four checks, in case of AVT (TS), three entries (DWRB160, DWRB182, and DWRB184) with five checks were analyzed.

Promising entries* for individual malting quality trait

Traits	Promising entries
Bold Grains (%)	DWRB 160, PL 907, DWRB 199, BH 1025, DWRB 196
Thousand grain weight	DWRB 160, DWRB 196, BH 1025, PL 907, DWRB 199, DWRB 198
Husk Content	RD 3008
Grain Beta glucan	DWRB 182, KB 1743, KB 1707
Malt Friability	DWRB 182, DWRB 184, RD 3008, BH 1025
Hot water extract	RD 3010, DWRB 184
Filtration Rate	PL 907, RD 3009, DWRB 199, RD 3008, RD 3007, DWRB 196
Diastatic Power	DWRB 198, KB 1743, RD 3008, DWRB 199
Kolbach Index	PL 908, DWRB 196. DWRB 197. RD 3008, BH 1025
FAN Content	RD 3009, DWRB 197, RD 3008, RD 3010, RD 3007
Wort beta glucan	DWRB 182, PL 908, KB1743, DWRB197, RD 3008, BH1025, RD 3009
Overall MQ	DWRB 182, DWRB 160, BH1025, RD3008

**Superior or at par to the best check*

Feed barley

The feed grain samples from various trials and grown at different locations were analysed for physical parameters and protein content. A total of 617 samples were received encompassing ten trials grown in different zones. The entries with highest value for each of the parameter analyzed are listed below

No.	Trial	Zone	Test weight	Thousand grain weight	Bold grain (%)	Thin grain (%)
1	IVT/AVT (HL)	NWPZ/ NEPZ/ CZ	K1149 (c)	PL 891	PL 891	PL 891
2	IVT FB (IR)	NWPZ/ NEPZ/ CZ	DWRB 203, BH 1023	DWRB137 (c)	DWRB137 (c)	BH 946 (c)
3	AVT (IR)	NEPZ	DWRB 137(c)	DWRB 137 (c)	DWRB 137 (c)	DWRB 137 (c)
4	AVT (SAL/ ALK)	NWPZ/ NEPZ	KB 1754, HUB 268, HUB 267, RD 3002, KB 1706, RD 3000	DWRB 207, RD 3002, RD 3000, DWRB 201, RD 2999	RD 3002, RD 3000, DWRB 207, KB 1762, HUB 268, DWRB 201	RD 3002, RD 3000, DWRB 207, HUB 268, NDB 1708, DWRB 201
5	AVT-IR-DP	NEPZ	DWRB 137 (c)	DWRB 137 (c)	DWRB 137 (c)	DWB 137 (c)
6	IVT-RF	NEPZ	PL910, DWRB203, DWRB202, DWRB200, PL911	PL910 RD3004 NDB1712	RD3004, DWRB202, NDB1712, DWRB200, KB1743, PL911, PL910, KB1762, DWRB203, HUB265	NDB1712 RD3004 DWRB202 KB1743 HUB265 PL910 DWRB200 DWRB203 PL911 RD3005 KB1762
7	IVT-RF	NHZ	HBL 858	BHS 477 VLB 162 HBL 848	UPB 1077	UPB 1077 VLB 164 BHS 477 HBL 851
8	AVT- DP	NHZ	HBL 276 (c)	VLB 155	VLB 118 (c)	VLB 118(c)

Technology Outreach Programme

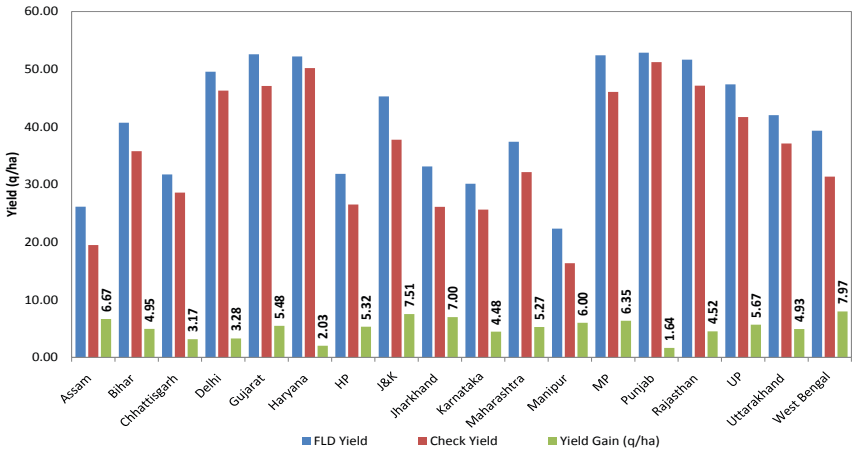
Wheat frontline demonstrations (2018-19)

To disseminate a new technology among farmers, it is necessary that the technology is demonstrated at farmers'field. Under this programme, 1500 wheat frontline demonstrations (FLDs) of one acre each were allotted to 83 cooperating centres across the country of which 1499 were conducted by these centres. The technologies such as improved wheat (*T.aestivum*, *T.durum* and *T. dicoccum*) varieties with complete package of practices, rotavator, zero tillage/happy seeder and bio-fertilizer were demonstrated at the selected farmers' fields. These WFLDs covered 1503.34 acres area of 1562 farmers in 19 states. The maximum number of WFLDs were conducted in UP (192) followed by Bihar (142), MP (137), Rajasthan (114), HP (104), Maharashtra (100), Assam (91), Haryana (89), Karnataka (75), Punjab (73), Jharkhand (65), Gujarat (50), West Bengal (50), J&K (49), Tamil Nadu (49), Chhattisgarh (43), Delhi (36), Uttarakhand (36) and Manipur (5).

State wise performance of improved wheat varieties

State	Mean yield (q/ha)		Gain (in %)
	Improved	Check	
Assam	26.15	19.48	34.28***
Bihar	40.72	35.77	13.85***
Chhattisgarh	31.75	28.58	11.09NS
Gujarat	52.57	47.09	11.63***
Haryana	52.21	50.18	04.06*
HP	31.85	26.53	20.07***
J&K	45.28	37.77	19.90***
Jharkhand	33.13	26.13	26.80***
Karnataka	30.12	25.64	17.45***
Maharashtra	37.41	32.14	16.39***
Manipur	22.33	16.33	36.74***
MP	52.40	46.05	13.79***
Delhi	49.56	46.28	07.10***
Punjab	52.87	51.23	03.18***
Rajasthan	51.65	47.13	09.59***
UP	47.36	41.69	13.60***
Uttarakhand	42.03	37.10	13.31***
West Bengal	39.32	31.35	25.45***
Tamil Nadu	29.44	-	-

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



State wise performance of improved wheat varieties during 2018-19

The state wise maximum yield gain was observed in Manipur (36.74%), followed by Assam (34.28%), Jharkhand (26.80%), West Bengal (25.45%), HP (20.07%), J&K (19.90%), Karnataka (17.45%) and Maharashtra (16.39%).

The variety wise mean yield data has revealed that variety HS562 gave the highest yield of 53.80 q/ha at Bajaura centre in NHZ. At Almora centre VL 953 gave yield of 37.48 q/ha,which was significantly higher than the check variety. In NEPZ, the highest significant average yield was recorded by K1317 variety at Kanpur (52.33 q/ha), followed by HD2967 at West Champaran (50.00q/ha). In NWPZ, the highest significant average yield was recorded by HD3086 at Durgapura (65.04 q/ha) as well as Ajmer (62.40 q/ha). In CZ, HI1544 gave highest average yield of 69.00 q/ha at Indore centre though non-significant, followed by DBW110 (67.14 q/ha) at Neemuch and GJW463 (64.00q/ha) at Junagarh centre which was significant. In PZ, MACS6478 gave the highest significant yield (49.82 q/ha) at Pune centre followed by UAS304 (40.92 q/ha) and DBW168 (40.29 q/ha) at Dharwad centre.

The mean yield data of the late sown varieties revealed that variety DBW173 gave significantly higher yield (51.04 q/ha) at Amity Noida centre in NWPZ. In CZ, the significant average yield was recorded by GW11 (52.87 q/ha) at Vijapur centre, followed by RAJ 4238 (51.56 q/ha) at Kota centre

The yield gain due to improved varieties over check was highest in NEPZ (20.21%), followed by NHZ (19.00%), PZ (15.28%), CZ (12.01%) and NWPZ (07.99%).

Zone wise productivity under FLDs over check during *rabi* 2018-19

Zone	Mean yield(q/ha)		Gain (in %)
	WFLDs	Check	
NHZ	33.26	27.95	19.00***
NEPZ	37.89	31.52	20.21***
NWPZ	52.27	48.40	07.99***
CZ	48.04	42.89	12.01***
PZ	33.76	29.28	15.28***

*** Significant at 1 percent level

FLDs on bio-fertilizer (Azotobactor & PSB) along with 100% inorganic fertilizer as compared to check (100% recommended dose of inorganic fertilizer) showed significant yield gain of 21.70% at Faizabad and 11.73% at Shillongani in NEPZ. In NWPZ, significant yield gain of 8.29% was recorded at Agra centre. In CZ, only non-significant yield gain of 3.36% was recorded at Jagdalpur, Bastar centre.

In case of improved durum varieties, the variety HD4728 and HD8759 gave a significant average yield of 65.00 q/ha at Indore centre in CZ. In PZ, the variety MACS3949 gave an average yield of 46.50 q/ha at Pune centre, though it was non-significant.

The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres monitored the FLDs at Khudwani-Anantnag, Rajouri, Kathua, Noida, Rewari, IARI-New Delhi and Ujwa-New Delhi, Indore, Ujjain, Ratlam, Kanpur, Dharwad, Belagavi, Wellington, Junagarh, Vijapur, Jaipur, Ajmer, Tonk and Karauli centres during the *Rabi* crop season 2018-19.

The analysis of wheat production constraints revealed that the high cost of inputs, small land holding, non-availability of seeds of newly released varieties, non-availability of labour, higher hiring rate of land levelling, field preparation, sowing, harvesting, and threshing and *Phalaris minor* were perceived as major constraints hampering wheat production in the country. All these constraints need immediate attention in order to increase wheat production in all major wheat producing zones of the country.

During the period under report, 250 barley frontline demonstrations of one acre each were allotted to 21 different cooperating centres all over India in six states namely, HP, UP, Punjab, Haryana, Rajasthan and MP. Out of these, 225 were conducted by 21 centres, covering 238.5 acres area of 264 farmers. Improved barley varieties with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.

The highest gain in barley yield was recorded in Uttar Pradesh (27.28%), followed by Madhya Pradesh (24.58 %). The lowest gain in yield was reported in Haryana (5.05 %). The yield gain due to improved varieties over check mean yield was highest in NEPZ (27.28 %), followed by CZ (20.39 %), NHZ (20.22 %) and NWPZ (9.90 %).

In NHZ, HBL713 was the highest average yielding (25.68 q/ha) variety at Bajaura centre. In NEPZ, HUB113 at Varanasi (42.94 q/ha), DWRB123 at Rewari (56.00 q/ha) in NWPZ and BH959 at Morena (49.93 q/ha) in CZ were the highest average yielding varieties.

The analysis of barley production constraints indicated that decline in water table, small land holding, low price of barley, high cost of inputs, lack of knowledge among farmers about recent technologies, high temperature at maturity, temperature fluctuation during crop growth, higher customer hiring rate of land levelling, field preparation, sowing, harvesting and threshing, *Chenopodium album* and erratic power supply were identified as major constraints affecting barley production and productivity in the country.

Costs and returns for wheat and barley FLDs vis-à-vis check plots

On an average, wheat varieties or technologies demonstrated at farmers' field under the FLD program gave ₹3.07 per rupee of investment in comparison to the check varieties (₹ 2.70). The returns per rupee of investment from FLDs ranged from ₹ 6.90 (Haryana) to ₹ 1.54 (West Bengal) across states, ₹ 4.06 (NWPZ) to ₹ 2.48 (NEPZ) across zones, and ₹ 7.37 (Happy Seeder) to ₹ 2.21 (Variety: Late Sown & Restricted Irrigation) across technologies. Haryana registered the highest returns per rupee of investment owing to the low operational costs *i.e.*, ₹ 16978 per hectare. On

the contrary, West Bengal registered lowest returns per rupee of investment due to higher operational costs per unit area (₹ 49232/ha). Overall, on an average, an Indian farmer by adopting a new wheat variety or production technology will earn ₹ 64592/ha. Further, ₹ 789 have to be spent to produce a quintal of wheat through adoption of a new wheat variety or production technology against ₹ 913 (check varieties).

In the case of barley, demonstrated varieties gave around 25 per cent profit per hectare in comparison to the check. Punjab registered the highest returns per rupee of investment (₹ 6.49) through demonstrations, followed by Uttar Pradesh (₹ 4.16) and Haryana (₹ 3.23). The difference in returns per rupee of investment between demonstration and check plots was highest in Punjab, followed by Uttar Pradesh and Madhya Pradesh. The returns per rupee of investment across barley growing zones were highest in the NEPZ (₹ 4.16), followed by NWPZ (₹ 3.56) and CZ (₹ 2.86). Estimates of cost of production indicated that the cost incurred in producing a unit quantity of output was least (₹ 271 per quintal) in Madhya Pradesh (CZ) owing to higher yield and remunerative price factor.

Overall, the profit analysis on wheat and barley indicated that additional returns per hectare from FLDs was more than the check varieties by ₹ 11912 and ₹ 12250, respectively establishing the fact that FLDs carry the successful technologies from lab to land.

Technology transfer

The technologies developed at the institute and other cooperating centres were made aware to the farmers through organizing foundation day, world soil day, Farmer-Scientist Workshop and seed day, field day, agriculture awareness programmes under 'Mera Gaon Mera Gaurav' scheme, participation in various exhibitions and kisan melas and TV programmes. Apart from these, the Social Sciences unit delivered eight lectures benefitting students, farmers and scientific community; attended the meetings and participated in seminars/symposia/conferences/ workshops and coordinated 45 visits of national farmers/students/ trainees at ICAR-IIWBR, Karnal. The advisory services were also provided

to the farmers through letters, phone calls and emails. The unit conducted 7 training programmes for the farmers. The Farm Advisories on wheat and barley crops were sent through the WhatsApp Group named 'Farm Advisories_IIWBR' to help the farmers timely in case of any disease and pest incidence. The advisories issued on different aspects of wheat and barley crops were linked/uploaded to MANAGE Portal for wide circulation and use.

Off Season Summer Nursery, Dalang Maidan (HP)

The ICAR - IIWBR Regional Station located at Dalang Maidan, Lahaul & Spiti, Himachal Pradesh acts as a national off-season crop facility for wheat and barley researchers. The station is located at Manali Leh Highway 14 Km towards East from District Headquarters Keylong. It is situated at $32^0$30' N and $76^0$59' E at an altitude of 3045 m (~10000 feet) above mean sea level.

Generation advancement of wheat and barley: During May-October 2018 off-season, more than 31000 lines of wheat and barley from different research institutes and state agricultural universities were sown for speeding the breeding and genetics work. The facility was utilized by 36 breeders and geneticists from all the five zones of the country. The maximum material was obtained from NWPZ, followed by NHZ, CZ, NEPZ and PZ. Apart from ICAR-IIWBR Karnal, researchers from ICAR-IARI New Delhi, CCS HAU Hisar, NABI Mohali and VPKAS, Almora utilized the off season facility. The sowing was done during first fortnight of May, 2018 and harvesting in the month of Sept- Oct, 2018 and supplied to the respective researchers well in time. There was unexpected heavy snowfall in the Lahaul valley on 23-24 Sept. 2018 which delayed the harvesting due to disruption in road connectivity. In the summer nursery 2019 more than 28000 breeding lines received from 42 researchers/teams have been planted at Dalang Maidan.

Corrective hybridization: During 2018 more than 300 corrective crosses, back crosses/three way crosses were attempted by the researchers from various institutes and SAUs during July and August 2018.

Disease screening and monitoring: The season was favourable for the screening for yellow rust and powdery mildew. More than 15,000 lines were screened. The yellow rust incidence was first observed during last week of July and the disease severity was highest during Mid-August, 2018. Powdery mildew disease appeared during the last week of August. Wheat disease monitoring nursery (WDMN) was also planted at this station and the samples of yellow rust were collected for pathotype analysis at Regional Station Flowerdale, Shimla.

Seed multiplication of important cultivars/varieties: The seed multiplication of the wheat variety DBW187 was carried out and 11 q seed was produced. In the summer nursery 2019, DDW47 has been planted at the station for seed multiplication. For grow-out test 19 lines received from ICAR-VPKAS, Almora has also been planted in the summer nursery, 2019.

Natural repository for wheat and barley germplasm: The off-season nursery acts as natural repository for wheat and barley germplasm and at present about 9000 wheat accessions and 2000 barley accessions are being conserved and maintained under natural cool temperature conditions. This low cost germplasm maintenance facility will be further strengthened by provision of separate germplasm storage room at the station.

Annexure I

Action taken report on the major recommendations of the 57th All India Wheat & Barley Research Workers' meet held at BAU, Ranchi, Jharkhand August 24-26, 2018

S. N.	Recommendations	Action Taken
Crop Improvement		
1.	Seven wheat varieties namely (DBW173, HI1612, K1317, DBW168, UAS375, MACS4028(d) HI8777(d) as notified by CVRC may be taken up for cultivation by the farmers of the concerned area.	Seed production and the distribution to farmers have already been taken with the help of DAC and Pvt. companies.
2.	Also seven wheat varieties namely (BRW3723, HW5207, GJW463, KRL283, HUW669, CG1013, UAS334) released for cultivation through SVRC may also be taken up for cultivation in the recommended areas.	Since these varieties have been released for specific states, therefore seed production programme was taken with the help of states and the breeding centres.
3.	Total 14 new wheat genetic stocks registered with NBPGR during 2017-18 for various traits may be utilized by wheat breeding programs across the country.	The seed of these stocks have been multiplied at ICAR-IIWBR and the seed was provided as per indent as well as through various national nurseries.
4.	In finalization of the work plan 2018-19, 418 new trials were proposed to be conducted across five wheat growing zones. These trials consisted of 138 NIVTs/IVTs, 236 AVTs and 44 Special trials.	This program was taken up very successfully and the report has been prepared and will be presented in this meeting at Indore.
5.	Out of 215 test entries thirty two (19 bread & 13 durum) NIVT/IVT entries were considered promising and promoted to AVT trials. While out of 76 test AVT entries 16 (12 bread + 4 durum) were promoted to 2nd year AVT.	The promising entries were promoted and the proposals for identification are being processed.
6.	In NHZ AVT early sown rainfed trial will be discontinued.	It has been discontinued
7.	A high yield potential trial (8 t/ha) will be constituted and conducted in NWPZ during 2018-19 jointly with agronomical trial with the same constitution. A maximum of 15 entries including checks will be evaluated at 8 locations.	The High Yield Potential Trial (HYPT) was constituted with 15 genotypes including two checks and planted at seven locations in NWPZ during 2018-19.
8.	Breeder seed allocation of 20321.78q for 141 wheat varieties has been made to 31 different centres.	The breeder seed production was taken up with the help of centres.
9.	It is recommended to discontinue the breeder seed production of wheat varieties which were released 15 years back or more.	The older varieties have been identified and discussed with DAC for which the seed production is to be discontinued from this year.
10.	National nurseries will be re-constituted as per requirement. NGSN should cater to evaluation and supply of registered genetic stocks. SSN & SWSSN will be merged.	The nurseries have been reconstituted and merged as recommended.
11.	With a view to bring in more precision in the conduct of wheat coordinated trials, necessary modifications were made taking into account the suitability of voluntary centres.	The proper norms and modifications for sowing date and site means etc have been done through consensus.

12.	The contribution of breeding lines from different centres for IPPSN will be routed through Crop Improvement, ICAR-IIWBR, Karnal.	This recommendation has been followed.
13.	The centres were advised to strengthen their breeding programmes by enhanced hybridization and making best use of nurseries for incorporation of variability and make judicious use of facilities at Dalang Maidan.	This summer season, only the material for generation advancement as well as that for corrective crosses has been planted.
14.	The training programme on data recording and conduction of trials for the benefit of new scientists and technical staff at funded and voluntary centres would be conducted at ICAR-IIWBR, Karnal during Feb-March, 2019.	The ICAR-IIWBR oragisned 03 days training on capacity building for ICAR Scientific staff during January 29-31, 2019.
Resource Management		
1.	Based on evaluation of broadleaf herbicides at 21 locations across wheat growing zones, it is recommended to apply readymix of Halauxifen-methyl Ester+ Florasulam 40.85% WG @12.76 g./ha or its reduced dose @10.21 g/ha with carfentrazone @ 20 g/ha along with 750 ml of surfactant for effective broad spectrum control of broad leaf weeds. These options are alternatives to the recommended use of metsulfuron+carfentrazone at 4+20 g/ha along with surfactant.	The recommendation has been implemented in the institutional programme and also conveyed to the concerned implementing authorities.
2.	To achieve higher wheat productivity under high fertility condition (150% RFD +15 t/ha FYM) it is recommended to use 2 sprays of Chlormequat chloride (0.2%)+ tebuconazole (0.1%) at First Node and Flag Leaf stages. The yield gain of 10-20% was observed.	The recommendation has been implemented in the institutional programme and also conveyed to the concerned implementing authorities.
3.	To improve the water use efficiency and productivity, micro irrigation should be applied at 3 days interval at 100% PE. Among micro irrigation systems, drip irrigation was better than sprinkler irrigation.	The recommendation has been conveyed to the concerned implementing authorities.
4.	Based on two year results of 4 to 5 locations in NWPZ, the performance of both the hydrogels was at par with a yield gain of 3 to 5% compared to control.	The recommendation has been conveyed to the concerned implementing authorities.
Crop Protection		
1.	The yellow rust susceptible varieties should be replaced with recently released varieties like WB 02, HD 3086, DBW 90, WH 1124, WH 1080, WH 1142, in NWPZ. Likewise in NHZ, varieties like, HPW 349, HS 507 and HS 562 are resistant and may be preferred. The susceptible varieties if grown should be sprayed with propiconazole @ 0.1% at the initiation of rust symptoms in districts close to foot hills in Punjab and Jammu and Yamunanagar in Haryana.	The farmers and state agriculture officials were suggested not to grow the susceptible varieties in the foot hills that facilitate rapid spread of yellow rust. As soon as there is report of yellow rust appearance in NWPZ, team from IIWBR or cooperating centres reaches to the site and advice suitable remedial measures and collect the samples for race analysis. The matter was also highlighted in strategy planning meeting on evolving strategies for enhancing wheat production with special reference to management of wheat rust and Karnal bunt held on 22.10.2018 under the Chairmanship of Secretary, DAC & FW in New Delhi. The state agriculture officials particularly from Haryana and U. P., were informed about the new yellow rust resistant varieties for different states for replacing old varieties of wheat and adoption of new technology in wheat production and protection.

2.	For management of aphids, foliar spray of quinalphos 25 EC @400ml/ha is recommended in wheat.	The recommendation of spraying of quinalphos 25 EC @400ml/ha in wheat was advocated to farmers through trainings, workshops and Kisan Mela etc.
3.	Seed treatment with Imidacloprid 600 FS @ 4 ml /kg, Thiamethoxam 35 FS @ 2.4 ml/kg and Fipronil 5 Sc @ 6 ml/kg is recommended for control of termites. Likewise, in standing crop, a combination of Fipronil 5 SC+Imidacloprid 40 % WG is most effective treatment in reducing termite population.	Farmers and state agriculture officials were made aware of these recommendations through trainings, workshops and Kisan Mela etc.
4.	A soil application of 5 q neem cake/ha and pre-sowing seed treatment with 10 ml neem oil / kg reduced CCN cysts from 40.4 to 7.2 cysts/ plant and increased wheat yields by 93% over untreated control under sick plot conditions and thus recommended for use in CCN affected sandy soils of Rajasthan, Haryana, Punjab and UP.	The cereal cyst nematode is sporadic problem in Rajasthan, Haryana, Punjab and UP and farmers and state officials were made aware of the recommendation for management of cereal cyst nematode by the cooperating centres through field visits, trainings, workshops etc.
5.	The use of farmers self grown wheat as seed should be discouraged in West Bengal. The resistant varieties like HD 2967 and DBW 187 (identified) may be grown in NEPZ. The seed treatment with carboxin+thiram (1:1) @ 2.5 g/ kg and two foliar sprays of tebuconazole (50%)+ trifloxystrobin (25%) WG @ 0.3 kg/ ha, first spray at boot leaf (booting) stage and second spray at 15 days after first spray are recommended for effective management of wheat blast like disease in West Bengal and other states of NEPZ.	About fifteen survey were conducted in West Bengal near Indo-Bangladesh border by the team of scientists from ICAR-IIWBR, Karnal, UBKV, Cooch Behar, and BCKV, Kalyani to make aware about not to grow the seed of self grown wheat and use of seed treatment and resistant verities identified. Strategy planning meeting was also conducted on "Preparedness on occurrence of blast disease in wheat" on 31.8.2018 in Kolkata under Chairmanship of Commissioner of Agriculture, GOI. It was attended by Director, Agriculture, Govt. of West Bengal, ADG (PP&B), Director, IIWBR and other higher officials of Govt. of West Bengal, ICAR and SAUs. For the supply of seed of resistant cultivars to the farmers and private seed companies three faster breeding centres were also created for variety DBW 187 (blast resistant) *viz.*, BAU, Sabour, BISA Pusa and BAU, Ranchi seed. One day farmer's training cum awareness programme was conducted on 17.01.2019 at BCKV, Kalyani mainly to enrich the knowledge of farmer's about disease and its preventive measures for raising healthy crop. A training programme on "Disease surveillance and adoption of new wheat and barley varieties for better productivity and resistance" was conducted on 31.10.2018 at BCKV Kalyani (West Bengal). About 60 farmers and state government officials participated. A brain storming session on blast proofing in agriculture was jointly organized by ICAR-IIWBR,Indian Phytopathological Society, Indian Society of Plant Pathologists and Society for Advancement of Wheat and Barley Research at ICAR-IIWBR Karnal on 8th August, 2018. It was attended by about 100 delegates all over India
Quality Improvement		
1.	Wheat varieties WH 1124 (IR LS) and DBW 71 (SPL VLS) and IInd year AVT entries HD 3237 (RITS) and PBW 757 (SPL-VLS) of NWPZ exhibited very good chapati characteristics and hence recommended for chapati quality.	The genotypes were recommended for promotion and identification.

2.	Wheat varieties WH 1124 (IRLS), HD 2967 (IRTS), HD 3059 (IRLS), WH 1080 (RITS) of NWPZ and HD 2733 (IRTS), DBW 71 (VLS) of NEPZ and IInd year AVT entries HD 3226 (IRTS) and PBW752 (IRLS) of NWPZ exhibited very good quality for bread and hence recommended for bread quality.	The genotypes were recommended for promotion and identification.
3.	Wheat varieties HS 490(NHZ) and DBW 168 (PZ) were found suitable for biscuit and hence recommended for cultivation by the farmers for this purpose.	The genotypes were recommended for cultivation in their respective zones for biscuit.
4.	Breeding for product specific varieties should be further strengthened by taking into consideration soft and hard wheat classes in bread wheat separately and yellow pigment content in durum wheat.	Breeders are taking quality traits into consideration while selecting desirable segregants and advanced lines. This has led to enhanced gluten strength as measured by sedimentation value. Soft genotypes have also been advanced into AVT IInd year during 2018-19. Similarly, the genotype with high yellow pigment has been advanced into IInd year of testing during 2018-19.
5.	Only the genotypes having unique/distinct quality traits should be submitted for quality analysis under QCSN. QCSN and Biofortification nurseries should be combined into one nursery.	Breeders have been requested to submit only the genotypes having unique/distinct quality traits for quality analysis under QCSN. QCSN and Biofortification nurseries have been combined into one nursery as QCWBN.
Barley Improvement		
1.	Malting quality facility is only at ICAR-IIWBR Karnal. So all co-operators who required malting analysis of new entries before contribution to IVT are requested to send the 5-7 entries sample (having good physical parameters for malting) to ICAR-IIWBR Karnal for malting analysis.	All the Cooperating centers were asked to send the 5-7 entries for malting analysis at ICAR-IIWBR Karnal for contribution in IVTs.
2.	Keeping in view of importance and present low yield level, a focus should be given to hulless barley and so group decided to initiate a new trial on hulless barley.	New trial series on hulless barley intiated keeing in view of low yield level and importance in food products.
3.	Dual purpose barley trials: During last 8 years, there is no entry performed better than checks in grain and forage yield in any of the zone in dual purpose trial. So to save the resources, only and if the entry is good for forage yield, it will be reflected in the variety identification proposal that it is suitable for dual purpose also.	Separate dual purpose trial as per group recommendations closed and the final year feed barley entries will be evaluated for forage and grain yield in agronomy trials and if the entry is good in forage as well as grain yield, it will be reflected in the variety identification proposal.
4.	More emphasis should be given to parameters like beta glucan, protein, amylose content of hulless/malt barley.	Hulless landraces have been screened for these parameters and two genotypes have been identified for low beta glucan.
5.	An interface meeting of farmers-seed growers-malting and brewing industries- Scientists will be organized at ICAR-IIWBR, Karnal to make aware of the new varieties and technologies and to promote contract farming.	Awareness programmes orgsnised to popularise barley for the health benefits (high antioxidant, higher beta glucan content). Scientists visited the malting, brewing and food industries to promote the use of malt and food barley in different products.
6.	Hydrogel experiment on barley should be conducted in selected dry areas	The experiment was conducted at Durgapura , Agra and Hisar

Annexure II

Financial Highlights for the Year 2018-19

A. Budget Utilization

(₹ in Lakhs)

Name of Scheme	Total BE 2018-19	Total R.E. 2018-19	Total Remittance Received 2018-19	TOTAL EXP.	% of EXP. Against RE
IIWBR, KARNAL	3292.40	3425.25	3425.25	3425.25	100.00
AICRP on Wheat & Barley	2276.18	1891.55	1891.55	1891.55	100.00

Expenditure Statement for the year 2018-19 in respect of ICAR-IIWBR, Karnal

(₹ in Lakhs)

Name of Scheme	HEAD	B.E. 2018-19	R.E. 2018-19	EXPENDITURE			TOTAL EXP.	% of EXP. Against RE
				Other than NEH & TSP	TSP	NEH		
IIWBR, KARNAL	Grants in Aid - Capital	370.50	300.00	300.00	0.0	0.0	300.00	100.00
	Grants in Aid - Salaries	1776.00	2053.00	2053.00	0.0	0.0	2053.00	100.00
	Grants in Aid - General							
	(1) Pension	240.00	314.50	314.50	0.0	0.0	314.50	100.00
	(2) Others	905.90	757.75	752.00	5.75	0.0	757.75	100.00
TOTAL		**3292.40**	**3425.25**	**3419.50**	**5.75**	**0.00**	**3425.25**	**100.00**

(₹ in Lakhs)

Name of Scheme	HEAD	B.E. 2018-19	R.E. 2018-19	EXPENDITURE			TOTAL EXP.	% of EXP. Against RE
				Other than NEH & TSP	TSP	NEH		
AICRP on Wheat & Barley	Grants in Aid - Capital	0.0	0.0	0.0	0.0	0.0	0.0	
	Grants in Aid - Salaries	1932.00	1641.60	1590.51	0.0	51.09	1641.60	100.00
	Grants in Aid - General :-							
	(1) Pension	0.0	0.0	0.0	0.0	0.0	0.0	0.00
	(2) Others	344.18	249.95	240.00	5.75	4.20	249.95	100.00
TOTAL		**2276.18**	**1891.55**	**1830.51**	**5.75**	**55.29**	**1891.55**	**100.00**

B. Revenue Generation for the year 2018-19

(₹ in Lakhs)

S. No.	Year	Target	Revenue Generated as per Schedule 8, 10 & 12 of Balance Sheet 2018-19.
1	2018-19	94.46	44.40

C. Status of Audit Paras (Office of Principal Director of Audit (Central), Chandigarh)

Sr. No.	Year	Number of outstanding Paras	Position of submission of reply as on 30.06.2019
1	2014-15	6	Replies of all audit paras have been submitted to the Sr. Audit Officer, Office of the Principal Director of Audit (Central), Chandigarh vide letter No. 8-3/Fin./IIWBR/16-17/3884-85 dated 22.6.2017 and Sr. Audit Officer has informed vide thier letter dated 31.07.2017 and 31.08.2017 that facts will be verified by the next Audit.
2	2015-17	6	
3	2017-18		Audit is yet awaited.

D. Status of ICAR Inspection Report as on 30.06.2019

Sr. No.	Year	Number of outstanding Paras	Position of submission of reply as on 30.06.2019
1	2013-14	1	Replies of all outstanding audit paras have been submitted to the Council along with all necessary annexures vide letter No. 8-21/ Fin./IIWBR/17-18/ dated 29.05.2019.
2	2015-16	2	
3	2016-17	13	
4	2017-19		Audit is yet awaited.

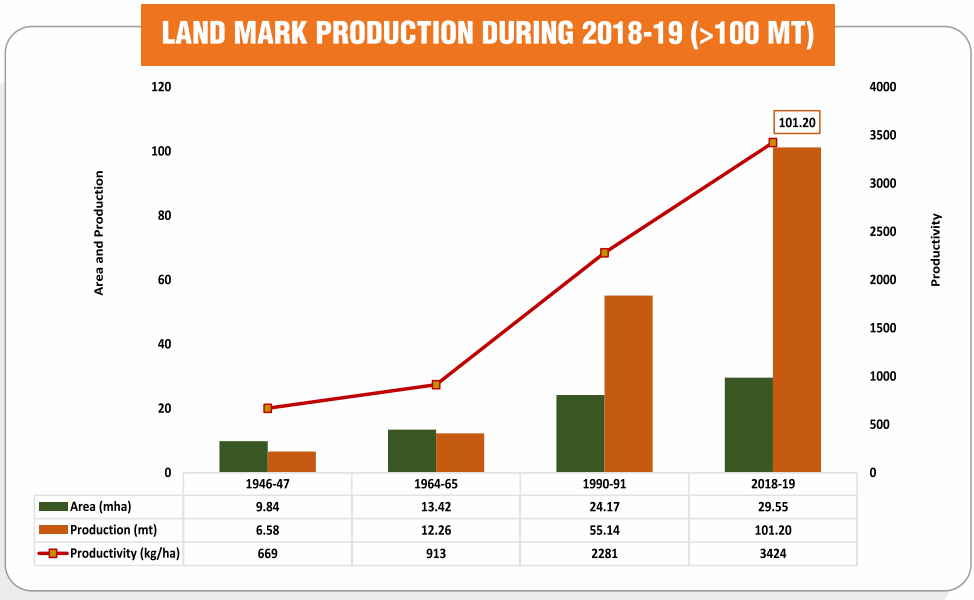
STATEMENT SHOWING NET GRANT RELEASED TO AICRP ON WHEAT & BARLEY CENTRES DURING THE YEAR 2018-19

(Amount in ₹)

Sr. No.	Name of Centre	Salary	TA	Rec. Cont.	Total General	TOTAL
1	BAJAURA	3292500	97706	374427	472133	3764633
2	BILASPUR	2670253	64049	375198	439247	3109500
3	COOCHBEHAR	3112500	90949	377116	468065	3580565
4	DHARWAD	4825921	224714	751033	975747	5801668
5	DURGAPURA	23171250	337500	1500000	1837500	25008750
6	FAIZABAD	7038282	225000	827895	1052895	8091177
7	GWALIOR	5133750	85420	375000	460420	5594170
8	HISAR	5674071	191250	1155918	1347168	7021239
9	IMPHAL	300159	50105	149694	199799	499958
10	JABALPUR	1977663	112250	377155	489405	2467068
11	JAMMU	5497500	82500	375000	457500	5955000
12	JUNAGADH	1949746	112437	403977	516414	2466160
13	KALYANI	2756298	108008	562500	670508	3426806
14	KANPUR	7579451	255733	1086301	1342034	8921485
15	LUDHIANA	12386250	150000	1200000	1350000	13736250
16	MAHABALESWAR	3675000	112128	375000	487128	4162128
17	NIPHAD	3450132	225250	767649	992899	4443031
18	PALAMPUR	8805000	116283	561860	678143	9483143
19	PANTNAGAR	8157750	225000	713687	938687	9096437
20	POWARKHEDA	7282500	135365	562500	697865	7980365
21	PUNE	9129930	167986	950396	1118382	10248312
22	RANCHI	3699333	112750	675000	787750	4487083
23	SABOUR	6986250	165242	562328	727570	7713820
24	SAGAR	1874809	55945	187500	243445	2118254
25	SHILLONGANI	4808841	54895	165306	220201	5029042
26	SRINAGAR	1237624	56250	225000	281250	1518874
27	UDAIPUR	3450000	112500	390412	502912	3952912
28	VARANASI	11210000	225000	1127986	1352986	12562986
29	VIJAPUR	3027237	194785	755005	949790	3977027
	TOTAL	164160000	4147000	17910843	22057843	186217843
	Voluntary centers/ Zonal Coordinating Units.			2362157	2362157	2362157
	TSP Grant			**575000**	**575000**	**575000**
	Grand Total	**164160000**	**4147000**	**20848000**	**24995000**	**189155000**

STATUS OF AUC FOR THE YEAR 2018-19 IN R/O CENTRES UNDER WHEAT & BARLEY

Sr. No.	Name of Centre	Name of SAU/Institution	Status of UC/AUC for the year 2018-19 received from the Centres
1	BAJAURA	HPKVV, PALAMPUR	UC
2	BILASPUR	IGKVV, RAIPUR	Not Received
3	COOCHBEHAR	UBKV, COOCHBEHAR	UC
4	DHARWAD	UAS, DHARWAD	AUC
5	DURGAPURA	RAU, BIKANER	AUC
6	FAIZABAD	NDUA&T, FAIZABAD	UC
7	GWALIOR	RVS KVV, GWALIOR	Not Received
8	HISAR	CCS HAU, HISAR	Not Received
9	IMPHAL	CAU, IMPHAL	UC
10	JABALPUR	JNKVV, JABALPUR	UC
11	JAMMU	SKUAS & T, JAMMU	UC
12	JUNAGADH	JAU, JUNAGADH	UC
13	KALYANI	BCKVV, NADIA	UC
14	KANPUR	CSAUAST, KANPUR	UC
15	LUDHIANA	PAU, LUDHIANA	AUC
16	MAHABALESWAR	MPKVV, RAHURI.	AUC
17	NIPHAD	MPKVV, RAHURI	AUC
18	PALAMPUR	HPKVV, PALAMPUR	AUC
19	PANTNAGAR	GBPUA & T, PANTNAGAR	AUC
20	POWARKHEDA	JNKVV, JABALPUR	Not Received
21	PUNE	ARI, PUNE	AUC
22	RANCHI	BAU, RANCHI	AUC
23	SABOUR	BAU, SABOUR	Not Received
24	SAGAR	JNKVV, JABALPUR	AUC
25	SHILLONGANI	AAU, JORHAT	UC
26	SRINAGAR	SKUAS & T, SRINAGAR	UC
27	UDAIPUR	MPUA&T, UDAIPUR	Not Received
28	VARANASI	BHU, VARANASI	UC
29	VIJAPUR	SDAU, SARDAR, KRUSHI NAGAR	AUC



58वीं अखिल भारतीय गेहूँ एवं जौ अनुसंधान कार्यशाला
भा.कृ.अनु.प. - भारतीय कृषि अनुसंधान संस्थान,
क्षेत्रीय केन्द्र, इन्दौर में आयोजित गोष्ठी के दौरान जारी किया गया