प्रगति प्रतिवेदन

PROGRESS REPORT 2020-21

निदेशक की रिपोर्ट

DIRECTOR'S REPORT

अखिल भारतीय समन्वित गेहूँ एवं जौ अनुसंधान परियोजना

AICRP on Wheat and Barley

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
2020-21

G.P. SINGH
DIRECTOR

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

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I greatly appreciate all the 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.

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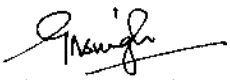


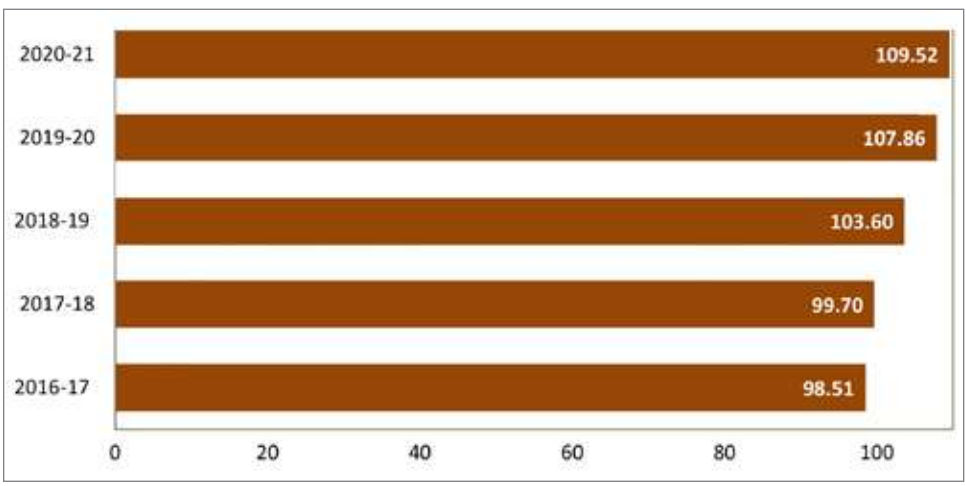
Place : Karnal
Date : August 15, 2021

(G.P. Singh)
Director

DIRECTOR'S REPORT 2020-21

Globally, wheat and barley have witnessed rapid strides in production and accounts a significant share in consumption basket ensuring food and nutrition security to a majority of the population. In the realm of food grains, the nutri-rich cereals (wheat and barley) were cultivated in 275.39 million hectares during 2020-21 (Wheat: 224.49 million hectares and Barley: 50.90 million hectares) with the annual production reaching an all-time highest output estimated at 945.87 million tonnes (Wheat: 792.40 million tonnes and Barley: 153.47 million tonnes) (Source: United States Department of Agriculture). In India, during the 2020-21 *Rabi* season, wheat has been cultivated in 31.76 million hectares and barley covered 0.61 million hectares, constituting around 25 per cent of the total crop acreage. In terms of production, wheat and barley together accounts for about 36 per cent of the India's total food grains production as per the 4th 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



In India, the production of wheat has been increasing consistently in the recent past. During 2020-21, the wheat output has reached a record gargantuan level of 109.52 mt with an average national productivity estimated at 3464 kg/ha. In comparison to the past, the current year production has witnessed a change of 1.66 million tonnes (+1.54%). The positive growth in production is attributed to the increased area by 0.82 per cent, followed by crop yield to the tune of 0.71 per cent. Increase in the support price by ₹ 50 per quintal

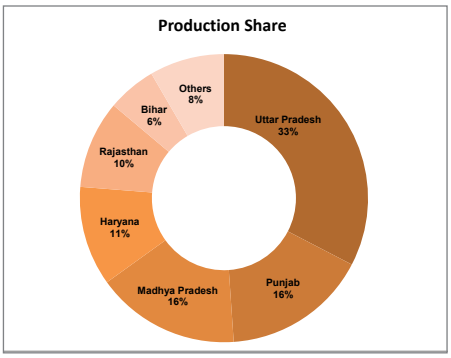
in comparison to the recent past year and announced as ₹ 1975 per quintal of wheat, followed by scaling up of new and promising varieites like DBW 187 and DBW 222 might have had a positive impact on the crop acreage (+0.40 million hectares). Increased area and crop productivity in a majority of the states is a major reason behind the record production. States like Maharashtra and Madhya Pradesh have shown a significant increase in the crop area. However, in 2020-21, there existed variation in area, production and productivity across states in comparison to the previous year's final estimates.

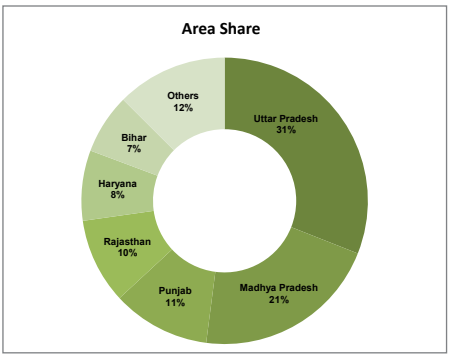
Quantum change in area, production and yield of wheat

State	2019-20 (Final Estimates)			2020-21 (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	11	14	1273	15	20	1363	3.66	6.01	90
Bihar	2150	5580	2595	2153	5957	2767	3	377	172
Chhattisgarh	110	115	1050	112	150	1340	2	34	290
Gujarat	1018	3327	3268	1017	3210	3156	-1	-117	-112
Haryana	2534	11876	4687	2521	12154	4822	-13	278	135
Himachal Pradesh	286	563	1970	320	631	1970	34.13	67.24	0.00
Jharkhand	215	439	2046	233	487	2091	18	47	45
Karnataka	150	180	1198	186	258	1388	36	78	190
Madhya Pradesh	6551	19607	2993	6691	17578	2627	140	-2029	-366
Maharashtra	1057	1794	1697	1272	2267	1782	215	473	85
Odisha	0.12	0.17	1390	0.12	0.17	1392	0.00	0.00	2
Punjab	3521	17616	5003	3510	17722	5049	-11	106	46
Rajasthan	3118	10916	3501	3066	10734	3501	-52	-182	0.00
Telangana	5	9.21	1842	7.00	13.00	1857	2.00	3.79	15
Uttar Pradesh	9853	33815	3432	9842	35471	3604	-11	1655	172
Uttarakhand	316	904	2861	312	841	2696	-4	-63	-165
West Bengal	188	510	2708	193	579	3000	4.69	69.06	292
Others	274	594	2171	310	677	2183	37	83	13

Source: DES, MoA&FW, India.

Among the wheat producing states, Uttar Pradesh accounted for the highest share of crop output estimated at 35.47 million tonnes (33%), followed by Punjab (17.72 million tonnes: 16%), Madhya Pradesh (17.58 million tonnes: 16%), Haryana (12.15 million tonnes: 11%), Rajasthan (10.73 million tonnes: 10%) and Bihar (5.96 million tonnes: 6%). The aforementioned six states hold a share of about 92 per cent in total wheat production. Barring





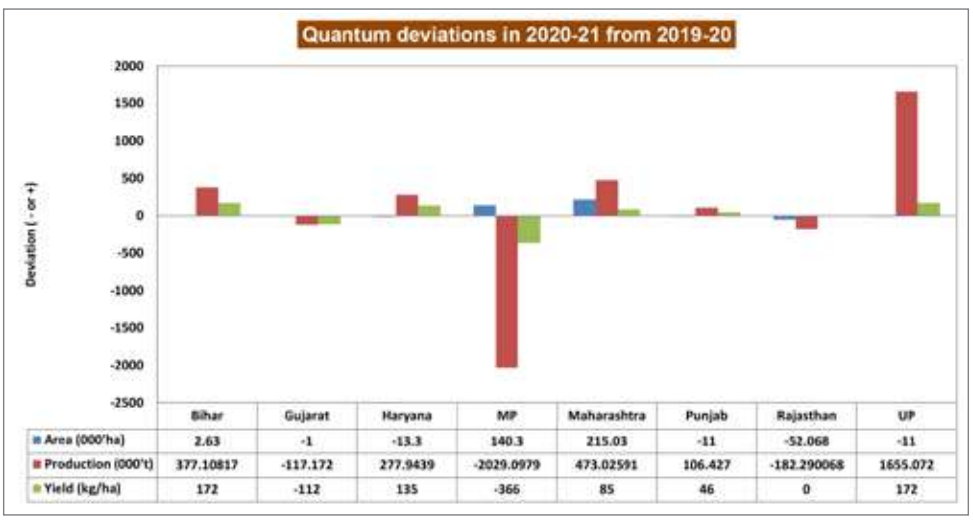
Gujarat, Madhya Pradesh, Rajasthan and Uttarakhand, the rest of the states registered an increase in production during 2020-21 in comparison to 2019-20. Overall production from all these states has declined by 2.39 million tonnes owing to the fall in yield levels and/or acreage. The highest fall in production was noticed in Madhya Pradesh (-2.03 million tonnes: -10.35%). Among states, the increase in production was maximum in Uttar Pradesh (+1.66 million tonnes: +4.89%), followed by Maharashtra (+0.47 million tonnes: +26.37%) and Bihar (+0.38 million tonnes: 6.76%). In percentage terms, the observed change in production was highest in Karnataka (43.67%: 0.08 million tonnes).

State wise area under wheat exhibited regional differences and it has increased by 0.40 million hectares (+1.28%) during the current season in comparison to the recent past. The highest increase was noticed in Maharashtra (+2.15 lakh hectares: +20.34%), followed by Madhya Pradesh (+1.40 lakh hectares: +2.14%). As usual, Uttar Pradesh holds the top slot in wheat acreage (9.84 million hectares: 31%), followed by Madhya Pradesh (6.69 million hectares: 21%), Punjab (3.51 million hectares: 11%), Rajasthan (3.07 million hectares: 10%), Haryana (2.52 million hectares: 8%) and Bihar (2.15 million hectares: 7%). The aforementioned states altogether comprise 87 per cent of the total area and states namely Assam, Bihar, Chhattisgarh, Himachal Pradesh, Jharkhand, Karnataka, Madhya Pradesh, Maharashtra, Telangana and West Bengal have shown a positive change in crop acreage ranging from 2.15 to 0.02 lakh hectares. In percentage terms, the decline in crop acreage was highest in the case of Rajasthan (-1.67%: 0.05 lakh hectares). State wise analysis indicated that Assam, Bihar, Chhattisgarh, Jharkhand, Karnataka, Maharashtra, Telangana and West Bengal have exhibited an increase in both area and yield which resulted in the incremental national output.

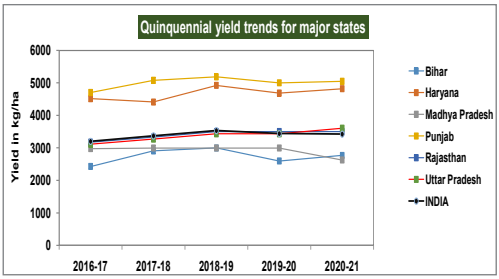
Contribution of yield and/or area to wheat production (2020-21)

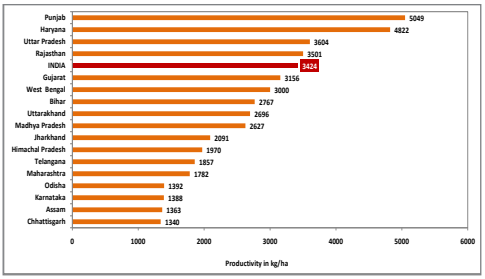
State/Country	Change in production in 2020-21 over 2019-20		% contribution by	
	Quantity (in '000 tonnes)	Deviation (in %)	Area	Yield
Assam	6.01	41.68	32.32	7.07
Bihar	377	6.76	0.12	6.63
Chhattisgarh	34	29.87	1.77	27.62
Gujarat	-117	-3.52	-0.10	-3.43
Haryana	278	2.34	-0.52	2.88
Himachal Pradesh	67.24	11.93	11.93	0.00
Jharkhand	47	10.76	8.37	2.20
Karnataka	78	43.67	24.00	15.86
Madhya Pradesh	-2029	-10.35	2.14	-12.23
Maharashtra	473	26.37	20.34	5.01
Odisha	0.00	0.14	0.00	0.14
Punjab	106	0.60	-0.31	0.92
Rajasthan	-182	-1.67	-1.67	0.00
Telangana	3.79	41.14	40.00	0.81
Uttar Pradesh	1655	4.89	-0.11	5.01
Uttarakhand	-63	-6.96	-1.27	-5.77
West Bengal	69	13.54	2.49	10.78
Others	83	14.06	13.40	0.58

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



Analysis on contribution of yield and/or area to the current year's overall wheat production indicated that the average national productivity has declined marginally by 0.46 per cent (-16 kg/ha) in 2020-21 but the significant increase in area (+4 lakh hectares: 1.28%) has been the major

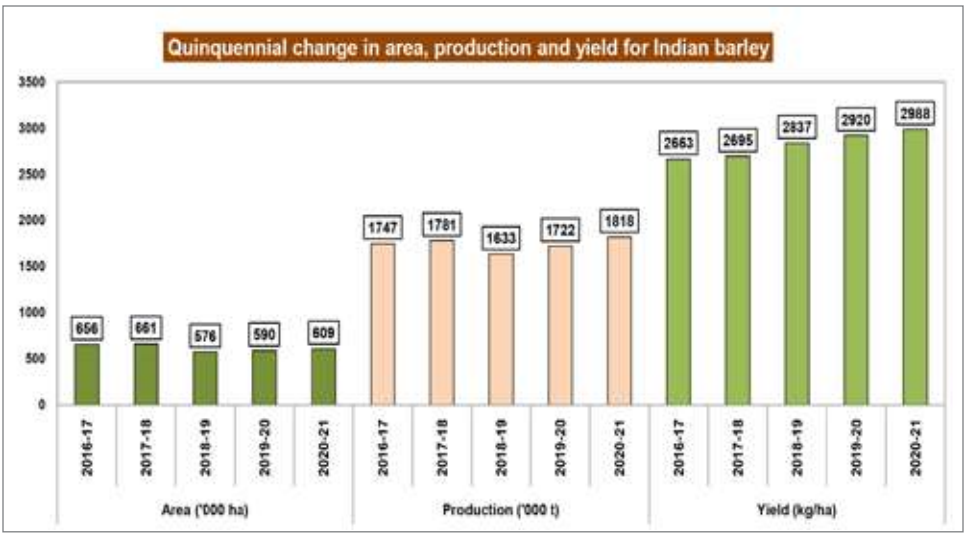


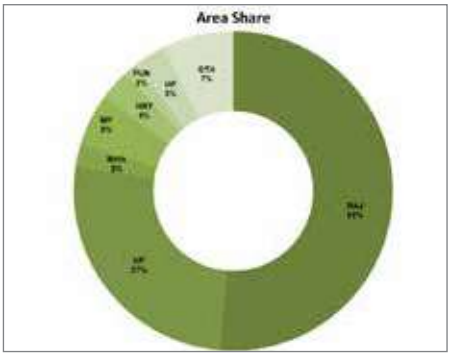


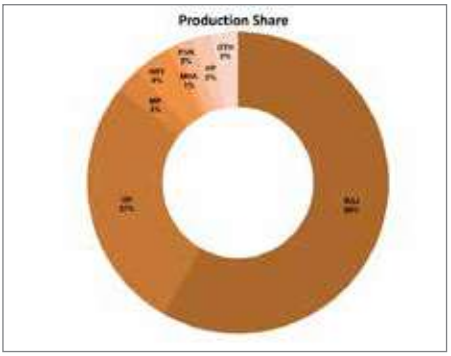
reason for quantum jump and record production of 109.52 million tonnes. State wise estimates indicated that Assam, Bihar, Chhattisgarh, Haryana, Himachal Pradesh, Jharkhand, Karnataka, Maharashtra, Punjab, Telangana, Uttar Pradesh and West Bengal witnessed a positive change in the crop output. Similarly, with the exception of Gujarat, Madhya Pradesh, and Uttarakhand, the rest of the states have witnessed an increase or maintained their productivity levels during the current season (2020-21) in comparison to the recent past. The crop yield varied across states and it ranged from as high as 5049 kg/ha in Punjab to 1340 kg/ha in Chhattisgarh. Punjab, Haryana, Uttar Pradesh and Rajasthan have registered yield levels much higher than the national average (3464 kg/ha). The increase in productivity during 2020-21 over the previous year was highest in the case of West Bengal (+292 kg/ha: +10.78%) and the highest reduction was noticed in the case of Madhya Pradesh (-366 kg/ha: -12.23%).

Scenario for Barley in India

Barley crop has shown a positive change in all the three variables viz., national area, production and productivity with regional diffrences across states. For the *Rabi* 2020-21 crop season, barley production was estimated at 1.82 million tonnes which is attributed to the increase in crop acreage by 3.23 per cent, followed by incremental productivity at the rate of 2.30 per cent (Source: Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare, India). The overall increase in area is marginal and estimated to be +0.02 lakh ha. The increase shall be attributed to the rise in the support price (+ ₹ 75 per quintal) in comparison to the previous year and announced as ₹ 1600 per quintal of barley. Year-to-year area under barley has witnessed a mixed pattern, but the long-run decline in barley area is a major concern since barley sowing depends on the demand (household and market) as well as its economic returns in comparison to the other *Rabi* crops.



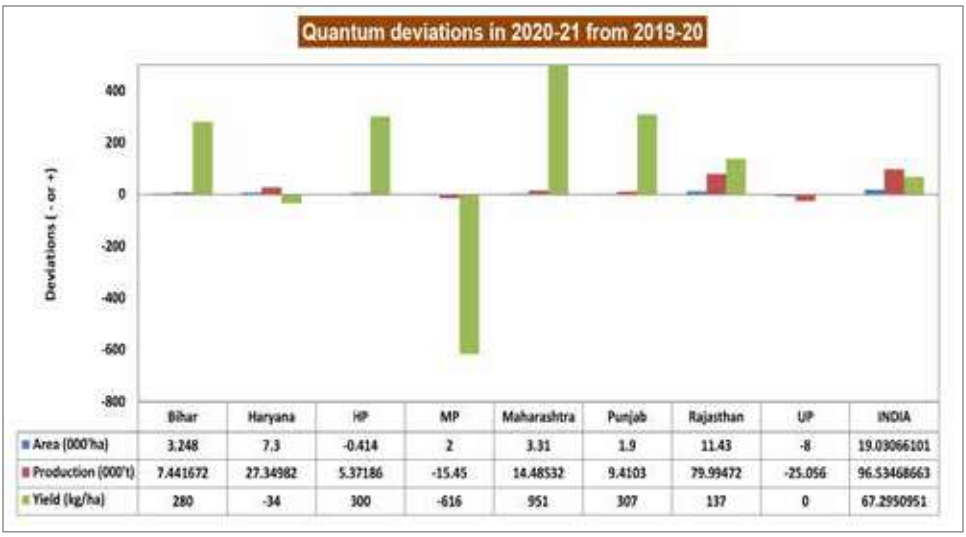




Quantum change in area, production and yield of barley

State/Country	2019-20 (Final Estimates)			2020-21 (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	7.4	10.2	1369	10.7	17.6	1649	3.25	7.44	280
Chhattisgarh	1.7	1.0	609	1.4	1.2	805	-0.24	0.13	196
Haryana	12.1	46.5	3837	19.4	73.9	3803	7.30	27.35	-34
Himachal Pradesh	20.4	30.8	1510	20.0	36.2	1810	-0.41	5.37	300
Madhya Pradesh	30.0	63.9	2131	32.0	48.5	1515	2.00	-15.45	-616
Maharashtra	10.7	3.8	351	14.0	18.2	1302	3.31	14.49	951
Punjab	6.2	22.6	3644	8.1	32.0	3951	1.90	9.41	307
Rajasthan	301.2	979.3	3251	312.7	1059.3	3388	11.43	79.99	137
Uttar Pradesh	167.0	523.0	3132	159.0	498.0	3132	-8.00	-25.06	0
Uttarakhand	24.0	34.3	1431	22.0	26.5	1203	-2.00	-7.88	-228
West Bengal	0.3	0.6	2155	0.5	1.0	2020	0.22	0.41	-135
Others	8.5	5.7	671	8.8	6.0	686	0.27	0.32	15
INDIA	590	1722	2920	609	1818	2988	19	97	67

Source: DES, MoA&FW, India.



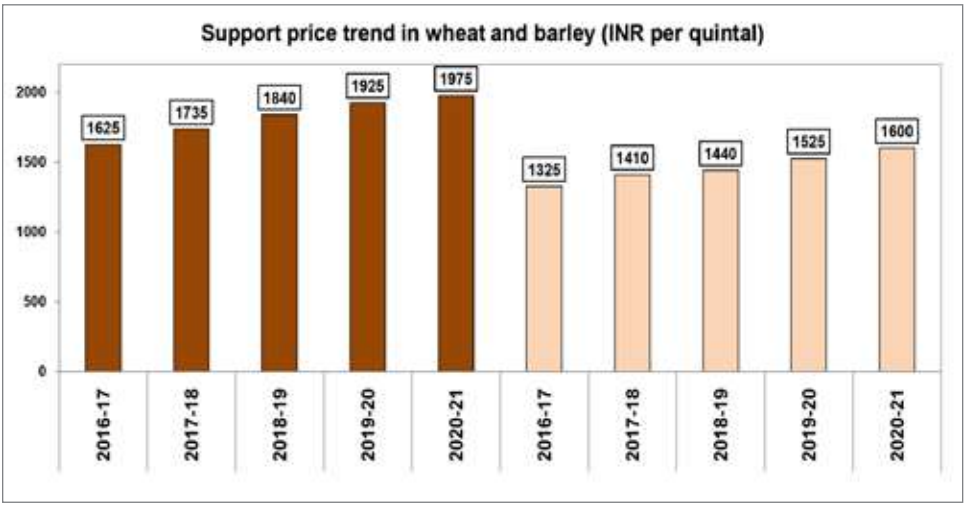
	Bihar	Haryana	HP	MP	Maharashtra	Punjab	Rajasthan	UP	INDIA
Area ('000'ha)	3.248	7.3	-0.414	2	3.31	1.9	11.43	-8	19.03066101
Production ('000't)	7.441672	27.34982	5.37186	-15.45	14.48532	9.4103	79.99472	-25.056	96.53468663
Yield (kg/ha)	280	-34	300	-616	951	307	137	0	67.2950951

Among states, Rajasthan holds the top slot in barley production (1.06 million tonnes: 58%), followed by Uttar Pradesh (0.50 million tonnes: 27%) and Madhya Pradesh (0.05 million tonnes: 3%). The aforementioned three states altogether accounted for about 88 per cent of the total barley produced in the country. Rajasthan consecutively ranks first in terms of barley acreage (0.31 million hectares: 51%) during 2020-21, a plausible reason for its high share in production (58%) as well. During 2020-21 *Rabi* season, the average productivity in barley was highest in the case of Punjab (3951 kg/ha), followed by Haryana (3803 kg/ha), Rajasthan (3388 kg/ha) and Uttar Pradesh (3132 kg/ha). The aforementioned states registered the productivity levels more than the national average (2988 kg/ha).

Among barley growing states, a wide range of variation has been noticed in crop acreage, production and productivity levels. Productivity has declined in states like Haryana, Madhya Pradesh, Uttarakhand and West Bengal ranging from 34 to 616 kg/ha. Maharashtra is the only state to show an apparent change in yield levels during the current season in comparison to the recent past. In quantity terms, the yield gain was +951 kg/ha which translates to +271 per cent. The crop acreage has witnessed an increase in a majority of the states barring Chhattisgarh, Himachal Pradesh, Uttar Pradesh and Uttarakhand. States like Bihar, Maharashtra, Punjab and Rajasthan have exhibited a positive change in all the three variables *viz.*, area, production and productivity of barley, and the rest have shown a decline either in area and/or crop yield. The decline in barley output was

highest in the case of Uttar Pradesh and it is estimated at 0.25 lakh tonnes (-4.79%) in comparison to previous year, which primarily can be attributed to the fall in crop acreage (-4.79%).

Price Scenario for Wheat and Barley

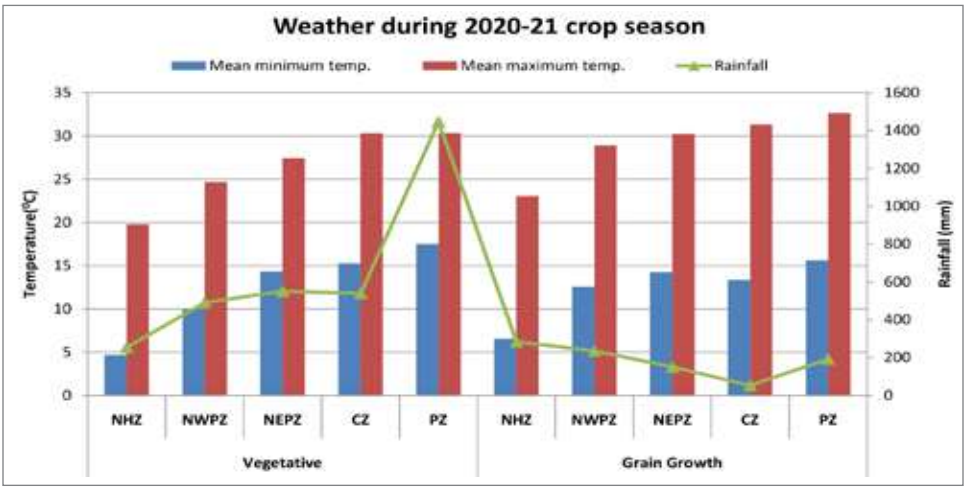


A comparison of the minimum support price for wheat and barley (in nominal terms) for the recent five years indicated a positive change over time. Government's policy decision on increasing the wheat procurement price by 2.6 per cent and barley by 4.9 per cent in comparison to past year support price helped farmers to take prior sowing decision. The extent of change in the support prices had a positive impact on both the crops acreage. The area under wheat has increased by 0.40 lakh hectares, whereas, barley acreage has increased marginally by 0.02 lakh hectares. It is also clear from the quinquennial data that the support price difference between wheat and barley hover around ₹ 400 to ₹ 300 per quintal and the divergence, surprisingly, decreased in 2020-21.

Weather Scenario (2020-21)

Meteorological data were received from 61 centres across NHZ (6), NWPZ (12), NEPZ (16), CZ (16) and PZ (11). The mean minimum temperature and mean maximum temperature were 6.6^{0}C and 23.1^{0}C in NHZ, 12.6^{0}C and 28.9^{0}C in NWPZ, 14.3^{0}C and 30.2^{0}C in NEPZ, 13.3^{0}C and 31.3^{0}C in CZ and 15.6^{0}C and 32.6^{0}C in PZ, respectively during the grain filling period. Compared to previous crop season, the mean minimum temperature was

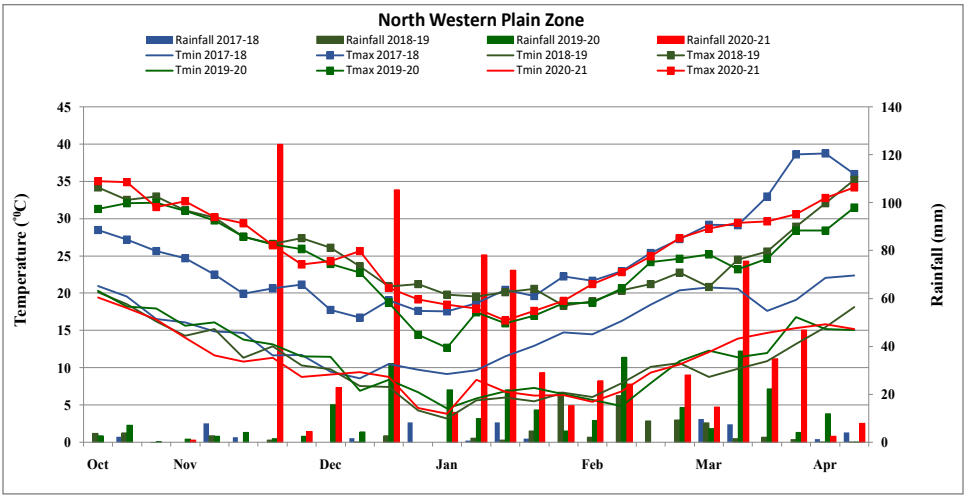
lower in NEPZ and PZ but higher in NHZ, NWPZ and CZ. The mean maximum temperature was higher across zones during grain filling period and more days during grain filling had temperature >30^{0}C. The mean minimum temperature was highest (15.6^{0}C) in PZ followed by NEPZ (14.3^{0}C) and CZ (13.3^{0}C) during grain growth. It was higher by 0.9^{0}C in NHZ, 0.8^{0}C in NWPZ and 0.5^{0}C in CZ compared to previous year. The mean maximum temperature was higher by 1.5^{0}C in NHZ, 3.3^{0}C in NWPZ, 2.2^{0}C in NEPZ, 3.0^{0}C each in CZ and PZ during grain growth period compared to previous crop season.



All the zones received rainfall during the crop season. Maximum rainfall of 1639 mm was recorded in PZ followed by 727mm in NWPZ, 702mm in NEPZ, 592mm in CZ and 538 mm in NHZ. Compared to previous year, significantly higher rainfall was observed all through the crop season in PZ, NWPZ, NEPZ and CZ but it was lower in NHZ.

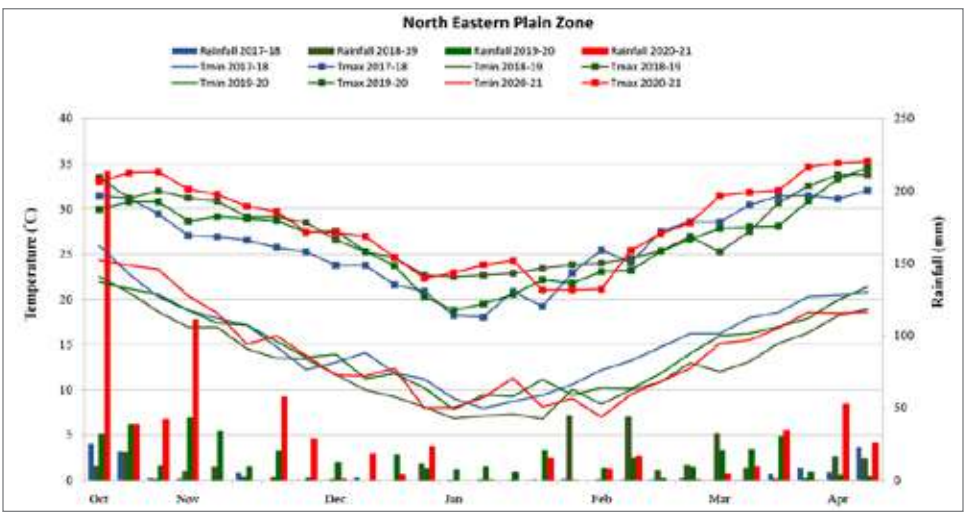
The weekly average weather data of cropping duration for all four major wheat growing zones (NWPZ, NEPZ, CZ and PZ) were compared with previous 3 years (2017-18, 2018-19, 2019-20) and the trend of minimum temperature, maximum temperature and rainfall were calculated.

In NWPZ, the weekly average minimum temperature was 4.5^0 lower to 2019-20 crop season, but was 0.2^{0}C higher than 2018-19 crop season. The weekly average maximum temperature was 1.6^{0}C, 0.8^{0}C and 2.1^{0}C higher than 2017-18, 2018-19 and 2019-20 crop seasons respectively. Temperature >30^{0}C was observed during 12th, 13th and 14th week. The rainfall received

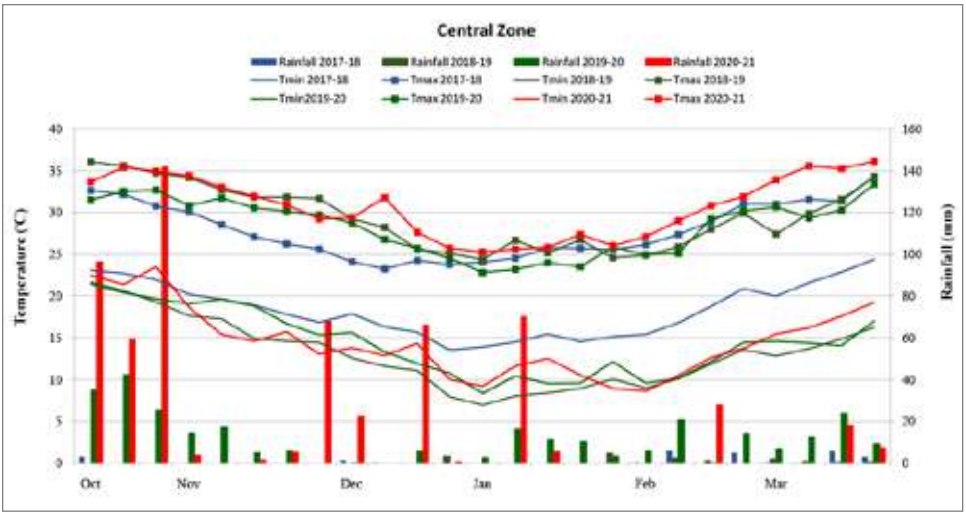


was significantly higher than all three previous crop seasons; however, it was more during vegetative phase.

In NEPZ, The weekly average minimum temperature was 1.1^{0}C and 0.3^{0}C lower compared to 2017-18 and 2019-20 crop seasons but was 1.4^{0}C higher than 2018-19 crop season and the maximum temperature was 2.4^{0}C, 0.9^{0}C, and 2.1^{0}C higher than 2017-18, 2018-19 and 2019-20 crop seasons respectively. The temperature >30^{0}C was observed from 9th -14th week which coincided with grain filling duration in the month of March and April. The rainfall received was higher than all three previous crop seasons.

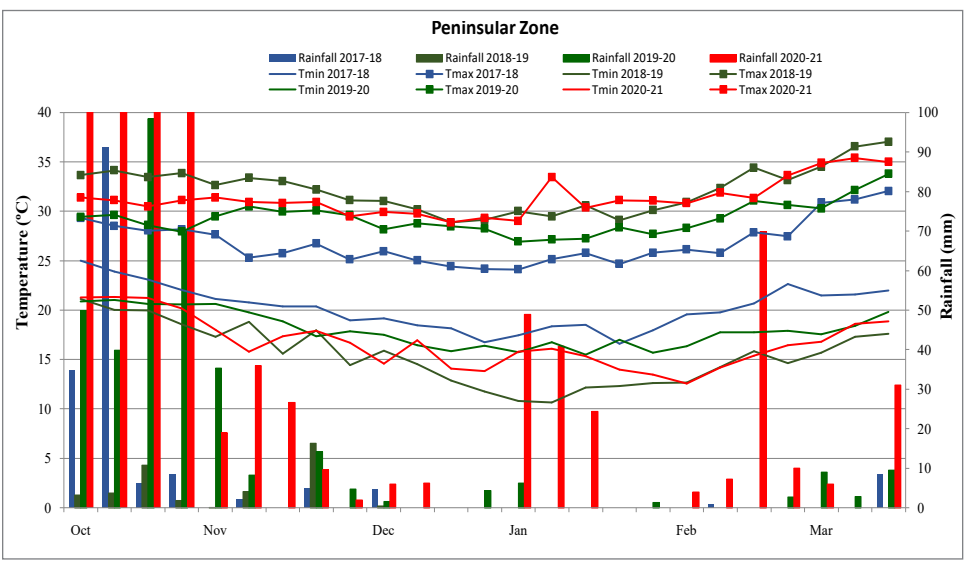


In CZ, the weekly average trend of minimum temperature was 3.9^{0}C lower to 2017-18 crop season but was 1.4^{0}C and 0.2^{0}C higher than 2018-19 and 2019-20 crop seasons respectively. The maximum temperature was 2.9^{0}C,



1.3^{0}C and 2.4^{0}C higher than all three previous crop seasons from 2017 to 2020. The weekly average temperature of >30^{0}C was observed from 7th to 12th week in the mid of February to March.

In PZ, the weekly average trend of minimum temperature was 3.5^{0}C and 1.3^{0}C lower than that of 2017-18 and 2019-20 crop seasons respectively, but was 1.3^{0}C higher than 2018-19 crop season. The mean maximum temperature was 4.5^{0}C and 2.1^{0}C higher than 2017-18 and 2019-20 crop seasons respectively, and was 0.9^{0}C lower than 2018-19 crop season. The rainfall received was significantly higher than all three previous crop seasons.



MAJOR RESEARCH ACHIEVEMENTS

CROP IMPROVEMENT

Development and release of new wheat varieties

Central Releases

The year 2020-21 was very fruitful as the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops recommended the release and notification of 11 varieties namely, NIAW3170, MACS4058, DBW303, WH1270, HD3298, HD3293, CG1029, HI1633, HI 1634, NIDW1149 (d) and DDW48 (d). The Sub-Committee also recommended the extension of area of cultivation for DBW 187 to early sown, high fertility, irrigated condition of NWPZ.

Wheat varieties released by the CVRC during 2020-21

Variety	Area and Production condition	Grain yield (q/ha)		Special features
		Potential	Average	
NIAW 3170 (Phule Satwik)	NWPZ, PZ TS, RIR	71.70 (NWPZ), 44.30 (PZ)	51.1 (NWPZ), 36.80 (PZ)	Soft grains, biscuit spread factor
DBW 303 (Karan Vaishnavi)	NWPZ IR, ES,	97.40	81.20	High yield under early sown and high fertility
DBW 187 (Karan Vandana) Area extension	NWPZ IR, ES,	96.6	75.5	High yield under early sown and high fertility
WH 1270	NWPZ IR, ES,	91.5	75.85	High yield under early sown and high fertility
HD 3298	NWPZ VLS, IR	47.40	39.00	Protein (12.1%); Fe=43ppm
HD 3293	NEPZ TS, RIR	60.70	39.30	Resistance to wheat blast
CG 1029 (Kanishka)	CZ LS, IR	94.90	52.10	Good Chapatti quality and tolerance to heat stress
HI 1634 (Pusa Ahilya)	CZ LS, IR	95.70	51.60	Good Chapatti quality, resistance to brown & black rusts
HI 1633 (Pusa Vani)	PZ LS, IR	65.80	41.70	Grain protein (12.4%), Iron =41.6ppm and Zinc =41.1ppm
NIDW 1149 (d)	PZ TS, RIR	36.80	29.70	Resistance to brown and yellow rusts
DDW 48 (d)	PZ TS, IR	72.00	47.40	High pasta score
MACS4058 (d)	PZ TS, RIR	37.10	30.60	Resistant to leaf & stem rusts, Protein content (12.8%)

State Releases

The state recommended wheat varieties were also notified (500 (E) dated 29.01.2021) by the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops for different production conditions prevailing in the named states.

Wheat varieties released by the SVRC during 2020-21

Variety	Developed by	Production condition	Grain yield (q/ha)		Special features
			Potential	Average	
Gujarat					
GW499 (Banas)	WRS (SDAU), Vijapur	LS, IR	59.90	46.02	Resistant to brown & black rusts
GW 1339 (BANAS) (d)	WRS (SDAU), Vijapur	TS,IR	67.60	49.60	Yellow pigment
Uttarakhand					
VL Gehun2015	ICAR-VPKAS, Almora	TS, RF hills (Organic)	36.67	19.88	Sedimentation Value (60ml),
UP2938	GBPUA&T, Pantnagar	TS,IR plains	92.75	53.81	High yield potential
UP2903	GBPUA&T, Pantnagar	TS,IR plains	70.05	50.59	Protein content (12.7%),
UP2944	GBPUA&T, Pantnagar	LS,IR plains	73.95	50.71	Protein content (14.5%),
Chhattisgarh					
CG1023 (Chhattisgarh Hansa)	IGKV RS, Bilaspur	TS,IR	42.0	32.14	Chapati quality (8.06)
Madhya Pradesh					
MP3465	JNKVV, Jabalpur	TS, RIR	73.2	59.41	Resistant to brown & yellow rust
Haryana					
DBWH221	ICAR-IIWBR, Karnal & CCSHAU, Hisar	TS,IR	76.1	62.8	Tolerant to heat stress, resistance to yellow rust
Uttar Pradesh					
AAI - W15	SHUATS, Prayagraj	TS, RF	26.26	19.86	Terminal heat tolerant
Bihar					
Rajendra Genhu-3 (WB 02)	RPCAU- Pusa and IIWBR, Karnal	TS, IR	50.0	47.0	Nutritional quality

Registration of genetic stocks: During the year 2020-21, thirty genetic stocks of wheat were registered by the Plant Germplasm Registration Committee for different traits of economic importance.

Genetic stocks registered during 2020-21

Genotype	INGR	Developed by	Trait(s)
DBW278	INGR20007	ICAR-IIWBR, Karnal	High sedimentation
DBW166	INGR20008		Water use efficient genotype
RWP-2017-21	INGR20009		Heat tolerant genotype
RW5	INGR20010		Drought & heat tolerance
Karan Poshan1	INGR20011		High zinc content (78.4ppm).
Karan Poshan2	INGR20012		High Iron content (62.9ppm).
QST1910	INGR20017		Drought tolerant (low DSI)
DWAP1608	INGR21021		Heat and drought tolerance.
KHTW-1 (BST1 (ST 1A)	INGR21022		Heat tolerance.
DBW243	INGR21023		High Water Use Efficiency.
DCMS17A & DCMS 17B	INGR21024		CMS line in DBW17 background with Chuan 18A
DCMS24A & DCMS 24B	INGR21025		CMS line in DBW 16 background with Chuan 18A
DCMS34A and 34B	INGR21026		CMS line in PBW 502 background with Chuan 18A
DCMS37A and 37B	INGR21027		CMS line in DBW 55 background with Chuan 18A
DCMS46A and 46B	INGR21028		CMS line in CBW 38 background with Chuan 18A
DCMS51A and 51B	INGR21029		CMS line in DBW 76 background with Chuan 18A
BRW3806	INGR21017	ICAR-IIWBR, Karnal & BAU, Sabour	Resistant to wheat blast disease.
GW2014-596	INGR20014	Wheat Research Station, Vijapur	High grain protein content (14.4%)
GW2010 288	INGR20015		Grains/spike (>60), high TKW and iron (>42 ppm).
GW2012-475	INGR20081		Early maturity with high yield
GW2010-321	INGR20082		Early maturity with high yield
UP2994	INGR20016	GBPUA&T, Pantnagar	High protein (14.3%), iron (49 ppm), zinc (43.5ppm)
ER9-700	INGR21018	ICAR-IARI, New Delhi	Leaf rust resistance. *Aegilops markgrafii* introgression.
TMD6-4	INGR21019		Leaf rust resistance. *Triticum militinae* introgression.
TMD11-5	INGR21020		Leaf rust resistance. *Triticum militinae* introgression.
HS628	INGR20013	ICAR-IARI, RS, Shimla	*Lr19/Sr25* - resistance to all the pathotypes of brown rust except 77-8
HI8791	INGR20005	ICAR-IARI, RS, Indore	Resistant to black, brown & yellow rusts; flag smut.
HI1619	INGR20006		Resistant to leaf & stripe rusts, KB & flag smut
IC128565	INGR21030	ICAR-NBPGR, New Delhi	Resistant to leaf rust.
IC128638	INGR21031		Resistance to leaf rust

Registration of varieties with the PPVFRA

Registration proposal of two varieties namely DBW303 and DDW48 under extant category, while the proposal of DBWH 221 under new category was submitted to the PPV&FRA, New Delhi. The PPVFRA registered

six wheat varieties namely DBW110 (Reg/2015/1422), HPW 349(267 of 2020), MPO1255 (Reg/2017/152), DBW222 (Reg2020/23), DBW252 (Reg/2020/24) and DDW47 (Reg/2020/25) during the year.

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 28 funded and 72 voluntary centres spread across five wheat growing zones in the country.

Zone-wise funded and voluntary centers of coordinated trials

Zone	Funded	Voluntary + ICAR centres	Total
NWPZ	5	21	26
NEPZ	8	14	22
CZ	8	14	22
PZ	3	16	19
NHZ	4	07	11
Total	**28**	**72**	**100**

During the crop season 2020-21, a total of 19 trial series (AVTs, NIVTs, IVTs and SPLs) were laid out in the different zones under six major production conditions *viz.*, early-sown irrigated, timely-sown irrigated, late-sown irrigated, timely-sown restricted irrigation, late-sown restricted irrigation and timely-sown rainfed. This year altogether 351 test entries were evaluated with 66 check varieties in different trials. In all, 443 trial sets were supplied to 100 centers out of which 442 trials were actually conducted. The non-reporting of the coordinated trials was mainly at voluntary centres.

Breakup of yield trials during 2020-21

Zone	Proposed	Conducted	Reported	Reason for not reported
NHZ	39	39	25	LSM (5), RMT (2), LS (2), LSM & HCV (3), LS&LSM (1), LSM+LS+HCV (1)
NWPZ	121	120	110	RMT (5), LSM (3), LS (1), TF (1)
NEPZ	99	99	69	LSM (21), RMT (5), LCV (3), LS (1)
CZ	97	97	85	RMT (7), LSM (4), HCV (1)
PZ	87	87	58	LSM (17), RMT (11), LS (1)
Total	443	442	347	95 (RMT - 30)

This year, out of total 442 trials conducted, 78.5% of trials have been found worth reporting based on set norms for disease resistance and yield performance.

Percent success in trial co nduction and reporting during 2020-21

Zone	Conduction (%)	Reporting (%)
NHZ	100	64.1
NWPZ	99.2	91.7
NEPZ	100	69.7
CZ	100	87.6
PZ	100	66.7
Total	**99.8**	**78.5**

Varieties under final year evaluation in AVTs

During this crop season, total 12 varieties were in the final year of yield evaluation in various AVTs and SPL trials of the different zones. The proposals received for identification of these varieties would be considered by the Varietal Identification Committee.

Varieties in the final year of evaluation in AVTs and SPLs during 2020-21

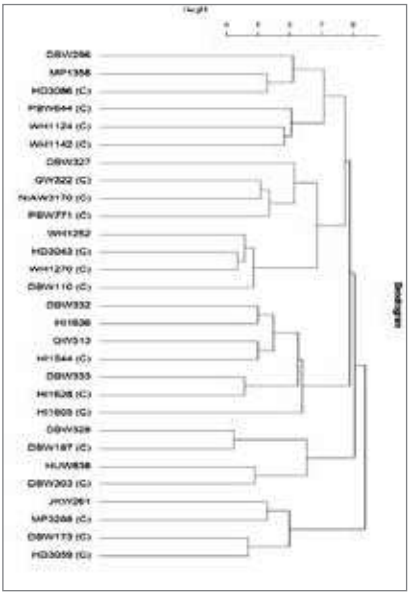
Zone/ Trial	Entries
North Western Plains Zone	
AVT-IR-LS-TAS	JKW261
AVT-RI-TS-TAS	DBW296, HUW838
Central Zone	
AVT-IR-TS-TAD	GW513, HI1636
AVT-RI-TS-TAD	HI8823(d)
Peninsular Zone	
AVT-RI-TS-TAD	MP1358
NWPZ + CZ	
SPL-HYPT-IR-ES-TAS	DBW327, DBW328, DBW332, DBW333, WH1252

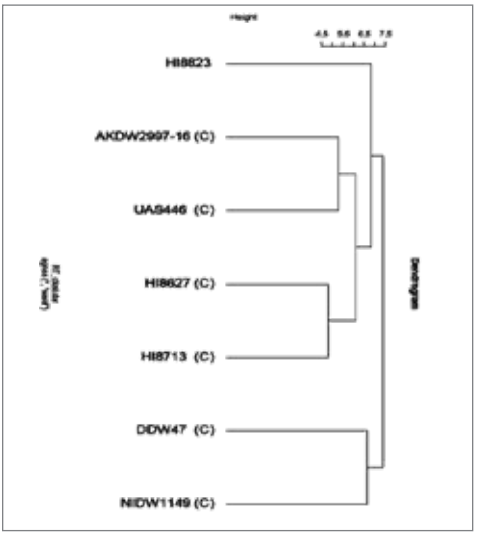
Marker assisted gene prospecting in AVT entries of wheat

Diversity in genetic & genomic resources is a key to the success of varietal improvement programmes aimed at yield, adaptation and it also plays a crucial role for providing needed protection against biotic & abiotic stresses in wheat. Keeping this in view, AVT final year entries and checks were screened using various STS/ AS-PCR markers linked to the gene(s) of Waxiness (*WxB*1), abiotic (drought) stress related (*DREB*), vivipary (*Vp*1*B*3), leaf rust resistance (*Lr*), photoperiod response (*PD*1), vernalization (*Vrn*) and aluminum tolerance (*Almt*).

The dendrogram constructed using these STS and more than 40 SSR markers depicted the genetic relationships among genotypes. Two separate clusters one for durum and the other for bread wheat was constructed. A close look

to the dendrogram shows that among the durum, the lone entry HI8823 is clearly distinct from already existing varieties as checks. In case of bread wheat DBW332 have closeness to HI1636 followed by the duo DBW296 and MP1358. However, entries such as DBW327, WH1252 and GW513 are appearing distinctly when the AVT entries are compared among themselves.





Bread wheat *Durum wheat*

Dendrogram showing diversity among AVT final year entries and checks

Promising varieties in Advanced Varietal Trials

Out of 66 genotypes evaluated in AVTs of different zones during this crop season, 12 genotypes were identified to be superior on the basis of their yield performance and response to the incidence of rusts and blast diseases. PBW826 has been promoted in both North Western and North Eastern Plains Zone. In the Special Trials, 20 entries were evaluated and four entries were found promising in SPL-High Yield Potential in NWPZ and one entry in CZ.

Most promising varieties in AVTs and Special trials

Zone	Timely sown, irrigated	Late sown, irrigated	Timely sown, RI
NWPZ	PBW826		HD3369, HI1653, HI1654
NEPZ	PBW826#	PBW833, DBW316#	
CZ	HI1650, MP3535		HI8830(d), CG1036
PZ	HI8826(d), MACS4100(d)	DBW 320	
Special trials HYPT			
NWPZ	DBW370, DBW371, DBW372#, PBW872#		
CZ	DBW372#		

#denotes resistance to wheat blast

Report on adaptive cum exploratory trials

During the crop season 2020-21, three adaptive cum exploratory trials were conducted in NEPZ, CZ and one in non-traditional area of Andhra Pradesh. The purpose of each adaptive trial was to identify promising entries for area extension and suitability for cultivation at farmers' field. The results indicated that genotype DBW 187 has the potential for area extension in central zone. Similarly, wheat variety DBW 222 was tested at different KVKs in NEPZ covering states of UP, Bihar, West Bengal and Jharkhand to find out its performance for area extension to NEPZ. Two genotypes viz. DBW 222 and HD 2967 formed the first non-significant group, however, based on overall yield, the DBW 222 out-yielded all other varieties and it could be a potential candidate variety for area extension under irrigated timely sown condition of NEPZ. For non-traditional area of Andhra Pradesh, three varieties DBW 17, DBW 39 and DBW 187 were found promising.

Promising varieties in initial trials

Among the total of 252 new entries evaluated for their performance in different NIVTs/IVTs, only 50 entries were found promising on the basis of high yielding ability and disease resistance including 7 entries possessing high level of wheat blast resistance. In addition, two MABB derived lines were also found promising and promoted for evaluation. Out of total promising entries, 47 were of bread wheat and three of durum wheat. Fifteen entries were observed to be promising for timely sown irrigated condition, 3 for late sown irrigated condition, 28 for restricted irrigation condition and 4 for rainfed conditions.

Most promising entries in NIVTs and IVTs

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Restricted irrigation	Timely Sown rainfed
NWPZ	HD3386	DBW353	DBW358, DBW359, WH1402, WH1403, HD3397, HD3400, HD3418, UP3090	-
NEPZ	PBW852, HD3386#, HD3388	HD3392	DBW359	-
CZ	DBW352#, NWS2194#	-	HI1665, HI1666, HD3401, DBW358, DBW359, UAS3019, MACS6795, NIAW4028, CG1040, GW532, MP1377	-
PZ	UAS3015, MP3552, MP1378,	MP1380#	UAS478(d), NIAW3922, NIAW4028, HI1665, HI8839(d), HI8840(d), DBW358, DBW359	-
NHZ	-	-	-	VL2043, VL2044, HD3402, HPW481

Zone	Timely sown, Irrigated	Late sown, Irrigated	Timely sown, Restricted irrigation	Timely Sown rainfed
SPL-HYPT-ES				
NW / NEPZ	DBW 318#, DBW373#, PBW868#, PBW871	-	-	-
CZ / PZ	DBW377, PBW870	-	-	-

 # Resistant to blast

Zonal monitoring of coordinated trials and nurseries

Multidisciplinary teams constituted to monitor trials in the four zones visited centres during February to April, 2021 for assessing the conduction of trials and performance of test genotypes. In NHZ, virtual monitoring was carried out. Out of total 100 trial conducting centres, monitoring of 67 centres (67%) was conducted during this crop season. The collective decisions of the monitoring team members on acceptance/rejection of a trial were considered during preparation of the monitoring reports.

Trials rejected by zonal monitoring teams

Zone	Centre	Trials
NWPZ	Bawal	AVT-IR-TS, AVT-IR-LS, AVT-RI-TS
	Ujhani	AVT-RI-TS
	Shikohpur (NC)	AVT-RI-TS
	Sriganganagar	AVT-IR-LS
NEPZ	Araul	AVT-IR-LS
	Gauria Karma,	AVT-RI-TAS
	Gorakhpur	AVT-RI-TAS
	Daleep Nagar	SPL-AST
	Lucknow	SPL-AST
CZ	Bilaspur	AVT-IR-TS, AVT-RI-TS, NIVT-2 & 4
	Sagar	AVT-IR-LS, NIVT-3B
	Amreli	AVT-RI-TS
PZ	Kolhapur	AVT-IR-TS, AVT-RI-TS, SPL-Dic., NIVT-2, 4, 5B
	K. Digraj	AVT-RI-TS, SPL-Dic.
	Ugar Khurd	NIVT-2
	Bagalkot	NIVT-5B
NHZ	Ranichauri	IVT-LS-RI, IVT-RF-TS

The comments of the zonal teams about genetic purity of test genotypes were compiled for promotion/ dropping of a particular test entry. Based on reports from different monitoring teams, this year 14 test entries have been dropped from further testing.

Seed Production

During 2020-21, a total indent of 17066.35q breeder seed of 163 wheat varieties was received from DAC&FW, New Delhi for its production and supply to 14 states, six public sector agencies (NSC, IFFDC, KRIBHCO, NFL, Hindustan Insecticide Ltd. and NAFED) and National Seed Association of India (NSAI). Maximum indent was for HD3086 (1700.60q) followed by HD2967 (1659.00q) and DBW187 (1617.35q). All the top ten indented varieties shared >55% in the total indent.

Top indented varieties in breeder seed chain during 2020-21

SN	Variety	Year of Notification	DAC Indent (q)	Breeder Seed Production (q)	Surplus/ Deficit (q)
1	Pusa Gautami (HD3086)	2014	1700.60	1528.80	-171.80
2	HD 2967	2014	1659.00	1734.00	75.00
3	KARAN VANDANA (DBW187)	2019	1617.35	2315.00	697.65
4	PUSA YASHASVI (HD3226)	2019	1151.30	1175.00	23.70
5	HI8759 (PUSA TEJAS8759)	2017	846.20	420.00	-426.20
6	RAJ4238	2016	676.40	807.41	131.01
7	Unnat PBW343(PBW723)	2017	593.00	620.00	27.00
8	KARAN NARENDRA (DBW222)	2020	506.30	880.00	373.70
9	HD2851(Pusa Vishesh)	2005	352.10	360.00	7.90
10	MP3382	2016	308.40	502.00	193.60
	Total		**9410.65**	**10342.21**	**931.56**
	Per cent share		**55.1%**	**51.3%**	

Also, breeder seed indent of 868.40q (5.1%) of 7 recently released wheat varieties (DBW 222, DDW 47, PBW 771, HI 1628, HD 3271, HD 3249 and DBW 252) notified during 2020 was received for production.

Breeder Seed Production: The total breeder seed production during the season was 20146.24q with surplus production of 3936.44q. The highest quantity of breeder seed was produced for DBW187 (2315.0q) followed HD2967 (1734.0q) and HD3086 (1528.80q). Variety HI8759 (Pusa Tejas) was produced deficit (-426.20q) against the indent (846.20q). Four BSP centres viz., IARI, Pusa (Bihar) (-567.15q), CCSHAU, Hisar, UAS Dharwad (-56.0q each) and RVSKVV, Gwalior (-17.0q) produced deficit breeder seed against the indent.

Nucleus Seed Production: Against an allocation of 431.75q nucleus seed of 128 wheat varieties, 961.54q of nucleus seed was produced with a surplus of 529.79q by 31 centres out of 33 centres (except SVBPUA&T, Meerut and SKUAST, Jammu). IARI-RS, Indore produced highest quantity (203.50q) of nucleus seed followed by JNKVV. Jabalpur (135.30) and PAU, Ludhiana

(85.80q). The maximum nucleus seed of variety MP3382 (80.0q) was produced followed by MP3288 (44.0q), HI8713 (40.0q) and Lok1 (35.0).

Test Stock Multiplication: National Seed Corporation has reported a total of 338.0q test stock multiplication of 7 out of 9 newly identified wheat varieties namely, HD3298 (84.0q), HD3293 (75.0q), HI1633 (71.0q), DBW303 (47.0q) HI1634 (36.0q), NIDW1149 (18.0q) and DDW48 (7.0q) during 2020-21 at its farms. The test stock of CG1029 was rejected by the monitoring team due to impurity and WH1270 could not be multiplied due to non-supply of basic seed to NSC.

Evaluation of National and International Nurseries/Trials

National Nurseries

During 2020-21, six national nurseries including SSN were constituted by ICAR-IIWBR and shared with centres across zones in the country for evaluation and utilization.

Nursery	Entries + Checks	Locations
National Genetic Stock Nursery (NGSN)	90+3	31
Short Duration Screening Nursery (SDTSN)	14+6	24
Drought Tolerance Screening Nursery (DTSN)	41+8	15
Salinity-alkalinity Tolerance Screening Nursery (SATSN)	34+2	10
Quality Component and Wheat Biofortification Nursery (QCWBN)	50+6	12
Segregating Stock Nursery (SSN)	216	25

International Nurseries and Trials

The ICAR-IIWBR, Karnal procured 1593 lines (1412 bread wheat and 181 lines of durum wheat) from CIMMYT, Mexico and 460 lines (340 bread wheat and 120 lines of durum wheat) from ICARDA, Morocco in form of different nurseries/trials that were evaluated at various wheat breeding centres during the crop season 2020-21. One set of each nursery/trial was planted at ICAR-IIWBR, Karnal for evaluation to facilitate in-situ selections and also disease screening particularly stripe rust.

Screening against wheat blast: A set of 350 wheat lines (test entries, pipeline material and new checks) were screened against wheat blast in Bangladesh during 2020-21. Among these 350 total lines, 250 were new AICRP test entries while remaining 100 were contributed from ICAR-IIWBR breeding programmes. Based on the disease score across two dates of sowings, 170 (70+100) resistant genotypes were shortlisted and are presented in the table below.

Wheat blast resistant genotypes

Wheat Blast reaction	AICRP /IIWBR	Genotypes	Total
0, 0 (Free)	AICRP	BRW3902, DBW342, DBW343, DBW348, DBW350, DBW352, DBW357, DBW366, DBW371, DBW372, DBW373, DBW374, DBW375, DBW378, HD3386, HD3400, HD3401, HD3405, HUW845, HUW847, MP1379, MP1380, NW8010, NW8013, NW8017, NWS2194, PBW849, PBW853, PBW856, PBW859, PBW860, PBW866, PBW868, PBW871, PBW875, UP3080, UP3084, UP3085, UP3088, UP3091, UP3094, WH1215, WH1292, WH1407 and Bari Gom33 (Check)	44
	IIWBR	DWAP-B-2001, DWAP-B-2002, DWAP-B-2003, DWAP-B-2005, LBP-2019-1, LBP-2019-17, LBP-2019-18, LBP-2019-2, LBP-2019-22, LBP-2019-7, NEP 2020-1, NEP2020-2, NEP 2020-3, PBS 1001, PBS1002, PBS1003, QYB-2002, QYB-2004, QYB-2005, QYB-2011, QYB-2014, QYB-2015, RWP1, RWP13, RWP6, RWP8	26
Total			**70**
Upto 10 (Resistant)	AICRP	BRW3895, BRW3897, BRW3901, DBW344, DBW345, DBW346, DBW347, DBW349, DBW351, DBW353, DBW354, DBW356, DBW358, DBW359, DBW360, DBW361, DBW362, DBW363, DBW364, DBW370, DBW377, HD3385, HD3391, HD3393, HD3394, HD3395, HD3397, HD3398, HD3399, HD3403, HD3404, HD3406, HD3410, HI1662, HI1661, HI8835(d), HP1971, HP1973, HUW844, HUW846, JKW287, KRL1912, KRL1914, MP1377, MP3541, MP3542, MP3545, MP3552, NIAW3923, NIAW4028, NW8004, NW8012, NW8019, NW8022, PBW852, PBW862, PBW872, PBW873, RAJ4555, RAJ4559, TAW119, TAW123, UAS3015, UP3082, UP3083, UP3086, UP3090, UP3096, WH1293, WH1295, WH1296, WH1299, WH1404, WH1406	75
	IIWBR	CB2005, CB2006, CB2007, DWAP-B-2006, DWAP-B-2010, DWAP-B-2014, DWAP-B-2015, EC609396, IC427824, LBP-2019-14, LBP-2019-15, LBP-2019-19, LBP-2019-24, PBS1006, QLD112, QYB-2003, QYB-2006, QYB-2009, QYB-2010, QYB-2012, QYB-2013, RWP15, RWP3, RWP5, RWP7	25
Total			**100**

Physiological studies on heat and drought stress tolerance: In order to identify the heat and drought tolerant lines among AVT genotypes; two sets of trials (MLHT-1 for NWPZ/NEPZ and MLHT-2 for CZ/PZ entries) were evaluated under timely sown (TS), late sown (LS) and drought (DR) conditions at 8 locations for each trial during 2020-21. The pooled analysis of MLHT-1 revealed that the HSI values ranged from 0.70 to 1.3 and DSI values ranged from 0.78 to 1.24. Whereas, in MLHT-2, the HSI values ranged from 0.33 to 1.69 and DSI values varied from 0.80 to1.13. The promising genotypes identified based on heat and drought stress tolerance indices in MLHT are listed below.

Genotypes identified as heat/drought tolerant during 2020-21

Zone	Heat tolerant	Drought tolerant
NWPZ & NEPZ	DBW327 (0.81), DBW333 (0.7), JKW261 (0.88).	DBW296 (0.98), DBW327 (0.78), DBW328 (0.99), DBW333 (0.98), HUW838 (0.95), JKW261 (0.93), WH1252 (0.98).
CZ&PZ	GW513 (0.91), HI1636 (0.71), MP1358 (0.78).	GW513 (0.8), MP1358 (0.9).

Values in the parenthesis indicate HSI/DSI

CROP PROTECTION

The crop protection programme aims to minimize yield losses of wheat and barley caused by biotic stresses through strict surveillance, identification of resistance sources, strategic deployment of resistant cultivars, and development of management strategies. Besides it works in hand to hand with breeding programme to develop disease and insect pest resistant varieties.

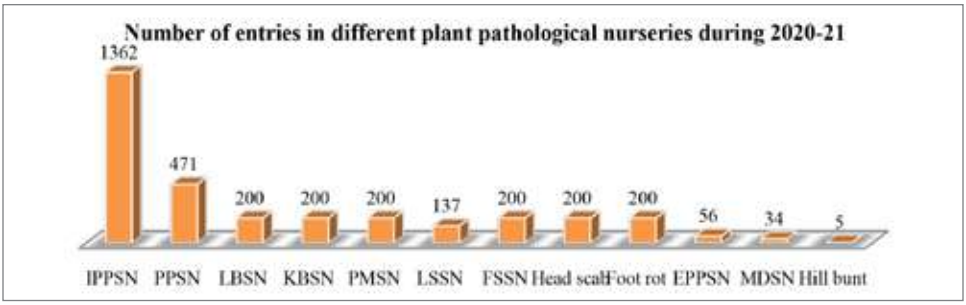
PATHOLOGY

Survey and surveillance for diseases

During 2020-21, to monitor the wheat and barley crop health, regular surveys were conducted with major emphasis on occurrence of yellow rust in NWPZ and surveillance for wheat blast in NEPZ. The surveys were conducted by the wheat scientists of different cooperating centres including ICAR-IIWBR Karnal and information was shared through the *"Wheat Crop Health Newsletter"*, Vol. 26 (Issues 1 to 5) which was issued during the crop season and also uploaded on ICAR-IIWBR website (https://iiwbr.icar.gov.in/). The first appearance of yellow rust of wheat was reported from village Pattii (Manakpur) block Sh. Anandpur Sahib, Rupnagar District of Punjab on 17.1.2021 on variety HD3226 and another report of yellow rust was from village Mangoli Jatan of Kurukshreta district in Haryana on variety HD2967. During the crop season in February there was a sudden rise in the temperature which is uncongenial for rusts. Therefore, the disease severity and spread remained low and there were minimal losses due to disease especially in NWPZ and NEPZ. 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.

Host resistance

Advance breeding material as well as pre-coordinated test entries were evaluated against disease and insect pests resistance at various hot spot locations under artificially inoculated conditions. The major nurseries were: Initial Plant Pathological Nursery (IPPSN), Plant Pathological Nursery (PPSN), Elite PPSN (EPPSN), Multiple Disease Screening Nursery (MDSN), and disease / insect pest specific nurseries. The numbers of entries tested under different plant pathological nurseries are as:



Constitution of different plant pathological nurseries during 2020-21

Entries and check varieties identified resistant against rusts in advance breeding trials

Rust resistance materials in AVT entries (2020-21) with ACI upto 10.0 are given below

Stem, Leaf and Stripe rusts

VL907 (C), PBW876, RAJ4548, PBW771 (C), DBW173 (C), HUW838, HI1654, DBW296, HI1628 (C), HD3369, HD3249 (C), DBW187 (C), DBW318, UP3060, DBW316, HD3368, HI1654, HD3369, K1317 (C), UP3062, HI8833(d), HI8832(d), HI8713(d) (C), HD3407, DDW47(d) (C), DBW326, HI8627(d) (C), HI8830(d), WHD965(d), UAS428(d) (C), MACS4100(d), MACS3949(d) (C), NIDW1345(d), MACS4106(d), HI8828(d), HI8827(d), MP1358, NIDW1149(d)(I)(C), UAS446(d) (C), DBW327, HD3410, DBW187(I) (C), WH1270(I) (C), DBW303(I) (C), HD3413, PBW867, DBW318, DBW187(I) (C), PBW870.

Stem and leaf rusts

VL2041, HD2967 (C), K1910, NIAW3170 (C), DBW39 (C), HD2967 (C), HI1563 (C), GW322 (C), MP3535, GW523, GW513, HI1636, MACS6768, HI1544 (C), HI1667, HI1650, HD2864 (C), HI8823(d), GW528, CG1036, HI1655, MP3288 (C), DDW55(d), HI8826(d), MACS6222 (C), HD3090 (C), HI1633(I) (C), HI1651, MACS6753, NIAW3170 (C), MACS5058, MACS6222(*a*) (C), DDK1029 (C), DDK1061, HW1098 (C), MACS5057, DDK1060, PBW872, WH1406, UP3096, WH1404, UP3095.

Stem and Stripe rusts

HPW349 (C), HS507 (C), PBW826, PBW838, WH1142 (C), UP3062, PBW826, DBW317, PBW848.

Leaf and Stripe rusts

DBW187 (C), HD3349, WH1283, HD3368, PBW835, PBW833, UAS475(d), DDW53(d), NIDW1348(d), DDW48(d)(I) (C), DBW325, UAS3014, DBW328, DBW370, WH1252, PBW874, DBW332, DBW375, DBW378, HD3405, DBW377, PBW869, PBW871, WH1407, DBW368, DBW363, K1805.

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 +

- **KB + FS:** NIDW 1158 (d), HI 8811b (d), GW 1348 (d), NIDW 1149 (d), HI 8802, DBW 302, PBW 820
- **LB+ KB + FS:** HI8805 (d)
- **KB:** HI 8807 (d)
- **LB + FS:** WH 1270, VL 3020
- **FS:** PBW 822, HI 8812 (d), HI 8808 (d), PBW 823, PBW 821, HPW 467

B. Resistant to Stem and Leaf rust +

- **KB + FS:** CG 1029, HI 1633, HI 1634, GW 509

C. Resistant to leaf and stripe rust +

- **LB + KB+ FS:** PBW 752, UP 3043
- **KB + FS:** DDW 48 (d), DDW 47 (d), VL 3021, PBW 825, PBW 796, DBW 303
- **KB:** PBW 771, HI 1628
- **FS:** WHD 963 (d)

Lr80: A new and widely effective source of leaf rust resistance in wheat identified from India

A wheat land race Hango-2, collected in 2006 from the Himalayan area of Hango, of Kinnaur district in Himachal Pradesh, exhibited a low infection type (IT;) at the seedling stage to all the Indian pathotypes of *P. triticina*,

except the pathotype 5R9-7 which produced IT 3+. Pathotype 5R9-7(16-1) does not infect bread wheat cultivars, however, it is virulent on tetraploid wheat Khapli. Pathotype 5R9-7 is not prevalent in nature for the last 15 years. Genetic analysis based on Agra Local/Hango-2-derived F_3 families indicated monogenic control of leaf rust resistance, and the underlying locus was temporarily named *LrH2*. Bulked segregant analysis using 303 simple sequence repeat (SSR) markers located *LrH2* in the short arm of chromosome 2D. An additional set of 10 chromosome 2DS-specific markers showed polymorphism between the parents and these were mapped on the entire Agra Local/Hango-2 F_3 population. *LrH2* was flanked by markers *cau96* (distally) and *barc124* (proximally). The 90 K Infinium SNP array was used to identify SNP markers linked with *LrH2*. Markers *KASP_17425* and *KASP_17148* showed association with *LrH2*. Comparison of seedling leaf rust response data and marker locations across different maps demonstrated the uniqueness of *LrH2* and it was internationally designated as *Lr80*.

This is the 6th rust resistance gene reported from India (others being *Lr10*, *Lr48*, *Lr49*, *Lr57*, and *Lr58*). *Lr80* is being used to develop rust resistant genetic stocks and wheat varieties. It will help in creating diversity and management of leaf rust in India.

Pathotype distribution of Puccinia species on wheat and barley

During 2020-21, 430 samples of three rusts of wheat, and stem rusts of barley were analyzed from thirteen Indian states, and Nepal.

Stripe rust of wheat and barley (*Puccinia striiformis*)

Population of wheat stripe rust was avirulent to *Yr5, Yr10, Yr13, Yr15, Yr16* and *YrSp*. Six pathotypes were identified in 118 samples of stripe rust on wheat. During the cropping season frequency of pathotype 238S119 was maximum (49.57%) followed by 110S119 (29.41%), first identified in 2013-14. The frequency of 46S119 (virulent on *Yr2*, *Yr3*, *Yr4*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr17*, *Yr18*, *Yr19*, *Yr21*, *Yr22*, *Yr23*, *Yr25*, *Yr*A) was reduced to 15.12%. Pathotypes 47S103, 110S84 and 6S0 were identified in 4, 2 and 1 samples, respectively.

Stem rust of wheat (*P. graminis* f. sp. *tritici*)

Eight pathotypes of *P. graminis tritici* were identified from 91 samples of wheat stem rust. Population analyzed during the year had avirulence to

Sr26, Sr27, Sr31, Sr32, Sr35, Sr39, Sr40, Sr43, SrTt3 and *SrTmp*. Pathotype 11 (79G31), virulent to *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, Sr*McN was recorded in more than 50% of the samples analyzed during the season, followed by 40A (62G29;15.3%) and 40-3 (127G29;14.28%).

Predominant pathotypes of *Puccinia* on wheat in India

Wheat Rusts	Predominant pathotypes
Stem	79G31(11), 62G29(40A) and 127G29 (40-3)
Leaf	121R60-1(77-9), 121R63-1,7 (77-13) and 121R63-1(77-5)
Stripe	238S119, 110S119 and 46S119

Other pathotypes were observed in few samples only. Diversity of black rust pathogen was highest in Wellington (Tamil Nadu).

Leaf rust of wheat (*P. triticina*)

A total of 221 samples of wheat leaf rust were pathotyped from 12 states of India and neighbouring country Nepal. Seventeen pathotypes were identified in these samples. Pathotype 77-9 (121R60-1) was the most widely distributed and occurred in 57% of the samples followed by 52-3 (121R60-1,7) in 20.3% samples. Pathotype 77-5 (121R63-1), which remained most predominant for more than 20 years was observed in 12.2% samples only. The remaining 14 pathotypes were identified in 11.5% samples only. In Nepal 10 pathotypes were observed in 49 samples. The predominance of pathotypes was almost like India and pts. 77-9(121R60-1) and 52-3(121R60-1,7) were most prevalent.

Seedling resistance to rusts and characterization of *Lr*, *Sr* and *Yr* genes in AVT material during 2020-21

To know rust resistance in wheat and barley, more than 4800 lines were evaluated at seedling stage during 2020-21. Among these, 342 lines including 200 of wheat AVT and 142 of NBDSN/EBDSN were subjected to multi-pathotype screening under controlled light and temperature conditions. Seedling rust resistance remains effective throughout the life of wheat plants. AVT I and II lines of wheat were screened at seedling stage against 62 pathotypes of three species of *Puccinia*. Sixteen pathotypes of stripe rust, 23 each of stem and leaf rust pathogens, which are most virulent and predominant were used for evaluation.

i. Rust Resistant Lines

The wheat lines showing resistance to one or other rusts are presented below:

Rust resistant wheat lines in AVT I and II

Rusts	No. of lines	Detail of lines
Leaf, stem and stripe	03	HD3407, PBW835, PBW867
Leaf and stem	17	CG1029, GW513, GW528, HD2864, HI1544, HI1563, HI1636, HI1650, HI1651, HI1667, MACS6222, MACS6753, MACS6755, MP3288, MP3535, MP4010, UP3095
Leaf and stripe	01	PBW869
Stem and stripe	01	HD3413
Leaf only	18	DBW316, DBW366, DBW375, DDW47, DDW55, HD3090, HD3349, HD3354, HD3410, HI1633, HI1634, MACS3949, MACS6768, PBW833, PBW869, UAS446, UAS475, WHD965
Stem only	19	DBW110, DBW303 (I) (C), DBW318, DBW326, DBW364, DBW374, DBW377, DBW378, HI1655, HI8833, HUW838, K1317, K1910, PBW868, PBW870, PBW872, UP3096, WH1404, WH1406
Stripe only	03	DBW376, PBW874, HD3412

Three AVT entries *viz*. HD3407, PBW835, PBW867 were resistant to all the pathotypes of *P. graminis tritici*, *P. triticina* and *P. striiformis*. Resistance to stem and leaf rusts was observed in 17 entries while resistance to leaf & stripe, and stem & stripe rusts was observed on PBW869 and HD3413, respectively. Eighteen lines were found resistant to leaf rust whereas 19 to stem rust pathotypes. Three entries (DBW376, PBW874, and HD3412) conferred resistance only to stripe rust pathotypes.

ii. Characterization of rust resistance genes

Yr genes

Among the 200 lines of AVT, *Yr* genes were characterized in 113 lines. *Yr* genes were postulated in lines where differential interactions were observed and in other cases tight linkage of *Yr* genes to other *Lr* and *Sr* genes also facilitated the inference for the presence of a resistance gene. Four *Yr* genes viz. *Yr2*, *Yr9*, *YrA* and *Yr18* contributed to stripe rust resistance in Indian wheat material. Among the postulated *Yr* genes *Yr2* was the most common and characterized in 89 lines. *Yr9* and *YrA* were postulated in 15 and 11 entries, respectively, whereas *Yr18* was characterized only in HD2733(C).

Diversity for rust resistance in AVT lines

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Stripe	113	Four: *Yr2, 9, A, 18*
Leaf	134	Nine: *Lr1, Lr3, Lr10, Lr13, Lr23, Lr24, Lr26, Lr28* and *Lr34*
Stem	1143	Thirteen : *Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30* and *Sr31*

***Sr* genes**

Thirteen stem rust resistance genes (*Sr*2, *Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30* and *Sr31*) were characterized in 143 AVT lines. The frequency of *Sr2* was maximum and was postulated in 62 AVT entries followed by *Sr11* and *Sr7b*, which were characterized in 43 and 34 lines, respectively. *Sr31* linked with *Lr26* and *Yr9* and conferring resistance to all the known *Pgt* pathotypes in Indian subcontinent was postulated in 15 AVT entries, while *Sr24* linked to *Lr24* was characterized in 14 entries. Other *Sr* genes i.e. *Sr13, Sr8a, Sr5, Sr30, Sr9b, Sr28, Sr9e, Sr8b* were postulated in 19, 15, 14, 112, 5, 3, 2 and 1 entries, respectively. The *Sr* genes were characterized singly or in combination of up to four genes. Two entries KRL19 (C) and DBW252 (C) had combination of four *Sr* genes viz. *Sr8b+9b+11+2+* and *Sr8a+5+11+2+*, respectively.

***Lr* genes**

Nine *Lr* genes viz. *Lr1*, *Lr3*, *Lr10*, *Lr13*, *Lr23*, *Lr24*, *Lr26, Lr28* and *Lr34* were characterized in 134 lines. *Lr13* was the most commonly occurring leaf rust resistance and was characterized in highest number of lines (66) followed by *Lr10* (49 lines), *Lr23* (45 lines) and *Lr1* (32 lines). *Lr24* was postulated in 14 entries. *Lr26* and *Lr3* were characterized in 15 and 11 entries, respectively. *Lr34* and *Lr28* were postulated only in HD2733 and PBW874, respectively. Majority of the resistant genes occurred in combination and many of the lines have leaf rust resistance derived from 3 or more *Lr* genes.

Rust resistance in barley NBDSN and EBDSN lines during 2020-21

All the NBDSN and EBDSN lines were screened against different pathotypes of three rusts of barley under precise conditions of temperature and light. To ascertain consistency of reaction types selected screening was undertaken. These lines were evaluated against seven pathotypes of *P. striiformis hordei* (24, 57, M, G, Q, 6S0 and 7S0), five pathotypes of *P. graminis tritici* (11, 21A-2, 40A, 117-6 and 295), and 5 isolates of *P. hordei* (H1, H2, H3, H4 and H5). None of the NBDSN and EBDSN entries was resistant to all the tested pathotypes of Pst, Pt and Pgt. The detailed information is presented below:

NBDSN

A total 108 entries of NBDSN were evaluated against the different pathotypes of *Puccinia* spp. on barley.

Seedling rust resistance in NBDSN during 2020-21

Rusts	No. of lines	Lines
Leaf and stripe	04	HUB279, RD3016, RD3039, RD3042
Stripe and stem	01	DWRB182 (C)
Stripe	17	BHS484, DWRB137 (C), DWRB222, HUB113 (C), PL911, PL917, RD2794 (C), RD2899 (C), RD3031, RD3032, RD3033, RD3034, RD3037, RD3041, UPB1091, UPB1092, UPB1095,
Leaf	17	BH1034, BH1037, BHS380 (C), BHS400 (C), HBL869, HBL870, HBL872, HBL873, PL929, RD3013, RD3028, RD3035, RD3036, RD3038, VLB118 (C), VLB170, VLB173

None of the lines was resistant to all three rusts of barley. Four lines (HUB279, RD3016, RD3039, and RD3042) were resistant to both leaf and stripe rust pathotypes/isolates. DWRB182 was resistant to stripe and stem rust pathotypes. In addition 17 lines each was resistant to stripe and leaf rust pathotypes only. Resistance to all the pathotypes of *P. graminis tritici* was observed only on DWRB182.

EBDSN

Twenty three EBDSN lines were evaluated for resistance to three rusts by using seven pathotypes of *P. striiformis hordei*, five of *P. graminis tritici,* and 5 of *P. hordei*. Resistance to all three rusts was not recorded on any EBDSN line. However, 2 lines (PL 908, RD 3016) were resistant to leaf and stripe rusts. DWRB197 was found resistant to all the pathotypes of leaf and stem rust pathogens. Resistance to all the pathotypes/isolates of *P. striiformis hordei* and *P. hordei* rusts was observed in 7 and 4 lines, respectively. DWRB197 conferred resistance to all the pathotypes of *P. graminis tritici*.

Seedling rust resistance in EBDSN during 2020-21

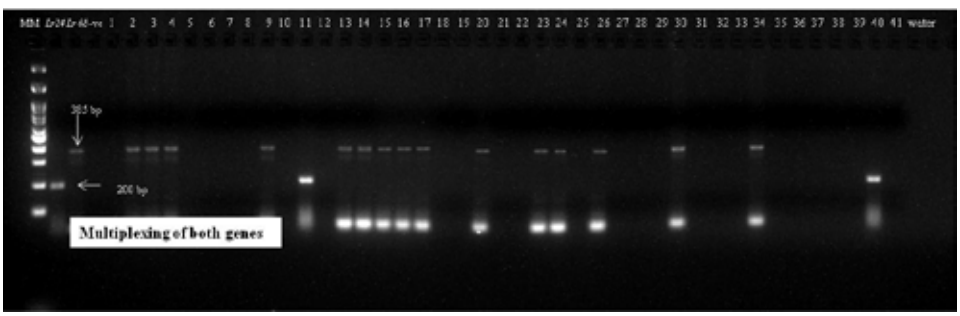
Rusts	No. of lines	Detail of lines
Leaf and stripe	02	PL 908, RD 3016
Leaf and stem	01	DWRB 197
Stripe	07	DWRB 210, KB 1817, KB 1830, RD 2552, RD 2794, RD 2899, RD 2907
Leaf	04	DWRB 217, HBL 113, VLB 118, VLB 168,

Identification of rust resistance genes through molecular markers

Accessions HD2851 and KRL2029 showed resistance to all the pathotypes of stem and leaf rusts at seedling stage and molecular marker analysis showed the presence of *Lr24/Sr24* in both the lines, whereas KRL2029 has *Lr26/Sr31/Yr9*. *Yr18/Lr34/Sr57* was amplified in twelve wheat genotypes while *Yr9/Lr26/Sr31* in eleven genotypes. Eight tested wheat genotypes showed the presence of *Yr17/Lr37/Sr38***.**

Development of multiplex PCR assay for detection of *Lr24* and *Lr68*

Multiplex PCR assay for leaf rust resistance genes *Lr24* and *Lr68* was developed. The PCR condition was standardized and optimized for amplification of genes *Lr24* and *Lr68* in a single PCR reaction. An amplification product of 200bp was observed in two wheat genotypes which confirmed the presence of *Lr24/Sr24*. However, amplified product of *CsGs-STS* molecular marker in the form of specific band of size 385 bp, evince the presence of *Lr68* in 15 wheat genotypes (KRL210, KRL213, KRL19, KRL238, KRL2002, KRL2003, KRL2004, KRL2005, KRL2006, KRL2009, KRL2012, KRL2013, KRL2015, KRL2019 and KRL2023).

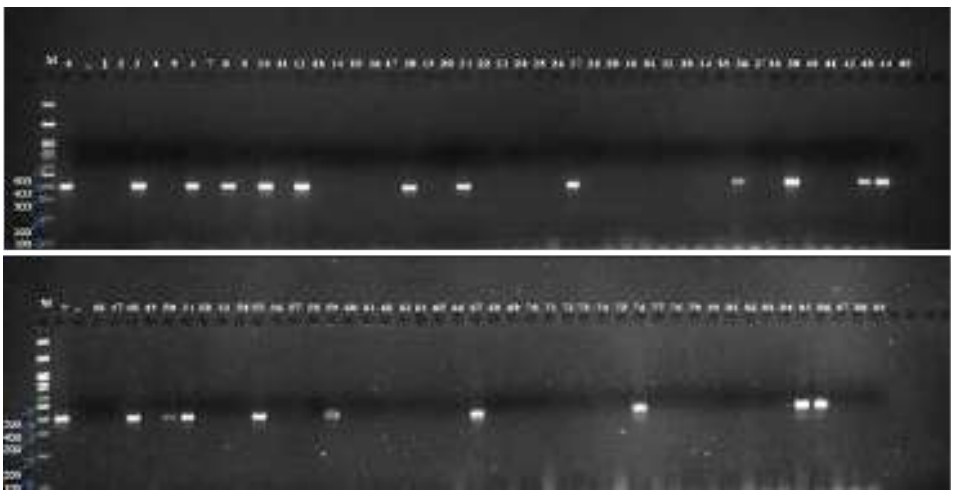


Electrophoresis on 2.5% agarose gel showing the presence of markers *Sr24#50* and *CsGs-STS* simultaneously. Lane 1, MM- GeneRuler 100 bp DNA ladder; Lane 2 (*Lr24*)– *Lr24* NIL as positive check for gene *Lr24*; Lane 3(*Lr68*) -*Lr68* NIL as positive check for gene *Lr68*; Lane 4(-ve)- LWH as negative check; Lane 5 to 45 - wheat genotypes 1-41; lane 46, 47(W)- water.

Validation of rust resistance genes

A panel of 81 wheat germplasm lines comprising genetic stocks, released wheat varieties as well as landraces were genotyped to check the presence of leaf rust resistance genes *Lr67* and *Lr68* through known molecular

markers. Out of 81, 6 genotypes i.e. Agra local, NP856, NP876, NP880, NP850, and NP101 showed presence of *Lr67* gene whereas presence of *Lr68* was confirmed in 4 genotypes (WH291, HD3043, FLW21, FLW22) only. Similarly, a panel of 89 releases wheat varieties was tested genotypically for the presence of *Lr68* genes. Out of 89, 21 varieties namely DBW90, DBW110, HD3043, HD3086, HD3118, HS542, HW5216, PBW644, UAS446, WH1124, NIAW34, HD2967, HPW251, HS507, VL804, MP1277, WH1021, HD2932, MACS6222, KRL19 and KRL210 were reported to possess *Lr68* gene.



Genotyping of eighty nine wheat varieties for presence of Lr 68 with the help of CsGS-STS primer; M-100 bp ladder, +(positive check)-Parula, - (negative check)-LWH, 3-DBW90, 6-DBW110, 8-HD3043, 10- HD3086, 12- HD3118, 18- HS542, 20- HW5216, 27- PBW644, 35- UAS446, 39-WH1124, 43- NIAW34, 44- HD2967, 48- HPW251, 50- HS507, 51- VL804, 55-MP1277, 59- WH1021, 67- HD2932, 75- MACS6222, 85-KRL19, 86- KRL210

Genetics of resistance and developing rust resistant genetic stocks

Pyramiding multiple rust resistance and generation advancement

The genetic stocks developed at ICAR-IIWBR, Regional Station, Shimla were screened against new pathotypes of *P. triticina* and *P. striiformis*. The resistant genetic stocks were selected and crossed in different combinations by considering their pedigree to develop genetic stock as well as to select other desirable recombinants.

The existing F_1 generations of the crosses between genetic stocks FLW3, FLW15, FLW17 & FLW19 and isogenic lines *Lr39*, *Lr22a* with Hango-2 carrying *Lr80* were advanced to F_2.

Development of rust resistant genetic stocks with salinity tolerance

In a search for new sources of resistance, 41 salinity tolerant lines obtained from ICAR-CSSRI, Karnal were evaluated for rust resistance at seedling stage. Of these, two lines namely KRL2024 and KRL2029 conferred resistance to the pathotypes of both leaf rust and stem rust. These were crossed with available genetic stocks for yellow rust resistance to pyramid multiple rust resistances with salinity tolerance.

Breeding for durable rust resistance

The short lived nature of the major genes has created the necessity to search for more durable type of resistance. The most efficient and best strategy to control the rusts lies in combining genes irrespective of whether the genes are minor or major. For achieving durable rust resistance best strategy is the utilization of slow rusting genes in combination with major genes. Impact of slow rust resistance genes in combination with major resistance genes to achieve durable resistance/near immunity has been undertaken in few cases only. Therefore, to estimate cumulative effect of slow ruster (SR) genes *(Lr34, Lr46, Lr67*) with major seedling leaf rust resistance (R) genes (*Lr26*) and adult plant resistance genes (APR *Lr13, Lr23* and *Lr10*) isogenic lines for these genes were planted and crossed.

Evaluation of advanced breeding lines for rust resistance

Four populations of wheat were phenotyped against *P. triticina* pathotypes for genetic analysis of rust resistance.

Population	Generation	Pathotype
LWH/HD2922	F_9	77-5
MACS5008/Local Red	F_6	77-5
LWH/UAS347	F_5	104-2
LWH/Lok-1	F_{10}	77-8

Utilization of resistance sources

Twenty one confirmed sources of disease resistance were identified and shared among 16 breeding centres across different agro climatic zones of country for their utilization in breeding for resistance to biotic stresses The most utilized entries were DBW 246 and PBW 757. Junagarh centre, utilized a maximum of 9 entries in their breeding programme, followed by Indore.

National repository of pathotypes of *Puccinia* species on winter cereals

More than 150 pathotypes of *Puccinia* species on wheat, barley and oat as well as *Melampsora lini* on linseed were maintained at ICAR-IIWBR, Regional Station, Flowerdale, Shimla (H.P.) and kept in long term storage also. To create artificial epiphytotics and conduct studies on wheat rusts elsewhere in India, nucleus/ bulk inocula of different pathotypes/mixture of pathotypes were supplied to 53 Scientists.

Wheat disease monitoring/ SAARC nursery

To keep an eye on the appearance of wheat diseases and their spread, Wheat disease monitoring nursery was planted at 38 locations during 2020-21. Information on wheat disease situation was received from Dhaulakuan, Malan (Kangra), Bajaura, ICAR-IARI Tutikandi, Shimla and ICAR-IIWBR, Shimla in Himachal Pradesh; Jammu, Kathua, Khudwani and Rajouri in Jammu and Kashmir; Pantnagar and Hawalbagh (Almora) in Uttarakhand; Hisar in Haryana; SBS Nagar, Ludhiana, Gurdaspur and Ropar in Punjab; RARI, Durgapura in Rajasthan, Sabour and Pusa in Bihar; Kanke (Ranchi) in Jharkhand; Faizabad, Araul (Kanpur) and Varanasi in Uttar Pradesh; Ladol (Vijapur) and Mangrol (Junagarh) in Gujarat; Raipur in Chhattisgarh, Indore and Khojanpur (Powarkheda) in Madhya Pradesh; A.R.S. Baner (Pune), WRU, Akola and ARS Niphad in Maharashtra; Ugar Khurd (Dharwad) in Karnataka and Wellington in Tamil Nadu.

Rust diseases were not recorded on any of the entries of WDMN planted at Tutikandi, Shimla, Raipur, Ranchi, Vijapur, Junagarh, Indore, Powarkheda, Akola and Niphad. The stripe rust was reported from all the locations of NHZ and NWPZ except at ICAR-IIWBR, RS, Shimla and ICAR-IARI Tutikandi, Shimla where all the WDMN entries were stripe rust free. All the entries of WDMN in other zones were free from stripe rust except at Kanpur in NEPZ, where stripe rust appeared on two WDMN entries. Stripe rust was very severe at many locations at NWPZ and NHZ, with severity of more than 40S was reported on many entries. Leaf rust was reported from Almora and Shimla in NHZ; and Kathua, Jammu, Hisar, Pantnagar, Gurdaspur, SBS Nagar and Ludhiana in NWPZ. Leaf rust appeared at all the locations of NEPZ except Ranchi. All the WDMN entries were brown rust free at the locations in CZ. It also appeared at Pune and Dharwad in PZ, and Wellington in SHZ. Of the 32 locations of WDMNs, stem rust was observed only at Pune and Dharwad in PZ and Wellington in SHZ. Leaf blight was reported from WDMN planted at Jammu, Kathua, and Rajouri in NWPZ; Sabour, Pusa, Ranchi, Faizabad, Kanpur, and Varanasi

in NEPZ; and Niphad and Dharwad in PZ. Kathua, Dhaulakuan, Jammu and Almora were the only locations where powdery mildew was observed on WDMN entries.

SAARC wheat disease monitoring nursery was planted at 31 locations in India, Bangladesh, Bhutan, Nepal and Pakistan. Data were received from all the countries with the exception of Pakistan.

Management of diseases through chemicals

Five different fungicides were evaluated for the management of yellow rust as well as powdery mildew of wheat during 2020-21 at different locations. All the fungicides were effective in managing the diseases in comparison to unsprayed control check. The fungicides provided maximum disease protection against yellow rust in different locations were Tebuconazole 50% + Trifloxystrobin 25% WG @ 0.06% and Picoxystrobin 7.05% + Propiconazole 11.7% SC @ 0.1%. Whereas maximum disease protection against powdery mildew infection was provided by Tebuconazole 50% + Trifloxystrobin 25% WG @0.06% and Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 0.1% across locations. Besides these, eight fungicidal combinations were evaluated against stem rust, leaf rust and *Fusarium* head scab diseases at different locations.

Strategy Planning Meetings

For the effective implementation of crop protection technologies strategy planning meeting was conducted on "Alternate crop plan to combat the wheat blast like disease" on 18.9.2020 through virtual platform. The meeting was chaired by the Agriculture Commissioner, DAC&FW, Govt. of India. It was discussed that resistant varieties need to be promoted in the disease prone areas. Five resistant varieties identified namely DBW 187, HD 3249 and HD 2967 (irrigated and timely sown) and DBW 252 and HD 3171 (restricted irrigation and timely sown) have been recommended to be grown in disease prone areas of West Bengal. It was suggested that continuous monitoring of wheat crop is required and if any suspected symptoms are observed, it should be reported to the ICAR-IIWBR immediately.

Advisory for stripe rust management: During the current season the weather remained uncongenial for diseases and pest, therefore the sporadic occurrence of yellow rust was reported from NWPZ. Need based advisory for stripe rust management was issued. Awareness among farmers for stripe rust management especially in Punjab, Haryana and Jammu was

created through mobile, internet, toll free number, newspapers, discussions and delivering lectures in farmers training programmes.

Preparedness to wheat blast

Survey were conducted in North and South West Bengal near the Indo-Bangladesh border by a team of scientists from UBKV, Cooch Behar, West Bengal and BCKV, Kalyani, Nadia, West Bengal and no wheat blast was observed. A strategy planning meeting was conducted on "Alternate crop plan to combat the wheat blast like disease" on 18.9.2020 through virtual platform. It was attended by officials from DAC&FW, Govt. of India, ICAR-IIWBR, Karnal, SAUs and state agriculture department of West Bengal. It was discussed that more emphasis should be given to grow alternate crops like pulse, oil seed, vegetables etc. instead of wheat in blast prone areas. Use of the identified resistant varieties is recommended in the wheat blast prone areas, if at all wheat is grown in these areas. It was suggested that continuous and strict monitoring of wheat crop is required. For identification of wheat blast resistant sources advance breeding lines and potential germplasm were screened at Jessore, Bangladesh and Quirassallis through CIMMYT. A total 350 entries sent in 2019 were screened against blast at Jessore, Bangladesh at two different dates of sowing during 2019-20 and at two locations i.e. Jessore, Bangladesh and Quirassallis at two different dates of sowing during 2020-21. Out of these, across the locations and years, 29 entries were found free from infection and 46 are categorised resistant on the basis of average disease upto 10% infection. Besides that 350 entries again sent in 2020 to screen against blast during 2020-21 at Jessore, Bangladesh at two different dates of sowing, and resistant genotypes were marked, on the basis of highest score upto 10% infection.

An anticipatory breeding programme has already initiated. Awareness was also created in farmers to take all preventive measures available against blast and to grow the identified resistant varieties.

Post harvest surveys for Karnal bunt

A total of 6396 grain samples collected from various *mandies* in different zones, were analyzed at cooperating centres. The overall 21.12% samples were found infected. The samples from Rajasthan showed maximum infection (37.67%). In general the Karnal bunt infection was less in comparison to previous year because of sudden rise of temperature in the month of February, when the crop is at the booting stages.

ENTOMOLOGY

Survey and surveillance for insect pests

- In Punjab, the aphid incidence during 2020-21 was above economic threshold level in some places viz. village Jodhan (Ludhiana) and Kattu Balian & Sangatpura (Sangrur) during the last week of February. The natural enemies viz. grubs and adults of coccinellid beetles, syrphid fly and chrysoperla were observed in some of the fields infested with aphids. Intensive surveys were carried out in the months of November-December to monitor the pest prevalence in residue managed wheat fields. No serious infestation of pink stem borer or armyworm was observed during 2020-21 crop year except few minor infestations. Minor incidence of pink stem borer (less than 1%) was also observed in one Happy Seeder sown wheat field in village Sanghera (Barnala).
- In Maharashtra state, a survey was carried out in the villages of Nashik and adjoining district Ahmdnagar, Aurangabad, Nandurbar and some part of Beed and Parbhani districts at different crop stages. Heavy incidence of aphids was recorded during the survey. The natural enemies such as *Coccinellid* & *Chrysoperla carnea* predator, grubs and beetles feeding on the aphid were also observed. The incidence of jassids was recorded in medium intensity.
- In Gujarat state, a survey of wheat & barley fields was carried out during the Rabi 2020-21 crop season. The termite damage in wheat fields was negligible across the area surveyed. The incidence of aphid was moderate during ear head stage of the crop. The population of *H. Helicoverpa armigera,* pink stem borer and surface grasshopper were not observed. Besides, in barley fields the aphid population was moderate to high. Among natural enemies, predators like coccinellid beetles, chrysoperla and syrphid fly were noticed predating on wheat and barley aphids.
- In Kanpur, a survey was conducted in villages viz., Araul, Magharwara, Kundi, Devpura, Jahanabad and Daleep Nagar during 2020-21. Incidence of shootfly was recorded to be 1 per cent for wheat variety HD2967, K1006, and PBW343 while it was 13.3% on PBW343 in village Daleep Nagar. The incidence of termite was observed 10 per cent on wheat variety HD2967 in Magharwara, Kundi, Devpura and Jahanabad. Moderate infestation (20-35 aphid/tiller) of foliar aphid was observed on barley variety namely, 'Barley Local' while the shootfly infestation was observed 1.66% at the village Araul (Kanpur). The moderate incidence of pink stem borer (1%) was observed in irrigated HD-2967.

- In Haryana, a survey was conducted from December -March in Yamunanagar, Ambala, Kurukshetra, Kunjpura, Ladwa etc. This year incidence of aphids, termites, pink stem borer and army worm was reported to be on lower side compared to 2019-20 season. Termites and root aphid was reported to be around 1-3% during November and December. Aphid infestation started appearing in the month of January and the population in the beginning was around 2-3 aphids/tiller but in February, higher infestation of aphids (average 25-55 aphids/tiller) was observed in the fields. Natural enemies, wasps, spiders and the grubs and adults of coccinellid beetles were seen during February and March frequently in the fields.

Screening against major insect-pests

Shoot fly: Based on the average infestation of shoot fly at two locations, the lowest infestation index (2.07%) of shoot fly entry was reported in HD3249 (C) and highest index of 8.75% in entry HD3403. At Ludhiana centre, the maximum infestation index of 8.53% was reported on HD3403 and minimum (3.95%) on HD3249 (C). At Dharwad, entry HD3249 (C) had lowest infestation of 2.85% and highest infestation (10.91%) in NIDW1149(d)(I) (C).

Brown wheat mite: At Ludhiana, two entries WH1406 and VL907 (C) recorded the minimum mite population of 4.7/10 cm^2 area while the maximum mite population of 15.3 /10 cm^2 in entry DDW48 (d)(I)(C). This season incidence of mite was very low at Durgapura and Kanpur locations; therefore data of insect incidence was not included.

Foliar aphid: Based on the average score of aphids at four locations; Ludhiana, Karnal, Niphad and Khudwani, four entries; DBW313, DBW317, HI8830(d) and RAJ4083 (C) were included in moderately resistance category (grade 3) and rest of entries were found to be either in susceptible (grade 4) or highly susceptible (grade 5) category. The infestation of aphids at Vijapur, Durgapur and Shillongani was recorded very low and therefore data was rejected.

Root aphid: Out of total 200 entries, four entries viz., WH1142 (C), PBW835, DBW110 (C) and WH1404 showed moderately resistance (grade 3) reaction at Ludhiana.

Screening against multiple pests

The average infestation index of shootfly recorded at two locations was lowest (2.8%) in entry PBW 771 and the maximum score of 9.6% was recorded for GW 1346. The lowest population of 6.67 brown wheat mites/10 cm^2 was recorded in entry HI8812(d) while entry GW1346 had lowest population of 9.6 mites/10 cm^2 at Ludhiana.

Based on the average score of four locations, 13 entries namely GW1348 (d), PBW822, DDW 48(d), DDW 47(d), DBW 303, DBW 302, MACS 5052, GW 1346, MACS 5052, DDK 1056, DDK 1057 and DBW 304 showed moderately resistance (grade 3) to foliar aphid. At Ludhiana, one entry *viz*., HI 1628 was found to be moderately resistant (grade 3) to root aphid.

Integrated pest management studies

- The integrated pest modules tested at four centres viz., Karnal, Ludhiana, Niphad, and Kanpur against the major pests of wheat viz., foliar aphids, shootfly, termites and pink stem borer revealed comparatively lower pest population in IPM module treatment as compared to the farmer practice (FP). However, in FP treatment the population of natural enemies was little higher than IPM treatment.
- Effect of zinc sulphate as foliar application on aphid abundance and their coccinellid predators in wheat was investigated at two centres; Karnal and Ludhiana . It can be concluded that $ZnSo_4$ can also be mixed with propiconazole and thiamethoxam without any adverse effect on yield. Similarly, coccinellid population was also not adversely effected by application of one or two sprays of $ZnSo_4$ mixed with insecticides and fungicides at reproductive stages of the crop.
- Keeping in view of the interest of farmers about zero budget farming, effect of organic treatments viz., Neemastra, Bramhastra, Agniastra, Deshparni, Fermented butter milk and Cow urine were evaluated against major insect-pests of wheat and natural enemies at two centres: Karnal and Ludhiana. The data revealed that Bramastra @7.5% was found to be the most effective treatment as compared to other organic treatments; fewer aphids recorded in this treatment. The organic treatments were found safer to natural enemies and little effect was seen on their population as compared to check of insecticide spray with Thiamethoxam 25 WG.

- Efficacy of various insecticides and their combinations against foliar aphid was determined at various centres. Overall, treatment of Beta-Cyfluthrin 9%+ Imidacloprid 21% (Solomon) was more effective in checking the aphid population. Besides, Lambda cyhalothrin 5% EC @ 500 ml/ha, Imidacloprid 17.8 SL @ 400 ml/ha and Beta-cyfluthrin 25 SC @ 1450 ml/ha were also found equally effective against it.
- In case of termite management through seed treatment, lowest termite damage was recorded in pre-mixed insecticide imidacloprid 18.5%+ hexaconazole 1.5% FS followed by tank mixture of Imidacloprid 600FS + Tebuconazole at Ludhina. However, at Vijapur, treatment of fipronil 5 SC @ 0.3 g a.i./kg seed was most effective followed by thiamethoxam 25 WG @ 0.8 g a.i./kg and thiamethoxam 30 FS @ 0.72 g a.i./kg.

NEMATOLOGY

Resistance against *Heterodera avenae*

Two hundred entries of AVT were screened for resistance against *H. avenae* (CCN) at Ludhiana, Hisar and Durgapura centres. No entry was found resistant or moderately resistant across all the centres. However, eight entries namely, PBW876, K1910, PBW835, HI8713(d) (C), HI8827(d), DBW370, HD3086 (C) and DBW366 have shown moderately resistant reaction at Ludhiana. Similarly, five entries namely HD3406, WH1124 (C), HI1653, HD3086 (C) and DDW53(d) showed moderately resistant reaction at Durgapura and five entries viz. DBW222 (C), DBW173 (C), HI1650, DDW48(d)(I) (C) and DBW327 were found moderately resistant at Hisar location.

Management of cereal cyst nematode (CCN)

A new nematicide *viz* Fluensulfone 2% GR at different doses was tried for nematicidal properties against CCN at three locations namely Ludhiana, Hisar and Durgapura. Fluensulfone 2% GR @ 0.5 kg a.i./ha was found most effective in managing the CCN.

Training for human resource development

A training was organized on "Creation of epiphytotics for disease and insect pests, uniform data recording and reporting in wheat and barley crop protection trials" from 28-30 January, 2021 through virtual mode at ICAR-IIWBR, Karnal for scientists working in crop protection under the coordinated system. The scientist and technical workers involved in disease and insect pest recording participated in the training.

RESOURCE MANAGEMENT

Availability of natural resources and suitable environmental conditions play a major role in achieving the full genetic potential of the newly released high yielding varieties of the crops. Though there is a continuous decrease in the available natural resources for agriculture in India, the production of food grains is steadily increasing by the efficient use of natural resources, better crop management practices, plant protection measures and use of high yielding wheat genotypes. However, imbalanced nutrients fertilisation and intensive tillage are still matters of concern leading to the degradation of natural resources. The multiple nutrient deficiencies are being reported from various parts of the Indo-Gangetic plains, the food basket of the country which is a result continuous mining of the soil coupled with imbalanced fertilisation. Nitrogen is generally applied in excess at the NWPZ, whereas situation in the NEPZ is just reverse. Potash and micronutrients are rarely applied. The situation is further worsened by crop residues burning, which besides causing losses of precious organic source and essential nutrients also leads to environmental pollution causing health hazards. The higher agricultural productivity has to be achieved along with the improvement or at least without further detrimental effect to the environment and natural resources for long-term sustainability. Research efforts are focussed, in addition to varietal improvement, on the refinement of the technologies, diversification/intensification by including leguminous crops, integrated nutrient, water and weed management, to make food production cost and input efficient in order to increase the profit margins to the farmers.

In three wheat growing zones, 12 varietal evaluation trial series were conducted at a number of locations under different growing conditions. The newly developed genotypes were evaluated against the existing varieties used as checks. In addition, seven special coordinated trials were also conducted to address the zone-wise problems and priorities.

In all, 52 trials were proposed, of which 46 were conducted. Out of the conducted trials, three trials (at Dharwad, Udaipur and Washim centres) were rejected due to low yield and/or high CV and improper data reporting. The overall conduct of trial was 88.5% with a success and rejection rate of 93.5%and 6.5%, 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-DOS-LS	10	09	01	Delhi	–	–
RIR-TS-TAS	10	09	01	Sriganganagar	–	–
SPL-IR-ES-HYPT	07	06	01	Delhi	–	–
Total	**27**	**24**	**03**	**–**	**–**	**–**
Central Zone						
IR-DOS-TAD	08	08	–	–	–	–
RIR-TS-TAD	07	07	–	–	–	–
SPL-IR-ES-HYPT	05	03	02	Indore, Vijapur	01	Udaipur
Total	**20**	**18**	**02**	**–**	**01**	**–**
Peninsular Zone						
RIR-TS-TAD	05	04	01	Akola	02	Dharwad, Washim
Total	**05**	**04**	**01**	**–**	**02**	**–**
Grand Total	**52**	**46**	**06**		**03**	

The performance of 12 final year test entries was evaluated and found that in the NWPZ, one AVT-II year late sown test entry JKW 261 was inferior to the best check PBW 771. In restricted irrigation timely sown trial, two test entries DBW 296 and HUW 838 were tested and DBW 296 found significantly better than the best check NIAW 3170 with a yield gain of 2.44%. In early sown high yield trial out of the five final year test entries viz. DBW 327, DBW 328, DBW 332, DBW 333 and WH 1252 were tested against the four checks. Out of these, one test entry DBW327 was found significantly better than the best check variety DBW 187 with a yield gain of 6.92 per cent. Two test entries namely DBW 332 and DBW 328 were found numerically better than the best check DBW 187 with a yield gain of 2.17 and 2.09%, respectively.

In the CZ, two test entries GW 513 and HI 1636 were tested against *durum* and *aestivum* checks in irrigated timely sown conditions. The genotype HI 1636 was found significantly superior to the best *aestivum* check variety GW 322 and numerically superior to the *durum* best check HI 8713 with a yield gain of 4.44 and 1.31%, respectively. In RIR trial, one test entry HI 8823(d) was evaluated and found significantly superior to the *durum* best check DDW 47(d) with a yield gain of 2.91 per cent. In early sown high yield trial five final year test entries viz. DBW 327, DBW 328, DBW 332, DBW 333 and WH 1252 were tested against the four checks. Out of these, two test entries

DBW 327 and DBW 333 were found significantly better than the best check HD 3086 with a yield gain of 4.68 and 4.30 per cent, respectively. One test entry namely DBW 328 was found numerically better than the best check HD 3086 with a yield gain of 0.86 per cent.

In PZ, under RIR trial one test genotype namely MP 1358 was tested against *aestivum* and *durum* checks. This entry was found significantly superior to best *aestivum* check NIAW 3170 and *durum* check NIDW 1149(dc) with a yield gain of 14.04 and 12.54 per cent respectively.

Performance of new genotypes in various agro-climatic zones

Zone wise trial	Test entries	Entry showing superiority		Best check	Yield gain,%	Locations
		Numerical	Significant			
North Western Plains Zone						
IR-DOS-LS	JKW 261	-	-	PBW 771	-	09
RIR-TS-TAS	DBW 296, HUW 838	- -	DBW 296 DBW 327	NIAW 3170 DBW 187	2.44 6.92	08
SPL-IR-ES-HYPT	DBW 327, DBW 328, DBW 332, DBW 333, WH 1252	DBW 332 DBW 328	- -	DBW 187 DBW 187	2.17 2.09	04
Central Zone						
IR-DOS-TAD	GW 513, HI 1636	- HI 1636	HI 1636 -	GW 322 HI 8713	4.44 1.31	08
RIR-TS-TAD	HI 8823(d)	- -	HI 8823(d) DBW 327	DDW 47 HD 3086	2.91 4.68	06
SPL-IR-ES-HYPT	DBW 327, DBW 328, DBW 332, DBW 333, WH 1252	- DBW 328	DBW 333 -	- HD 3086	4.30 0.86	02
Peninsular Zone						
RIR-TS-TAD	MP 1358	-	MP 1358	NIAW 3170 NIDW 1149	14.04 12.54	02

In case of special trials, a total of 106 trials were proposed, out of which 86 were conducted. The maximum numbers of special trials were conducted in NEPZ (27) followed by NWPZ (21), CZ (18), PZ (14) and NHZ (7).

Zone-wise details of the special agronomic trials

Trial Series	Locations	Trials conducted	Trials not conducted	
			Number	Centres
Northern Hill Zone				
SPL-1: Fine tuning of sowing and nutrient management	05	02	03	Almora, Khudwani, Shimla
SPL-2: Effect of seaweed extract	02	02	–	–
SPL-4: Optimisation of NPK doses	05	03	02	Almora, Shimla
Total	**12**	**07**	**05**	

Trial Series	Locations	Trials conducted	Trials not conducted	
			Number	Centres
North Western Plains Zone				
SPL-1: Fine tuning of sowing and nutrient management	10	08	02	Delhi, Sriganganagar
SPL-2: Effect of seaweed extract	04	04	–	
SPL-4: Optimisation of NPK doses	10	08	02	Delhi, Sriganganagar
SPL-5: Lodging management in dicoccum wheat	01	01	–	
Total	**25**	**21**	**04**	
North Eastern Plains Zone				
SPL-1: Fine tuning of sowing and nutrient management	11	06	05	Coochbehar, Faizabad, IARI Pusa, RPCAU Pusa, Varanasi
SPL-2: Effect of seaweed extract	04	04	–	
SPL-3: Effect of surface seeding	06	06	–	
SPL-4: Optimisation of NPK doses	11	11	–	
Total	**32**	**27**	**05**	
Central Zone				
SPL-1: Fine tuning of sowing and nutrient management	08	08	–	
SPL-2: Effect of seaweed extract	02	02	–	
SPL-4 Optimisation of NPK doses	08	08	–	
Total	**18**	**18**		**–**
Peninsular Zone				
SPL-1: Fine tuning of sowing and nutrient management	05	02	03	Akola, Niphad, Washim
SPL-2: Effect of seaweed extract	02	02	–	–
SPL-4 Optimisation of NPK doses	05	03	02	Akola, Washim
SPL-5: Lodging management in dicoccum wheat	03	03	–	–
SPL-6: RCT in soybean-wheat	03	03	–	–
SPL-7: Precision NM through fertigation	01	01	–	–
Total	**19**	**14**	**05**	
Total Trials	**106**	**87**	**19**	

NORTH WESTERN PLAINS ZONE

In this zone, under late sown conditions, one test entry, JKW 261 was evaluated against four checks *viz*. DBW 173, WH 1124, HD 3059 and PBW 771 at nine locations (Agra, Durgapura, Gurdaspur, Hisar, Jammu, Karnal, Ludhiana, Pantnagar and Sriganganagar) under late (10th December to 16th December) and very late (1st January to 7th January) sown conditions. The pooled analysis showed that late sowing gave higher productivity of all genotypes compared to very late sowing and on an average yield declined by 20.8% when sowing was delayed from late to very late situations.

In restricted irrigation trial, two test entries namely DBW 296 and HUW 838 were evaluated against five checks [HI 1628 (c), NIAW 3170(c), WH 1142(c), HD 3043(c), PBW 644(c)] at no irrigation, one irrigation (CRI stage) and two irrigations (CRI and boot stage). The trial was conducted at nine locations (Agra, Delhi, Durgapura, Gurdaspur, Hisar, Jammu, Karnal, Ludhiana and Pantnagar). The pooled analysis showed that increasing number of irrigations successively gave significantly higher grain yield. Maximum and significantly higher grain yield (49.26 q/ha) was obtained with two irrigations as compared with zero and one irrigations levels. The test entry DBW 296 produced significantly higher mean grain yield (47.41 q/ha) than other entries and checks.

High Yield Potential Trial

This experiment was conducted for maximising the wheat productivity with a target yield of 8 t/ha by using higher level of inorganic and organic fertilisers combined with spraying of growth retardant to control lodging. This experiment consists of two nutrient management treatments {recommended doses of fertilizers (RDF) and 150% RDF + 15 t FYM/ha + two sprays as tank mix-Chlormequat chloride (Lihocin) @ 0.2% + tebuconazole (Folicur 430 SC) @ 0.1% of commercial product dose at first node and flag leaf stages} in main plots and 16 high yielding wheat genotypes in sub plots. The experiment was conducted at six centres (Gurdaspur, Hisar, Karnal, Ludhiana, BISA Ladowal and Pantnagar). The data showed significant effect of fertiliser application and growth regulators on wheat productivity. The grain yield enhanced significantly with increased fertiliser doses. Addition of 150% RDF and two sprays of growth retardants increased the grain yield (67.60 q/ha) significantly as compared to RDF (61.47 q/ha). This increase was to the tune of 10.0% over RDF. Genotype DBW 327 ranked first on mean yield basis with yield of 69.69 q/ha, which was significantly higher than other genotypes. This genotype also yielded 72.91 q/ha under 150% RDF + 15 t FYM/ha + two sprays of growth regulators.

CENTRAL ZONE

In the CZ, two coordinated trials (evaluation of genotypes under different sowing dates and evaluation of genotypes under restricted irrigation) were conducted to evaluate the performance of new genotypes as compared to existing varieties as checks. In addition to this one special coordinated high yield potential trial was conducted to evaluate wheat genotypes with an objective of finalising the package of practices for achieving the target productivity of 8 t/ha.

In date of sowing trial, two test entries *viz.* GW 513 and HI 1636 were evaluated against three checks (GW322, HI1544, HI8713(d)) at eight centres (Bilaspur, Gwalior, Indore, Jabalpur, Junagadh, Powerkheda, Udaipur and Vijapur) under timely and late sown conditions. Yield decline in late sown condition was 10.87% as compared to timely sown condition. Test entry HI 1636 ranked first on average basis as well as in late sown condition whereas it ranked second under timely sown conditions

In the RIR trial, one test entry (HI 8823) was evaluated against four check varieties and the trials were conducted at seven locations (Bilaspur, Gwalior, Indore, Jabalpur, Powerkheda, Udaipur and Vijapur) under three irrigation levels (zero, one and two).

One and two irrigation application gave 22.9 and 36.1% higher grain yield, respectively, over no irrigation. The test entry HI 8823 (d) ranked first and produced significantly higher grain yield (31.73 q/ha) than the best check variety DDW 47 (d) (30.83 q/ha).

The HYPT trial was conducted at four locations (Gwalior, Jabalpur, Udaipur and Vijapur) to test 16 high yield potential genotypes under different nutrient management options. The pooled analysis of data showed that 150% NPK + FYM 15 ton +GR gave 6.76% higher grain yield (63.58 q/ha) over RDF (59.28 q/ha). On mean yield basis genotype DBW 370 ranked first and produced significantly higher grain yield (64.94 q/ha) followed by DBW 327 (64.82 q/ha).

PENINSULAR ZONE

In the PZ, one varietal evaluation trial (restricted irrigation) was conducted to evaluate the performance of new genotypes as compared to existing varieties as checks. The performance of one *aestivum* test entry (MP 1358) against five checks {NIDW 1149(d), NIAW 3170, AKDW 2997-16(d), HI 1605, UAS 446(d)} was evaluated at three locations (Dharwad, Niphad and Pune) under no, one and two irrigation levels. The pooled data for Dharwad and Pune indicated that grain yield significantly increased on shifting from no irrigation to one irrigation level. The grain yield under two irrigation levels was at par with one irrigation level. The mean grain yield under no, one and two irrigations was recorded to be 25.98, 29.64 and 29.30 q/ha, respectively. In one irrigation level, test entry MP 1358 performed superior over the best checks {NIDW 1149(d) and NIAW 3170}.

PRODUCTION TECHNOLOGIES

Various special coordinated trials on optimising the sowing time in different zones, effect of seaweed extract, effect of surface seeding/ seed priming, optimisation of fertiliser doses in wheat, lodging management in *dicoccum* wheat, RCTs in soybean-wheat and precision nutrient management through fertigation were conducted to address the various issues in different wheat growing zones.

SPL-1: Maximizing wheat productivity by fine tuning sowing time and fertilizers

For exploring the role of higher nutrients with growth regulators and optimising the sowing time in improving productivity and nutrient usage in wheat under wheat based cropping systems field trials were conducted across the wheat growing zones. The trial was laid out in a split plot design with sowing time (25th October, 05th November, 15th November and 25th November) in main plots and nutrient management {Recommended fertilizer dose (RFD), 150% RFD+ FYM15 t/ha and 150% RFD+ FYM15 t/ha + growth regulators (GR)} in sub plots with three replications. Two sprays of GR as tank mix-Chlormequat chloride (Lihocin) @0.2% + tebuconazole (Folicur 430 SC) @0.1% of commercial product dose at first node and flag leaf stages were done. The sowing was done using the normalized (adjusted considering 1000 grains weight of 38 g) seed rate of 100 kg/ha at a row-to-row spacing of 20 cm. One third nitrogen, full phosphorus and potash as basal dose as per treatments and the remaining 2/3rd nitrogen as 1/3rd at first irrigation and 1/3rd at second irrigation.

In the NHZ, pooled analyzed data revealed that significantly average maximum wheat grain yield (51.32 q/ha) was obtained by application of 150% RFD + GR owing to improvement in the earhead density and thousand grains weight. Sowing on 25th October and 5th November produced significantly higher grain yield than 15th November and 25th November.

In the NWPZ, the data revealed that the maximum wheat grain yield (57.75 q/ha) was obtained by application of 150% RFD + FYM 15 t/ha + GR owing to more earheads/m^2 and thousand grain weight. Early sowing (25th October to 5th November) resulted in significantly higher grain yield as compared to delayed sowing (15th and 25th November). Grain yield reduction in 15th and 25th November sowing was 4.6 per cent and 11.3 per cent, respectively, as compared to 5th November sowing.

In the NEPZ, the pooled data revealed that the maximum grain yield (42.22 q/ha) was obtained by application of 150% RFD + FYM 15 t/ha + GR at Sabour, whereas in Ranchi maximum grain yield was realized by application of 150% RFD + FYM 15 t/ha. Sowing on 15th November resulted in significantly higher grain yield compared to 25th October and 25th November sowing.

In CZ, this trial was conducted at seven centres out of which six centres (Bilaspur, Gwalior, Jabalpur, Powarkheda Udaipur and Vijapur) had four dates of sowing. The pooled data revealed that third date of sowing (15th November) was the best suited sowing date for all nutrient management options which produced the maximum (52.76 q/ha) and significantly higher grain yield than other dates of sowing.

Among nutrient management options, 150% RFD + FYM 15 t/ha + GR was found significantly superior with 51.29 q/ha grain yield over other options.

The results of Junagadh centre revealed that 25th November is the best time for wheat sowing, which produced higher grain yield (59.36 q/ha) than earlier dates of sowing.

In the PZ, this trial was conducted at Dharwad and Pune centres. The data of Dharwad centre were rejected due to inappropriate data. The results of Pune centre showed that effect of sowing time and fertilizer on wheat yield was insignificant. Overall, the addition of FYM and growth regulator with RDF could not make any significant change.

SPL-2: Seaweed extract usage in wheat

Seaweed is an important naturally occurring plant nutrients source. For exploring the role of sea weed extract in wheat, a field trial was conducted across the wheat growing zones.

In the NHZ, this experiment was conducted at two locations (Bajaura and Malan) and maximum wheat grain yield (47.44 q/ha) was obtained in treatment where wheat crop seeds were treated with seaweed extract followed by two foliar spray of sea weed extract @4ml/litre of water at tillering and heading. Seed treatment with sea weed extract at the rate of 3.0 ml per kg of seed before sowing of the crop also resulted in significantly higher yield as compared to control (without seed treatment).

In the NWPZ, this experiment was conducted at four locations (Agra, Durgapura, Gurdaspur and Jammu) and pooled analysis data revealed that seed treatment with seaweed extract caused significant improvement in grain yield (53.05 q/ha) compared to untreated control (49.48 q/ha). Among foliar spray treatments, two spray of seaweed extract at tillering and heading using either 2ml/lit or 4 ml/lit recorded better yield compared to when sprayed either at tillering or heading stage.

In the NEPZ, pooled data of this experiment conducted at four locations (Coochbehar, Sabour, Ranchi and Varanasi) and the maximum grain yield (50.02 q/ha) was obtained by foliar application of seaweed extract @ 4ml/litre water at tillering & heading stages. However, the effect of foliar application of seaweed extract at different doses and time on yield was at par.

In the CZ, pooled data of this experiment conducted at two locations (Dhandhuka and Udaipur) revealed that the maximum grain yield with seed treatment @ 3ml/kg seed was 45.05 q/ha over the control (42.63 q/ha), but statistically remained at par. The effect of foliar application of seaweed extract at different doses and time on yield was at par among themselves.

In the PZ, the trial was followed at Dharwad and Niphad centres and the results of Niphad centre revealed that seed treatment and foliar application of seaweed extract had significant effects on wheat yield. The maximum wheat yield of 51.19 q/ha was observed with treatment having foliar application of seaweed extract @4ml/litre water at tillering& heading + seed treatment.

SPL-3: Exploring surface seeding, seed priming and seed rate in NEPZ

In the NEPZ, this experiment was conducted to explore the possibility of surface seeding for timely sowing of wheat to maximize the productivity in situations where fields remain wet for longer periods. This trial was conducted at six locations (Ayodhya, ICAR-IARI Pusa, Kanpur, RPCAU Pusa, Sabour and Varanasi). The seed priming with 1% KNO_3 @150 kg/ ha resulted in the highest wheat grain yield (45.35 q/ha) which was significantly higher than all other treatments except seed priming @1% KNO_3 having 125 kg/ha seed rate.

In comparison to the dry seed-surface seeding, all the treatments produced significantly higher grain yield except soaked seed-surface seeding at lower seed rate (100 kg/ha).

SPL- 4: Optimisation of NPK doses for high yield potential

Nitrogen, phosphorous and potash are the main plant nutrients required in large quantity and respond to their application in majority of the Indian soils. Absence of nitrogen even inhibits the utilization of phosphorus, potash and other minor and micro nutrients. The experiment was laid out in randomised complete block design with ten fertilizer treatments *viz.* absolute control, 50, 75, 100, 125 and 150% recommended dose of NPK, 125 and 150% recommended dose of NPK with growth regulators spray at first node and boot leaf stage.

In the NHZ, the pooled analysis of two centers (Bajaura, and Malan) revealed the highest wheat grain yield (49.57 q/ha) by applying 150% recommended dose of NPK and two sprays of growth regulators at first node and boot leaf stage.

In the NWPZ, the data revealed the maximum wheat grain yield (56.50 q/ha) by applying 150% recommended dose of NPK and two sprays of growth regulators at first node and boot leaf stage but was at par with other treatments having 125% Rec NPK or more.

In the NEPZ, this trial was conducted at 11 locations (Ayodhya, Burdwan, Coochbehar, IARI Pusa, Kalyani, Kanpur, Ranchi, RPCAU Pusa, Sabour, Shillongani and Varanasi). The data showed the highest grain yield (49.2 q/ha) by applying 125% recommended dose of NPK and two sprays of growth regulators at first node and boot leaf stage as compared to other treatments. The yield gain over 100% recommended dose of NPK was 9.55%.

In the CZ, this trial was conducted at eight locations (Bilaspur, Gwalior, Indore, Jabalpur, Junagadh, Powarkheda, Udaipur, Vijapur). The results showed the maximum yield (52.76 q/ha) with treatment having 150 percent recommended dose of NPK with growth regulators spray at first node and flag leaf stage followed by the treatments having 150 percent recommended dose of NPK (51.19 q/ha).

In the PZ, the trial was conducted at three centres (Dharwad, Niphad and Pune) and the data revealed that wheat yield increased with NPK dose. The wheat yields with 100–150% recommended NPK + GR spray at first node and boot leaf stage were at par to treatment having 150% recommended

dose of NPK. The highest yield of 46.17 q/ha was recorded with treatment having 150% recommended NPK + GR spray at first node and boot leaf stage followed by 45.11 q/ha with 150% recommended dose of NPK.

SPL- 5: Lodging management for enhancing *dicoccum* wheat yield using PGR

In the NWPZ, this experiment was conducted at Durgapura centre only to explore the possibility of reducing lodging for yield enhancement of *dicoccum* wheat using plant growth regulators. The experiment was laid out in split plot design with three varieties (MACS 2971, DDK 1029 and HW 1098) in main plot treatments and five growth regulator treatments {G_1: Control; G_2: CCC (2 chloroethyl- trimethyl ammonium chloride) @ 1000 ppm; G_3: CCC @ 1500 ppm; G_4: Ethephon @ 10 ppm and G_5: Ethephon @ 30 ppm} in sub plots. The data revealed that varietal differences were non-significant whereas, the effect of growth regulator was significant. Among growth regulator treatments, the application of CCC @ 1500 ppm produced the maximum yield (41.20 q/ha) and it was at par with the lower rate of CCC @ 1000 ppm but significantly superior to control as well as both of the ethephon treatments. While in the PZ, this trial was conducted at three locations (Dharwad, Niphad and Pune) and pooled results revealed that the varietal effect on yield was insignificant. The maximum wheat yield (41.35 q/ha) was observed with the treatment having Ethephon @30 ppm followed by 40.39 and 39.13 q/ha for Ethephon @10 ppm and CCC @1500 ppm, respectively.

The use of CCC @1000 ppm could not make any significant advantage in wheat yield. The use of Ethephon @10 ppm provided 18.08% advantage in wheat yield as compared to control (no growth regulator).

SPL-6: RCTs in soybean-wheat cropping system

In the PZ, this trial was conducted at three centres (Dharwad, Niphad and Pune) and the results showed that wheat yield on flat and broad bed under zero-till practice was significantly lower than that of CT-flat bed. The wheat yield slightly improved under CT-broad bed; however, it was at par with CT-flat bed. The treatments having crop residue produced significantly higher yield than control treatment. The maximum mean wheat yield of 45.21 q/ha was recorded for the treatment having soybean + wheat residue @3t/ha, which was 7.08% higher than control treatment.

WHEAT QUALITY

Zone wise variability in wheat quality and grain nutrition parameters has been recorded. During 2020-21, 146 AVTs, 271 NIVTs and IVRs, 55 SPL, 80 QCSN, were analysed from different centres representing 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 II year AVT entries including checks were subjected to baking evaluation for chapati, bread, biscuit and gluten content. Details are given below.

Promising *T. aestivum* genotypes for chapati (Score >8.0)

Category	Genotypes
Check	HI1628 (NWPZ-RITS), HI1544 (CZ-ITS), DBW187(I) (C) (NWPZ-HYPT)
AVT	GW513*, HI1636* (CZ-ITS)

* indicates the final year entries

Promising *T. aestivum* genotypes for bread (Loaf volume >600 ml)

Category	Genotypes
Check	NIL
AVT	DBW296* (NWPZ-ITS)

* indicates the final year entry

Promising *T. aestivum* genotypes for Biscuit (SF ~10.0)

Category	Genotypes
Check	NIAW3170 (C) (NWPZ-RITS) (9.9), NIAW3170 (C) (PZ-RITS) (10.4)
AVT	DBW296* (NWPZ-RITS) (9.5)

* indicates the final year entry

Promising genotypes for various quality traits

In addition, promising genotypes were identified both for *T. aestivum* and *T. durum* 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 the NWPZ and CZ having soft grain characteristics and thus suitable for biscuit making quality. The Fe and Zn contents were comparatively lower in entries from the NEPZ and higher from the NHZ.

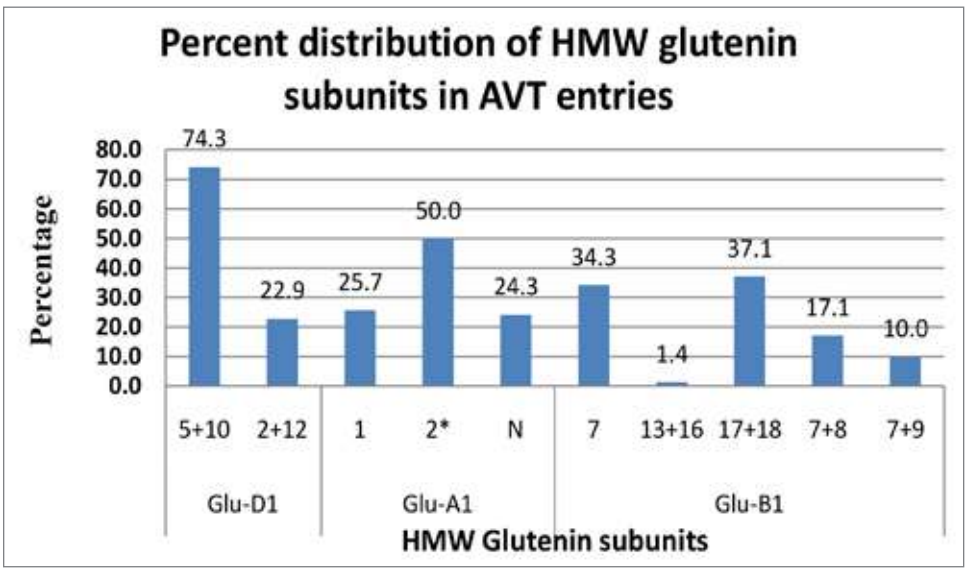
Promising Genotypes for Various Quality Parameters

Parameter	Value	Genotypes
T. aestivum		
Protein	≥12.5%	**NHZ:** VL2041, VL 907 (C), HS 507 (C) (RFTS) **NWPZ:** HD3406, DBW313, PBW834, , HD 3043 (C) (RITS), NIAW 3170 (C) (RITS) **NEPZ:** HD3406M , HD3411M, DBW317, DBW318, PBW835, PBW834, UP3060, DBW316, PBW833, HD3360, DBW 187 (C) HD 2967 (C), HD 3086 (C) DBW 107 (C) HI 1621 (C) **CZ :** MACS6768, HI1667B **PZ :** MP1358 (RITS), MACS6753, HD 2932 (ILS), HI 1633 (ILS), RAJ 4083 (ILS) NIAW 3170 (RITS)
Sedimentation value	> 60 ml	**NHZ :** HPW349 (C) (RTS) **NWPZ :** HD3369, HI 1653 (RITS) **NEPZ :** DBW 187 (ITS), UP 3060 (ILS) **CZ :** NIL; PZ: NIL
Hardness Index	< 40	**NHZ :** VL2041 **NWPZ :** PBW 876 (ITS) NIAW 3170 (C) (RITS) **NEPZ:** HI 1654 (RITS) **CZ:** NIL; PZ: NIAW 3170 (C) (RITS)
Iron	≥40ppm	**NHZ :** HS 562 (C), HPW 349 (C), **NWPZ :** DBW313#, DBW296*, HD 3086 (C), WH 1142 (C), HI 1628 (C), HD 3043 (C), PBW 644 (C) **NEPZ :** PBW835, DBW316, PBW833, HD3360, HD 3249 (C), DBW 107 (C) and others under ILS conditions. **CZ :** MACS6768, HI1667B, **PZ :** HI1651, MACS6755 (C), MACS6753 MACS 6222 (C), , RAJ 4083 (C), NIAW 3170 (C),
Zinc	≥40ppm	**NHZ :** NIL **NWPZ :** PBW876B, HUW838#*, DBW296*, NW7096, K1910, WH 1142 (C), WH 1124 (C), PBW 644 (C), **NEPZ:** DBW317, DBW316, UP3060, HD3360, **CZ :** HI1636*, MP3535, GW523, MACS6768, HI1667B, HI1650, GW528, HI1655 (Most of the entries had higher (>40 ppm) Zn content this year) **PZ :** HI1651, MACS6755, MACS6753
T. durum		
Protein	>12.5.0%	CZ : NIL; PZ : NIL
Sedimentation value	≥ 40ml	CZ : NIL; PZ : MACS4100(d),
Yellow Pigment	>8.0ppm	CZ : UAS475(d), DDW 47 (c), PZ: HI8828(d)
Iron	≥ 40ppm	CZ : HI 8713 (c) (ITS), PZ : NIL
Zinc	≥ 40ppm	CZ : HI8833(d)M, HI8832(d)M, HI8823(d)*, DDW55(d) (Most of the entries had higher (>40 ppm) Zn content this year. PZ : UAS 428 (c), UAS 446 (c), DDW 48 (c), WHD965(d), HI8826(d), NIDW1345(d), MACS4106(d), NIDW1348(d), HI8828(d), HI8827(d)

# indicates the final year entries*

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 74.3% and 22.9% of the total entries, whereas entries having 1, 2* and N subunits were 25.7%, 50.0% and 24.3%, respectively. Entries with subunits 7, 13+16,7+8, 7+9, and 17+18 were 34.3, 1.4, 17.1, 10.0, 37.8, 1.75 and 4.38% respectively.



Quality Component & Wheat Biofortification Nursery (QCWBN)

In 2020-21, the Quality Component and Wheat Biofortification Nursery (QCWBN) was evaluated from 10 locations having 80 entries including checks namely WB02, GW 322, HS 490, DDW 47, DBW 187, HD 3226. Grain quality analysis was done at the ICAR-IIBWR, Karnal. Samples from 11 centres were analysed for 4 parameters namely grain protein content at 12% grain moisture level, hectolitre weight, sedimentation value, grain appearance score and grain hardness index from 6 centres. Iron and zinc analysis was conducted of the hand thrashed samples provided by 10 centres. Varanasi centre showed very low sedimentation volumes (<73.0 Kg/hl).

WB02, QBP-18-15 and BNSR-6, recorded highest grain protein content (>14.0%) in all the zones. QBP-18-15 recorded highest sedimentation value (64.4 ml) followed by WB 02 (61.8ml) in all the zones. QLD121 was the

softest genotype with grain hardness index of 21. QLD 122 recorded highest Fe content of 44.0 ppm followed by BNSR-6 with 43.4 ppm. 3 entries (QBP-18-15, IC296727 and UP3101) showed > 50.0 ppm Zn content and 9 entries >48.0 ppm including BNSR-6.

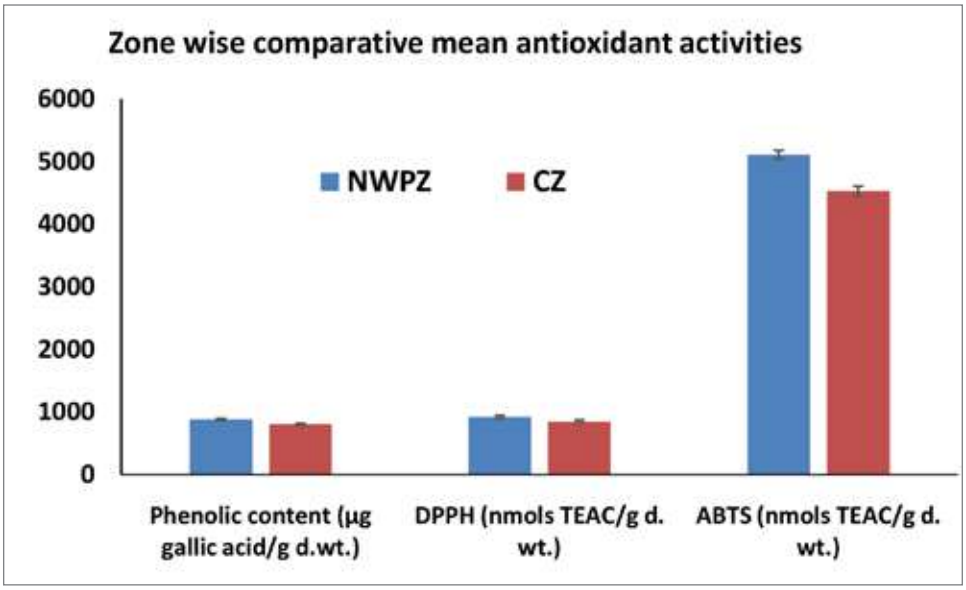
Progress in transferring genes for enhanced Fe, Zn, protein and low phytate and high phytase levels into high yielding backgrounds

Increasing essential micronutrient content in wheat genotypes and their bioavailability for monogastric animals and humans consumption could ultimately lead to improved animals and human health. Therefore, to achieve this goal, several crosses were developed into high yielding wheat cultivars background (HD 2967, HD 3086, HD 3226, DBW 173, DBW 187, WB 02) using previously high phytase and low phytic acid mutants in the background of PBW 502) during the main crop season 2017-18 at ICAR-IIWBR, Karnal. F_1s were advanced and backcrossed using off-season nursery facility at Dailang Maidan, Lahaul spiti (Himachal Pradesh) during 2018. F_2s and BC_1F_1s of above crosses were planted and selection was done for disease free plants at research field of the ICAR-IIWBR, during 2018-19 and promising progenies were advanced at the ICAR-IIWBR, Karnal during 2019-20 and 2020-21 (F_4 generation). Three way crosses were attempted during 2019-20 for combining high Fe, Zn, protein and high phytase and low phytic acid traits into high yielding backgrounds. The available material of F_2, F_3, F_4, BC_1F_1, BC_1F_2, BC_2F1, BC_2F_2 generations including threeway crosses between were sown for the crop season 2020-21.

Determination of antioxidant properties in wheat genotypes of North-Western Plains Zone and Central Zone environments

In an investigation, 19 and 12 wheat genotypes grown at three different locations of two production environments representing the North-Western Plains Zone (NWPZ; locations: Karnal, Ludhiana, Pantnagar) and Central Zone (CZ; locations: Junagarh, Powarkhera, Vijapur), respectively, were used for evaluating their antioxidant potential. The zone wise comparative profiling of mean phenolic content and trolox equivalent antioxidant activities (TEAC) between NWPZ and CZ were analysed. Overall, the NWPZ environment was found to have higher phenolic content and antioxidant activity (both in terms of DPPH as well as ABTS radical

scavenging activity) compared to the CZ. In the case of NWPZ, there was a significant positive correlation between total phenol and ABTS activity ($p<0.01$) while non-significant with DPPH scavenging activity. However, there was a significant positive correlation of phenolic content with DPPH ($p<0.01$) and ABTS ($p<0.05$) radical scavenging activities in CZ genotypes. The analysis of variance based on additive main effects and multiplicative interaction (AMMI) indicated highly significant effect of environment, genotype and genotype x environment interactions on phenolic content and antioxidant levels for both the zones.



Comparative profiling of mean phenolic content and trolox equivalent antioxidant activities between North-Western Plain Zone and Central Zone

BARLEY NETWORK

The crop season 2020-21 was good for barley production as the crop experienced nearly 5.6% increase in production over the previous year, despite with only 3.2% increase in area and the productivity increased by 2.3% from 29.2 to 29.88 q/ha. According to 3rd advance estimates for *Rabi* 2020-21, nearly 1818 thousand tonnes of barley has been produced in 609 thousand ha area with a productivity of 29.9 q/ha. Rajasthan continues to be the largest state having >58% in production and >51% area followed by Uttar Pradesh. In the case of Rajasthan, there is an increase of 4.8% in area and 8.2% in production over last year, while Haryana and Punjab have also witnessed a little increase in barley area and production. Maharashtra has an increasing trend for barley in recent last three years. Uttar Pradesh and Uttarakhand have indicated downward trends and in other states only minor fluctuations were there for barley area/ production.

Very often, a concern is usually raised at various platforms for barley area decline in India. However, in recent years, the area has more or less stabilized and there has been gain in productivity resulting in higher production. The possible reasons for the non-preference by farmers for barley could be the difficulties or lack of profit in selling the produce as per convenience. Though the MSP of barley is announced (much lower than wheat), but there is no procurement by government agencies, which makes it non assured procurement crop and farmers are not willing to take such risk except in cases where there are no better options are available. Sometimes industry is taking care of limited procurement on premium price for malt barley either directly or through market people based in important mandis. A few of such industries had also followed "contract farming" with malt type varieties to ensure regular supply of the raw material for their units. This has given much needed impetuous to the barley cultivation under well managed conditions with rise in productivity levels at small holder farmers.

During the year some damage/losses in quantity and quality of the grain was observed in timely sown crop due to poor winter rains in different areas. The monitoring teams during the season, observed that the crop season was by and large a rust-free year in major barley growing areas, with some incidence of aphids in the plains and net blotch in some areas because of cool dry situation. The incidence of spot blotch was more in the eastern zone. The smuts (both covered and loose) were common in fields where the seed was not treated by farmers.

Release and identification of new barley variety

One malt barley variety *viz.* DWRB182 was released and notified by the CVRC for commercial cultivation in the North Western Plains Zone during 2020-21. This variety combines most of the mating and brewing traits required by industry. DWRB182 is the only genotype reported with *very low levels of grain β-glucan content (<5.0%), and wort β-glucan (506 ppm***)** Another trait of current preference is *malt diastatic power, which is highest (86^{0}L) in the proposed genotype***.** DWRB182 *is highly resistant to yellow rust in field as well as in SRT testing to all known pathotypes in country*. Additionally, it has better resistance to the leaf blights.

Another variety of barley namely KB1425 (Azad Jau 33) has been recommended by the Uttar Pradesh SVRC in its recent meeting in June 2021 for saline-sodic soils areas (pending notification by the CVRC).

Barley varieties released by the CVRC/SVRC during 2020-21

S.N.	Variety	Parentage	Zone	Developed at	Production condition	Average yield (q/ha)	Potential yield (q/ha)
1	DWRB182	DWRUB52/ DWRB78	NWPZ	ICAR-IIWBR, Karnal	Malt barley under Irrigated timely sown	49.7	74.5
2	KB1425*	K508/ NNDB1295	Uttar Pradesh	CSAUA&T Kanpur	Irrigated timely sown, in saline-sodic soils	33.1	47.3

**CVRC notification awaited*

Registration of genetic stocks

Seven genetic stocks namely DWRB206, DWRB207, UPB1065, UPB1070, BHS474, BCLA3, and BCLA11-6 were registered with the ICAR-NBPGR for their unique traits during the year, including two of them for resistance to corn leaf aphid tolerance for the first time in the country.

Genetic stocks registered with the ICAR-NBPGR New Delhi during 2020-21

S.N.	Name	INGR	Year	Parentage	Trait	Institute
1	DWRB207 (DWRFB19)	20019	2020	CDC Manley/ BCU2881	Highly resistant to stripe rust. High 1000 grain weight (47.5g). Low protein content (9.5).	ICAR-IIWBR, Karnal
2	BHS 474 (BBM 777)	20018	2020	BLG132/ BHS369	Resistant against all the pathotypes of yellow rust and brown rust in seedling and adult plant stage. Seedling resistance against all the pathotypes of black rust except for pathotype 11.	ICAR-IARI Regional Station, Shimla,
3	UPB 1065	20083	2020	LIMON/ BICHY2000 //NE167/ CLE176	Low Beta glucan content (<3.5%) and high Filtration rate and Kolbach index.	GBPUA&T, Pantnagar

S.N.	Name	INGR	Year	Parentage	Trait	Institute
4	UPB 1070	20020	2020	DOLMA / BH 947	Resistance to yellow rust (ACI 0.0). High yield potential in NHZ (29.2 q/ha). High bold grain percentage (89.4%) and other good agronomic traits	GBPUA&T, Pantnagar
5	DWRB206*	NA*	2021	ZIGZIG/4/ TOCTE// HIGO/ LINO/3/ PETUNIA1	High resistant to stripe rust in huskless back ground	ICAR-IIWBR, Karnal
6	BCLA 3*	NA*	2021	EB921/ Alfa93	Corn leaf aphid resistance in two-row back ground	ICAR-IIWBR, Karnal
7	BCLA 11-*6	NA*	2021	BCU390 / alfa93	Corn leaf aphid resistance in six-row back ground	ICAR-IIWBR, Karnal

**Proceedings awaited*

CROP IMPROVEMENT

Coordinated Yield Evaluation Trials

In all 88 test entries, contributed by 11 centres, were evaluated against 23 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 purposes types and mostly were hulled type with a few hull-less types in the northern hills and plains. These trials were conducted at 11 main centres and 30 additional testing centres (including the ICAR, SAUs and State Department of Agriculture) during *Rabi* 2020-21. Out of 94 yield evaluation trials proposed, 93 trials were conducted. Two trials failed at Navgaon and Ranchi. The data were received in time for 91 trials. After the analysis, only 65 trials (69.1% of proposed, 71% of conducted) were found good for reporting. This rejection includes the IVT/AVT huskless barley trial failed at all 15 locations because of extremely poor germination of two entries and one recent check PL891, this made the rejected trials number exceptionally high this year.

Promising entries in AVT/IVTs during 2020-21: Based upon the promotion criteria *i.e.* significantly superior or better than check with additional trait(s), monitoring reports for purity, disease/pest reactions and the quality (as applicable), 19 entries were found promising in the different varietal evaluation trials.

Promising entries in different trials during 2020-21

S.N.	Trial name	Zone	Entry
1	AVT-IR-FB	NWPZ	RD3012
2	AVT-IR-FB	NEPZ	PL911, PL917
3	AVT-RF	NHZ	UPB1093, BHS484
4	AVT-SST	NWPZ/NEPZ	DWRB224, RD3039
5	IVT-IR-MB	NWPZ	DWRB2019, BH1036, DWRB221, DWRB220, DWRB218
6	IVT-FB	NWPZ	-
7	IVT-FB	NEPZ	NDB1756, UPB1095, RD3034
8	IVT-FB	CZ	K1912, PL927, RD3032,
9	IVT-RF	NEPZ	RD3037

Molecular diversity analysis of new entries in coordinated trials

In order to develop molecular markers-based amplification profiles for varietal characterization and assess the level of genetic diversity in the coordinated trials entries and checks during 2020-21 were characterized at molecular level. Total 100 genotypes were screened with a set of 46 barley specific SSR/STS markers covering seven chromosomes to develop molecular profiles. Total 95 alleles were scored for PCR based amplification profiles. These genotypes were grouped within similarity coefficient (GS) value around 0.52 to 0.99 and showed sufficient genetic variability at molecular level. All entries except BHS483 and BHS484 are placed at separate nodes in dendrogram thus distinguishing from the check lines, respectively.

Breeder seed production: The breeder seed production of 638.06q of 24 varieties was allocated among 10 BSP centres against 644.24q breeder seed indent of 28 varieties from the DAC&FW for production during 2020-21 for eight states *viz*., Punjab, Haryana, Himachal Pradesh, Jharkhand, Madhya Pradesh, Rajasthan, Uttar Pradesh and Uttarakhand and four public sector agencies *viz*., National Seeds Corporation, IFFDC, NAFED & NDDB as well as private seed companies under the National Seed Association of India. The highest breeder seed indent was placed by Rajasthan (230.00q), followed by the NSAI (130.30q), Uttar Pradesh (120.0q) and National Seed Corporation (105.0q). Maximum breeder seed indent was received for the variety DWRB 137 (121.66q) followed by RD 2899 (80.0q), BH 393 (53.0q) and RD 2786 (50.0q).

A total of 830 q of breeder seed of 22 varieties was produced by 10 BSP centres during 2020-21 with a surplus of 186.16q. Among 10 breeder seed production centres, maximum breeder seed was reported from RARI, Durgapura (394.40q) with a surplus of 157.20q against allocation followed

by the ICAR-IIWBR, Karnal (172.0q) and CCSHAU, Hisar (123.50q). Top ten varieties contribute to the tune of 70.90% in total allocation of breeder seed and finally these varieties contribute 83.94% share in total breeder seed production during 2020-21. Total 39.76q nucleus seed of 24 varieties was also produced against 22.65q allocation in BSP-1 with a surplus of 17.11q seed during 2020-21 at 10 centres.

Germplasm Evaluation & Exchange

In order to facilitate the availability of promising new diversity in the national barley program, the All India Coordinated Research Project (AICRP) on Wheat and Barley organizes the import and conduct of international trials and nurseries in the country. During *Rabi* 2020-21, two international yield trials and two observation nurseries were supplied from the ICARDA which included a total of 272 genotypes for different production conditions. One set each of these nurseries and trials was also evaluated at the ICAR-IIWBR, Karnal. Following COVID-19 norms, visitors' week was organized to give an opportunity to the NARS barley breeders to select material from these nurseries.

International trials and nurseries evaluated during the crop season 2020-21

S.N.	Trial/Nursery	Entries	National Check	# Sets	Locations
1	IBYT-HI-2021	24	DWRB137	4	Durgapura, Hisar, Pantnagar, Karnal
2	8th GSBYT-2021	24	Lakhan	4	Varanasi, Kanpur, Bajaura, Karnal
3	IBON-HI-2021	112 + 3 checks	DWRB137	4	Durgapura, Pantnagar, Hisar, Karnal
4	8th GSBON-2020	112 + 3 checks	Lakhan	4	Kanpur, Varanasi, Bajaura, Karnal

In addition, one set each of EIBGN with 45 entries selected from ICARDA trials/ nurseries of 2019-20 crop season with six released varieties (BH946, BH959, BHS400, RD2715, DWRB101 and DWRB137) as checks was supplied to 10 barley breeding centres for further evaluation /utilization.

A National Barley Genetic Stock Nursery (NBGSN), constituted during the year, consisted of 20 entries as promising sources for important traits from AICW&BIP trials/ nurseries during 2019-20 crop season. The NBGSN was supplied as suggested crossing block for evaluation and utilization at 10-centres (Durgapura, Ludhiana, Karnal, Hisar, Faizabad, Varanasi, Pantnagar, Kanpur, Shimla and Bajaura).

During the year 2020-21, around 500 barley accessions from the ICAR-IIWBR active collection were rejuvenated as a regular maintenance activity of germplasm conservation.

Zonal Monitoring

The teams constituted for monitoring of Barley Yield Trials & Nurseries visited different locations in the CZ, NWPZ and NEPZ, at the most appropriate stage of the crop and recorded observations about the varietal performance, conduct of trials, disease/ pest incidence and genetic purity of the test entries. The team in the NHZ conducted the virtual monitoring due to COVID-19 pandemic related restrictions. On the spot decisions were taken about the rejection of trials and purity of test entries.

CROP PROTECTION

Survey and surveillance for diseases and pests

The field surveys were conducted by different scientist of cooperative centres, none of the rust was observed in the surveyed areas. Incidence of loose smut, covered smut, leaf stripe and bacterial streak diseases was noted *in traces* to 2 per cent on some fields in the Jaipur and Dausa district of Rajasthan. The crop was also experiencing force maturity due to sudden rising of day temperature in the areas. Surveys were also conducted to determine the incidence of insect-pests and their natural enemies on barley crop. The main insect pest observed was aphid and its population was found to be moderate to high in barley fields. Among natural enemies, coccinellid beetles, chrysoperla and syrphid fly were frequently noticed predating on barley aphids.

Pathotypes distribution and seedling resistance tests

There was insignificant incidence of barley rusts in India during 2020-21. Only a few sporadic incidents of barley stripe rust were reported from Northern India and Rajasthan. There was no report of stem and leaf rusts of barley from the farmer's fields.

All the NBDSN and EBDSN lines were screened against different pathotypes of three rusts of barley under precise conditions of temperature and light. Confirmatory and selected testing was also undertaken, wherever needed. These lines were evaluated against seven pathotypes of *Puccinia striiformis hordei* (24, 57, M, G, Q, 6S0 and 7S0), five pathotypes of *P. graminis tritici* (11, 21A-2, 40A, 117-6 and 295), and 5 isolates of *P. hordei* (H1, H2, H3, H4 and H5). None of the NBDSN and EBDSN entries was resistant to all the tested pathotypes of Pst, Pt and Pgt. In seedling rust resistance evaluation, out of 108 lines of NBDSN, none of the lines was resistant to all three rusts

of barley. Four lines were resistant to both leaf and stripe rust pathotypes/ isolates whereas one-line DWRB182 was resistant to stripe and stem rust pathotypes. In addition, 17 lines each was resistant to stripe and leaf rust pathotypes only. Resistance to all the pathotypes of *P. graminis tritici* was observed only in DWRB182. Twenty-three EBDSN lines were evaluated under SRT and resistance to all three rusts was not recorded in any line. However, 2 lines were resistant to leaf and stripe rusts and one was found resistant to all the pathotypes of leaf and stem rust pathogens. Resistance to all the pathotypes/isolates of *Puccinia striiformis hordei* and *P. hordei* rusts was observed in 7 and 4 lines, respectively.

Field screening and chemical control experiments on diseases and pests

In case of field screening for diseases and pests the significant findings are as below:

- A total of 514 entries consisting 383, 108 and 23 entries in different nurseries IBDSN, NBDSN and EBDSN, respectively, were screened for resistance against various diseases, aphid and CCN at different cooperating centres during the crop season 2020-21.
- Out of 383 entries in IBDSN from different breeding centres, 30 entries were found free from yellow rust (ACI = 0) and 234 entries showed resistant reaction having ACI less than 10. In case of leaf blight screening, 38 entries were found moderately resistant against leaf blight with an average score of 14-35 and HS < 57 in double digit scoring system.
- A total 108 entries evaluated in NBDSN, 7 entries found free from yellow rust, 89 entries showed resistant reaction having ACI less than 10. In case of leaf blight screening, 9 entries showed moderate level of resistance with an average score (double digit) 14-35 and HS < 57.
- Among 23 EBDSN entries, 3 found free from yellow rust, whereas 19 showed resistant reaction. The 3 entries also showed moderate level of resistance against leaf blight with an average score 14-35 and HS < 57.
- Among five different fungicidal treatments, two sprays of Tebuconazole 50% + Trifloxystrobin 25% WG@ of 0.06% was found most effective in management of yellow rust.
- A total of 108 barley NBDSN entries including checks were screened against foliar aphid. On the basis of average score of five locations, 16 entries (BH1029, BH1039, DWRB219, DWRB220, NDB1752, PL911, PL917, PL927, RD3031, RD3032, RD3041, RD3042, BH902(C), BH946 (C), DWRB137(C) and HUB113(C)) were scored below 4.0 scale.

- A total of eight chemicals were tested for their efficacy against foliar aphid in barley. Treatment of Beta-Cyfluthrin 9% + Imidacloprid 21% (Solomon) @ 400 ml/ha was found the best treatment followed by Sulfoxaflor 12% SC @250 ml/ha in managing aphid population in barley.
- A total 108 entries of NBDSN and 23 of EBDSN were screened against the CCN at three locations *viz*. Durgapura, Ludhiana and Hisar. Most of the entries fall in the category of susceptible or highly susceptible.

RESOURCE MANAGEMENT

To increase the production, productivity and profitability of the barley growing farmers, updating of package of practices of barley crop is continuous process and the need of the hour. Resource management group (barley) conducted 48 trials including six special trials at different locations, out of which 45 were reported, while three trials (two at Agra and one at Kanpur) were rejected by the monitoring team due to error in layout or poor germination. The significant findings are as follows:

- There was no significant difference in three sowing dates (1st November to 25th November) but significantly superior to December sowing in the NWPZ. In the NEPZ, the yield was highest in 11-15 November sowing and thereafter yield decreased significantly. In the NHZ, the yield increased as the sowing delays till 11-15 November and thereafter it decreased significantly.
- In the NWPZ with N and Zn applications, the productivity was at par among treatments when three splits of nitrogen and urea and Zn was applied as foliar spray. Highest protein was obtained with three splits of nitrogen i.e. 1/3 at basal+1/3 at tillering (35-40 DAS) +1/3 at flag leaf stage.
- In the NWPZ, the highest but statistically at par yield was obtained with RDF 125%+10t FYM+PGR followed by RDF+10t FYM+PGR. In NEPZ, both RDF 125%+10t FYM+PGR; RDF 150%+PGR and RDF + 10t FYM treatments were at par and better than rest. In NHZ, also these treatments were superior to others. In all the zones, the yield increased with the increase in level of fertilizer and also with the addition of FYM and PGRs.
- The experiment was conducted at six locations, five in the NWPZ and one at Udaipur (CZ) and different combinations of nano fertilizer were used to optimize the dose for barley. Nano nitrogen affected the barley productivity significantly only at low level of nitrogen.
- Zinc treatments as soil application, foliar application (0.5% zinc sulphate) and in combinations were used in two varieties in each zone. In NWPZ,

soil application with zinc sulphate @ 25 kg/ha was found superior; producing 9.2 per cent more yield compared to no zinc application. In NEPZ, soil application with zinc sulphate @ 25 kg/ha followed by foliar application (0.5% zinc sulphate) at heading and early milk stage was found superior with 9.78 per cent more yield compared to no zinc application. In NHZ, (Bajaura and Malan locations), soil application with zinc sulphate @ 25 kg/ha followed by foliar application at heading and early milk stage were at par and superior to other treatments with 10.5 per cent more yield compared to no zinc application.

- The trial was conducted in the dry areas of NWPZ (Agra, Durgapura and Hisar) and Udaipur in split plot design having 3 irrigation levels and 4 Silicon doses (levels). Pooled results of the NWPZ revealed that irrigation levels and silicon doses significantly affected the productivity of barley. The highest yield was obtained with three irrigation and 200 kg Silicon per ha which is significantly superior to all other treatment combinations. At Udaipur, two irrigations with 200 kg silicon and three irrigations with 150 kg silicon per ha were at par and superior to other treatment combinations.

QUALITY EVALUATION

Malt barley trial

The malt is one the major industrial use of barley and to make higher quality malt the raw material should have certain minimum quality traits. This year a total 168 samples of malt barley received from eight locations of the NWPZ were analyzed in the quality laboratory of Barley Improvement programme. The samples consisted of 16 genotypes of the Initial Varietal Trial (IVT) and five checks.

Promising entries for individual malting quality traits

Trait	Promising entries
Hectoliter weight	DWRB 221, PL 930
Bold Grains	RD 3028, BH 1036, DWRB 218
Protein content	PL 930, RD 3028, UPB 1097, DWRB 218, PL 931, BH 1036, BH 1034, BH1035, RD 3029
Husk Content	DWRB 221
Hot water extract	DWRB 220, UPB 1098, PL 930
Filtration Rate	PL 930, RD 3027
Diastatic Power	RD 3029, RD 3030, PL 930, BH 1034, RD 3027
FAN Content	RD 3030, UPB 1098, RD 3028, PL 930, RD 3027, RD 3029, DWRB 218
Kolbach Index	RD 3027, DWRB 220, RD 3028
Over all MQ	DWRB 221

**Better or at par to the best check*

Barley quality screening nursery

This year nursery had two components *i.e.* for better malting quality traits and hulless barley with better quality traits. In hulless trial 32 genotypes and the malting quality 48 genotypes including checks was grown at Karnal, Hisar, Ludhiana, Pantnagar, Durgapura and Kanpur.

Promising sources of hulless barley for different traits

Traits	Promising entries
Thousand grain weight	DWRFB 58
Bold grains	DWRFB 40, DWRNB 14, DWRFB 58
Protein content	BCU 8028, BCU 8032, BCU8041, BCU 8038
Starch content	DWRNB 25, DWRB 204, DWRB 217

Promising sources of malt barley for different traits

Trait	Promising entries
Hectoliter weight	BCU 4966
Thousand grain weight (40-46 g)	ICARDA 12, ICARDA 18, ICARDA 9, BK 306, ICARDA 28, ICARDA 1, ICARDA 19
Protein content (12-13% db)	BCU 4966, DWRB 211, ICARDA 26, ICARDA 5, PL912, ICARDA9, ICARDA 18, RD 3025, BK 316, ICARDA 17, ICARDA 11, ICARDA 28, K 647
Starch content	ICARDA-1
Beta glucan content (low)	ICARDA 5, ICARDA 9

FEED BARLEY

The feed grain samples from various trials grown at different locations in four zones were analyzed for 1000 grain weight, starch and protein content. A total of around 367 samples were received encompassing different trials grown in different zones and the following promising entries identified.

Promising sources of malt barley for different traits

S.N.	Trial	1000 grain weight	Protein content (% db)	Starch content (% db)
1	AVT (RF) NHZ	VLB174, UPB1093, BHS484, HBL870	HBL871, VLB171, VLB170, VLB173, BHS485, BHS483, UPB1091	BHS352 (C), BHS485
2	IVT (IR) NWPZ	BH 902 (C)	KB1946, HUB277	NDB1756, KB1912, PL929, RD3034
3	IVT (IR) NEPZ	HUB277, RD3033	KB1946, KB1916	PL927, HUB277, PL932, KB1912, DWRB222
4	IVT (IR) CZ	RD3032, RD3031, HUB277	RD3033, HUB279, PL932, NDB1756, BH1038, RD3034	PL927, KB1946, RD3031
5	IVT (RF) NEPZ	RD3037, RD3035, RD3036, HUB276	HUB276, RD3037	K603 (C)
6	AVT (SST) All Zones	KB1911, RD3040, RD3016, KB1822	RD2907 (C)	RD3039, BH1039, RD3041

TECHNOLOGY OUTREACH PROGRAMME

Frontline Demonstrations (2020-21)

To disseminate a new technology among farmers, it is necessary that the technology is demonstrated at the farmers' field. During the *rabi* crop season 2020-21, 250 Barley Frontline Demonstrations (BFLDs) of one acre each were allotted to 31 cooperating centres all over India in eight states namely, Himachal Pradesh, Uttar Pradesh, Jammu & Kashmir, Punjab, Haryana, Rajasthan, Madhya Pradesh and Karnataka. All 250 BFLDs were conducted by 31 centres, covering 262.38 acres area of 315 farmers. Improved barley varieties with a complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated. The maximum number of BFLDs were conducted in UP (62), followed by Rajasthan (43), MP (39), Punjab and Haryana (33 each), Karnataka (10) and J&K (8).

State wise performance of improved barley varieties during *rabi* 2020-21

State/UT	Mean yield (q/ha)		Gain (%)
	Improved variety	Check variety	
HP	24.63	18.25	34.93***
UP	36.70	25.18	45.78***
Punjab	37.68	34.80	08.26*
Haryana	44.68	42.28	05.68*
Rajasthan	53.38	44.70	19.41***
MP	38.60	29.00	33.10***
J&K	34.55	-	-
Karnataka	23.75	-	-

**** Significant at 1 per cent level, * Significant at 10 per cent level*

The state wise highest gain in barley yield was recorded in UP (45.78%), followed by HP (34.93%), MP (33.10%), Rajasthan (19.41%) and Punjab (08.26%). The lowest gain in yield was reported in Haryana (5.68%). The check variety was not reported in J&K and Karnataka states.

The yield gain under barley FLD was highest at Mirzapur (132.12%) centre and lowest at Hisar (03.81%) centre.

The varieties HBL 713 (25.63 q/ha) at Bajaura centre in NHZ, RD 2907 (48.88 q/ha) at Mirzapur in NEPZ, RD 2907 (66.25 q/ha) at Durgapura, Jaipur in NWPZ, RD 2899 (50.50 q/ha) at Vidisha in CZ and DWRB 137

(23.75 q/ha) at Dharwad in PZ were the highest average yielding varieties. The huskless barley variety PL 891 yielded 31.50q/ha at Ludhiana centre, however, the huskless check was not reported. Checks were also not reported at Kathua and Dharwad centres; the demonstrated new barley varieties were introduced for the first time in these areas.

Zone wise productivity over check during *rabi* 2020-21

Zone	Mean yield (q/ha)		Gain (%)
	BFLDs	Check	
NHZ	24.63	18.25	34.93***
NEPZ	36.05	23.63	52.59***
NWPZ	44.58	41.93	06.32*
CZ	40.43	32.00	26.33***
PZ	23.75	-	-

**** Significant at 1 per cent level, * Significant at 10 per cent level*

The yield gain due to improved varieties over check was highest in NEPZ (52.59%), followed by NHZ (34.93%), CZ (26.33%) and NWPZ (06.32%).

The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres, monitored the barley FLDs, TSP wheat demonstrations and SCSP wheat demonstrations at Dharwad, Udaipur, Rajasmand, Jhansi, Lalitpur, Tikamgarh, Hisar, Rewari, Bhiwani, Sangrur, Mansa, Bathinda, Muktsar, Kanpur, Varanasi and Ayodhya centres during the *rabi* crop season 2020-21.

Overall analysis of barley production constraints in different zones clearly indicated that high cost of inputs, decline in water table, *Phalaris minor*, non-availability of labour, lack of canal irrigation facility, low price of barley grains, small land holding, lodging, poor information delivery by state extension machinery and poor participation in exposure visits arranged by various departments were identified as major constraints affecting barley production and productivity in the country. All these constraints need immediate attention in order to increase wheat production in all the major barley producing zones of the country.

Farmers need to be educated and trained on recent barley production technologies, complete package of practices, and soil health management. There is a need of government intervention to ensure quality seeds as well as quality inputs. Farmers need to be updated on impact of climate change on barley cultivation and what are the coping strategies they adopt

to mitigate it. To ensure better price, farmers have to go for quality barley production. There is a need to register barley growers on e-NAM platform for selling of barley.

Wheat Demonstrations conducted under the SCSP Programme during *rabi* 2020-2021

Under the SCSP Programme, 160 varietal demonstrations of wheat variety DBW 222 (Karan Narendra) were organized during 2020-21 *rabi* crop season to assess the yield potential under high fertility condition so that its highest yield potential could be achieved. The demonstrations were carried out through the KVKs of Punjab (6) and Haryana (4) benefitting 160 farmers. The demonstrations were conducted in 6 aspirational districts (Sangrur, Mansa, Bathinda, Muktsar, Faridkot and Rupnagar) of Punjab covering 85 acres area and 85 farmers of SC category. In Haryana, the demonstrations were conducted in four aspirational districts (Ambala, Yamunanagar, Fatehabad and Sirsa) covering 75 acres of area and benefitting 75 SC farmers. At all the locations yields were highly satisfactory. Improved wheat variety DBW 222 with a complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) was demonstrated.

The district wise yield gain due to improved wheat variety (DBW 222) under SCSP wheat demonstrations was highest in Mansa (14.71%) district in Punjab state followed by Fatehabad (08.46%) district in Haryana state. The lowest yield gain was in Faridkot (02.96%) district in Punjab state. State wise yield gain was highest (06.19%) in Punjab state. The yield gain was 05.89% in Haryana state. Overall yield gain was 06.02%.

Yield gain in wheat demonstrations under the SCSP programme during *rabi* 2020-21

State and Zone	Yield (q/ha)		Gain (%)
	Demonstrations	Check	
Punjab	54.03	50.88	06.19***
Haryana	54.38	51.35	05.89***
North Western Plains Zone (NWPZ)	54.18	51.10	06.02***

*** *Significant at 1 per cent level*

The analysis of varietal performance indicated that the yield gain due to improved wheat variety DBW 222 over check mean yield was highest at Mansa (18.53%) in Punjab state. In Haryana state, the highest yield gain due

to improved wheat variety DBW 222 was at Fatehabad (14.63%), though it was non-significant.

The highest yield potential of variety DBW 222 was 70.00 q/ha in Fatehabad district in Haryana and 62.00 q/ha in Muktsar district, in Punjab.

Costs and Returns in the SCSP Wheat Demonstrations and Barley FLDs vis-à-vis Check Plots

Wheat

The analysis of data indicated that on an average, demonstration of DBW 222 wheat variety at the farmers' field under the SCSP programme gave ₹ 3.24 per rupee of investment in comparison to the check varieties (₹ 3.03).

A significant difference in returns per rupee of investment was noticed between the demonstrated and the check plots in Haryana and Punjab. The profit per hectare in demonstrated plot was highest in Punjab (₹ 85805), followed by Haryana (₹ 77351). The difference in profit levels between demonstration and check plots was highest in the case of Punjab (₹ 6945 per hectare). Operational costs were found to be marginally lower in wheat demonstrations in comparison to the check plots, in both the states. Overall, by adopting a new wheat variety (DBW 222 in our case), a farmer earns ₹ 82142/ha in the NWPZ. Further, ₹ 694 have to be spent to produce a quintal of wheat through new variety against ₹ 744 (farmers' variety: check plots).

Barley

The economic analysis of barley FLDs data indicated that on an average, improved barley varieties demonstrated at the farmers' field under the FLD programme gave around ₹ 47117 profit per hectare. A significant difference in returns per rupee of investment was noticed between the demonstration and check plots across states and zones.

Jammu & Kashmir registered the highest returns per rupee of investment (₹ 2.88) through demonstrations (without any check), followed by Punjab (₹ 2.74) and Rajasthan (₹ 2.62). The difference in returns per rupee of investment between demonstration and check plots was highest in Himachal Pradesh, followed by Uttar Pradesh and Rajasthan. The profit per hectare in FLDs was highest in Rajasthan (₹ 58535), followed by Jammu &

Kashmir (₹ 54448) and Haryana (₹ 52385). The difference in profit between FLD and check plots ranged from ₹ 31207 in Himachal Pradesh to ₹ 3055 in Haryana. Interestingly, operational costs in Punjab were lower in FLDs than check plots. The probable reason might be reduction in the use of inputs based on the recommendation. The returns per rupee of investment across barley growing zones were highest in the NWPZ (₹ 2.67), followed by CZ (₹ 2.53) and PZ (₹ 2.39). Estimates of cost of production indicated that the cost incurred in producing a unit quantity of barley output was least (₹ 679 per quintal) in Punjab owing to less operational costs coupled with increased yield levels.

Technology Transfer

The technologies developed at the institute and other cooperating centres were made aware to the farmers through organising foundation day, world soil day, Mahila Kisan Diwas, Agriculture Education Day, Kisan Diwas and Sanitation Drive, International Women's Day, World Water day, agriculture awareness programmes under 'Mera Gaon Mera Gaurav' scheme. Apart from these, the Social Sciences unit delivered fifty lectures benefitting students, farmers and scientific community; attended the meetings and participated in seminars/symposia/conferences/ workshops and coordinated twelve visits of farmers and students at ICAR-IIWBR, Karnal. The advisory services were also provided to the farmers through letters, phone calls and emails. The unit conducted ten 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 outbreak.

Annexure I

Action taken report on the major recommendations of the 59th All India Wheat & Barley Research Workers' meet held in Virtual Mode during August 24-26, 2020

S.N.	Recommendations	Action Taken
Crop Improvement		
1	Newly released varieties will be taken up in seed chain for cultivation. Also, 14 new genetic stocks will be shared. The newly identified varieties proposals will be now put up to CVRC for release and notification	All the newly released bread and durum wheat varieties namely HI1621, HD3271, DBW222, PBW771, HI1628, NIAW3170, DBW252, HD3249, UAS466 (d), DDW47 (d), MACS4958, GW1346, HI8805 and HI8802; along with two varieties (DBW187 and HD3086) recommended for area extension have been taken up in seed chain. Also, genetic stocks registered with the ICAR-NBPGR have been shared regularly with all the collaborating centres in form of a National Genetic Stock Nursery. All the identified varieties (DBW303, WH1270, HD3298, HD3293, CG1029, HI1633, HI 1634, NIDW1149(d) and DDW48 (d)) have been approved by the CVRC for commercial cultivation.
2	Work plan (2020-21) with a total of 439 new trials sets to be executed. Also, work plan for national nurseries including SSN will be taken up during 2020-21.	The Work plan (2020-21) of Crop Improvement was executed successfully in the form of 443 trials sets at different cooperating centres. Also, six national nurseries were constituted and conducted successfully at all cooperating centres as per plan.
3	It is proposed to get contribution from major centers to contribute material for national nurseries.	The material from centres have been contributed towards NGSN, SSN, DTSN, SATSN, SDN and QCWBN during 2020-21 crop season and will be taken up accordingly in the coming crop seasons.
4	Plan proposed for trait specific hybridization targets and directed program on pre-breeding by major wheat breeding centres and accordingly contribution in national nurseries including SSN.	Trait specific crossing programme targets of contributing centres based on the requirement of their zone was executed successfully. The segregating lines from major centres were also contributed and shared for evaluation and site-specific selections. Information on the AICRP (wheat) centre hybridization plan (2020-21) along with the list of trait specific donors available and being utilized at each centre, was compiled and uploaded on the website for information and sharing of material.
5	Strategy for harvesting 9 tons/ha in early sown high potential environments in mega zones	A special early sown, high fertility trial have been conducted and success have been achieved in releasing varieties of >8.0 tonne/ha potential yield under high input conditions. In this direction, early sown trials were extended to the CZ during 2020-21 and results compiled.
6	Limit of ACI revised to 20.0 under both natural and artificial	Limit of ACI=20 has been fixed and is adopted for promotion and retention of entries from 2020-21 crop season.
7	Revisiting site means for different zones particularly RI trials	Site means of all the RI trials in different zones have been revised by raising (5q/ ha) above the existing to improve productivity.
8	The plot size (AVT/IVT) in NHZ will be uniform across locations.	It has been implemented from 2020-21 crop season and all trials were planted in the said plot size.
9	Contribution of MABB/Biofortified entries to AVTs should be supported by valid passport data	Contribution of biofortified/ MABB entries were considered only with supported data and also circulated guidelines for inclusion of proposals meeting criterion.
10	The AICRP will take up screening of 350 wheat genotypes against wheat blast disease in Bangladesh and Bolivia.	Two sets of 350 wheat genotypes (NIVT and pipeline material) were sent for wheat blast screening and results obtained have been used for promotion of entries in different trials.
11	In view of COVID-19, constitution & dispatch of all coordinated trials will be done by ICAR-IIWBR, Karnal.	All the coordinated trials (NIVT/AVT/SPL etc.) including agronomy were constituted at the ICAR-IIWBR, Karnal and dispatched timely to respective centres.

S.N.	Recommendations	Action Taken
12	Under HRD, one training programme on data recording and conduction of trials during Feb-March, 2021.	A training programme on "Capacity building to improve efficiency of AICRP on Wheat and Barley" was conducted in Virtual mode during March 3-9, 2021 in which 58 participants from different institutes participated.
13	As suggested by DDG, one training on molecular aspects for wheat breeders will be organized during the crop season (December 2020).	The above-mentioned programme on Capacity building to improve the efficiency of AICRP on Wheat and Barley covered both field and molecular aspects of breeding related to Wheat and Barley. Virtual visit to field / lab activities including practicals were organised and e-compendium was shared with participants.
14	The grain yield of all trials is to be reported for gross plot only.	The gross plot yield was reported in all the Crop Improvement trials in the 2020-21 crop season and will be continued.
Resource Management		
1	In NHZ and NWPZ, last week of October is the optimum time of sowing for getting higher yield.	Recommended to the co-operating centres for implementation in respective zones. This recommendation is being used in technical programme for evaluation of entries in HYPT. It is also being popularized among farmers through different extension activities.
2	In all zones application of 150% NPK + FYM (15 t/ha) + GR (0.2% CCC and 0.1% tebuconazole) produced maximum grain yield and yield attributes than recommended fertilizer dose.	The recommendation conveyed to the co-operators of the NWPZ for implementation. It is also being disseminated among farmers through different extension activities. This recommendation is also being used in the HYPT.
3	The need based N application with Green Seeker can save up to 20 kg N/ha.	Conveyed to the co-operating centres for implementation.
Crop Protection		
1	Growing of newly released yellow rust resistant varieties in Punjab, Haryana, Himachal Pradesh and Jammu in view of current pathotype prevalence and discourages old varieties.	Awareness among farmers were created to grow the newly released resistant varieties through visits at farmers field, crop health surveys and also by SMS, whatsapp messages etc. especially in the yellow rust prone areas like Punjab, Haryana, Himachal Pradesh and Jammu. Popularization of resistant variety and management practices were also done through TV talk and Kisan Gosthi. The information was also shared with the state agriculture officials and suggested to grow the recently released resistant varieties and not to grow the susceptible varieties in the foot hills that facilitate rapid spread of yellow rust. The information on newly released resistant varieties and management practices were also published in first wheat crop health newsletter in Vol. 26 (1) issued for the crop season 2020-21, which is shared among all stakeholders and also uploaded on the website. The issue was also discussed during the strategy planning meeting organised by the DAC&FW Govt. of India, which was attended by higher official of agriculture department of different states.
2	Deploy blast resistant cultivars in NEPZ more specifically in West Bengal that are as follows: • DBW 187, HD 3249 and HD 2967 (irrigated and timely sown) • DBW 252 and HD 3171 (restricted irrigation and timely sown)	The awareness was created among state agriculture officials and farmers about blast resistant varieties through small trainings, farmer's field visits and variety awareness campaign by the cooperating centres in West Bengal. Published literature on resistant varieties and other preventive measures in *Bengali* language and distributed to farmers and state agriculture department officials. Farmers awareness programme and interaction meetings through virtual mode on "Promotion of resistant varieties of wheat and disease monitoring for enhanced productivity" from 19th – 21st January, 2021 for West Bengal farmers and state agriculture department officials. The issues to grow resistant varieties identified, implementation of preventive measures and not to use self-grown seed were discussed in strategy planning meetings organised by the DAC&FW, Govt. of India on "Alternate crop plan to combat the wheat blast like disease" on 18.9.2020 through virtual platform. The meeting was attended by the officials of the DAC&FW, Govt. of India, ICAR-IIWBR and West Bengal state agriculture department. The variety DBW 187 and DBW 252 (blast resistant) was provided for multiplication to UBKV and private seed companies in West Bengal.

S.N.	Recommendations	Action Taken
3	Strict monitoring for wheat blast in NEPZ specially areas bordering to Bangladesh. Use of preventive measures i.e. seed treatment with Carboxin + Thiram (1:1) @ 2.5 g/kg and spray of Tebuconazole (50%) + Trifloxystrobin (25%) WG @ 0.06%, if any symptoms observed.	Survey was conducted in West Bengal near the Indo-Bangladesh boarder by a team of scientists from 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 varieties. Published literature on resistant varieties and other preventive measures in *Bengali* language and distributed to farmers and state agriculture department officials. Farmers awareness programme and interaction meetings through virtual mode on "Promotion of resistant varieties of wheat and disease monitoring for enhanced productivity" from 19th – 21st January, 2021 for West Bengal farmers and state agriculture department officials.
4	It is recommended to record the leaf blight score at least three times with 10-15 days interval for effective screening and harnessing the variability for leaf blight resistance.	Implemented. The leaf blight was recorded three times during the crop and AUDPC was calculated.
5	For the management of CCN use of Chalcone @40 ppm conc. + half dose of Carbofuran 1kg ai. per ha found effective.	Farmers and state agriculture officials were made aware of these recommendations through trainings, workshops and *Kisan Mela* etc.
6	For the management of aphid use Beta-Cyfluthrin 9%+ Imidacloprid 21% @ 400 ml /ha found effective.	For the management of aphid in wheat, farmers and state agriculture officials were made aware of these recommendations through trainings, workshops and *Kisan Mela* etc.
7	The monitoring of PPSN trial will be through digital mode.	The monitoring of PPSN trial was done through digital mode to the centers where monitoring team not reached. However, physical monitoring was also done because that time COVID situation was under control.
8	A training to crop protection co-operators for diseases scoring, recording and reporting is needed to further improving screening.	A training was organized on "Creation of epiphytotics for disease and insect pests, uniform data recording and reporting in wheat and barley crop protection trials" from 28-30 January, 2021 through virtual mode at ICAR-IIWBR, Karnal for scientists working in crop protection under the coordinated system
Quality Improvement		
1	It is recommended to use bench marks of traits in combination to identify superior entries for different end-use products and nutritional quality traits having distinct superiority in the trial.	Benchmarks of quality traits have been developed to identify entries having distinct superiority in the trials. The benchmarks have been used for the purpose.
2	It is recommended to have breeding for soft and hard wheat classes separately in bread wheat. Emphasis should be on high yellow pigment and protein content with strong gluten in durum wheat. This is required to meet the rising demand of baking products in the country. For this purpose quality scientists and breeders should go hand in hand.	Breeding for both soft and hard wheat classes have been initiated by several centres and entries contributed by the ICAR-IIWBR, Karnal, PAU, Ludhiana and ICAR-IARI regional station, Shimla have been tested in advanced trails.
3	Issue of nutritional quality was discussed in length and it was suggested to develop catalogue/technical bulletin of nutritional quality traits including bioavailability of Fe and Zn, dietary fibre, resistant starch, glycemic index etc of popular released varieties. For this purpose institutions (including NABI, Mohali, NIN, Hyderabad, NIFTAM, Kundli) where such facilities are available will be involved.	We have initiated work on nutritional quality traits including bioavailability of Fe and Zn, dietary fibre, resistant starch, glycemic index etc. in wheat. We wrote to the Director, NABI, Mohali but did not get response and also could not get support from the NIN, Hyderabad. However, now NABI,Mohali has been included in the CRP Biofortification and we expect support from them in this area of wheat nutritional quality. We have also developed a bulletin on both processing and nutritional quality traits in current wheat varieties.

S.N.	Recommendations	Action Taken
4	Self assessment and reviewing the AICRP-WAB programme as a whole should be done under the chairmanship of ADG (FFC) to identify quality traits for evaluating AICRP trials.	Self assessment was done and the AICRP-WAB programme was reviewed under the chairmanship of ADG (FFC) to identify quality traits for evaluating the AICRP trials.
5	Since protein content showed large variations across centres and zones, it is suggested that after keeping in view the total N requirement, the possibility of balancing added N-fertilizer with the available N, may be explored.	An experiment under in-house project has been initiated for exploring the possibility of balancing added N-fertilizer with the available N.
6	For checking uniformity of data, PI quality should provide check samples of selected wheat varieties to coordinating centres where NIVTs are being analysed. In turn centres should also send few random samples to ICAR-IIWBR, Karnal for checking data uniformity and thus minimising the lab to lab variations.	Five entries from each centre were evaluated at the ICAR-IIWBR, Karnal for grain protein, hectolitre weight, grain appearance, phenol test and sedimentation value and data compared with data generated by each centre. There was no discrepancy in the data generated by the centres. We also conducted training programme in 2018 for all the centres working in wheat quality which helped in generating uniform data across centres. In near future also we would conduct training for the AICRP centres for quality analysis.
7	Considering the nutritional and therapeutic value of Dicoccum wheat, the dicoccum trials should be analyzed for nutritional parameters like protein content, total dietary fiber, soluble fiber, resistant starch content, Zn and Fe content.	Considering the nutritional and therapeutic value of Dicoccum wheat, the dicoccum trials were analysed for nutritional parameters like protein content, Zn and Fe content. However, total dietary fiber, soluble fiber, resistant starch content could not be analysed because of the closing of Food Science Department in UAD, Dharwad due to COVID pandemic.
8	It is recommended that samples from a centre having average value of hectolitre weight below 73.0 will not be used for further analysis and thus no data of the centre will be reported.	The recommendation was followed in analysing the data.
9	Because of Covid-19 crisis, samples from Mandi/Farmers' filed could not be collected during this year, it is therefore, recommended that AICRP centres involved in sending trial samples for quality analysis in different zones should collect and send samples from Mandi/ Farmers' field samples for quality analysis to ICAR-IIWBR, Karnal.	Because of COVID-19 crisis, samples from *Mandi*/Farmers' filed could not be collected during this year also except two centres. However, the recommendation will be followed during next year.
Barley Improvement		
1	The regular trials of NH Zone will also include a treatment for dual purpose evaluation by having a cut for green fodder in two replications and the remaining two will be as non-cut for generating all required information on grain and forage yield, however this should be discussed with the statistician before taking any decision.	Implemented The combined AVT-RF-TS in NH Zone was constituted and conducted as per the recommendation during *Rabi* 2020-21.

S.N.	Recommendations	Action Taken
2	The Salinity trials will also be conducted at Kumher, Bhilwara and CSSRI Karnal locations, while will be discontinued at Rampura and Banasthali. The request to CSSRI may be made through proper channel for taking up barley trial also in addition to the regular wheat trial at the institute.	Implemented. The salinity trials were conducted at Bhilwara and ICAR-CSSRI, Karnal locations, while Kumher could not be included because of technical reasons. The trial was discontinued at Rampura and Banasthali.
3	Screening for barley blights (spot blotch) will also be carried out at Arabhavi location under UAS Dharwad for which an extra set of NBDSN will be supplied from PI CP, ICAR-IIWBR, Karnal. Dharwad location will continue for black rust screening as usual. In addition to the aphid screening, data on shoot fly is also to be recorded at two locations.	Implemented. One extra set of the NBDSN was supplied to centre during 2020-21 season.
4	Observations on leaf blight will be recorded at least at three appropriate growth-stages in order to calculate the AUDPC of barley genotypes for their reaction to leaf blight. The AUDPC may be considered for comparison of entries and checks instead of highest score only, which sometimes is not sufficient to differentiate the genotypes.	Implemented. The AUDPC for NBDSN will be computed and considered for leaf blights resistance during 2020-21 season.
5	Breeders may practice the selection of new malt barley genotypes in the range of 42 to 48 g of TCW to avoid extra bold grains, which becomes disadvantageous during malting process.	Implemented. The issue was communicated to all breeders dealing with the malt barley improvement program to look in to it while making selections in breeding material.
6	The resource management trials should include components like ZnSO4 and osmo- protectants/suppressants.	Implemented. Two trials one on fertiliser scheduling including treatments of ZnSO4 was initiated and one trial on Zn application and varieties is also going on from previous year. Trial on Osmo-protectants conducted during 2016-17 to 2018-19, resulted that there was no significant difference on yield and yield components, when osmo-protectant was included in the treatment.
7	From crop season 2020-21 all entries of the coordinated yield trials will be analysed for molecular diversity, which is currently being done for only AVT final year entries.	Implemented. All the entries in varietal yield evaluation trials have been analysed for molecular diversity.

Annexure II

Financial Highlights for the Year 2020-21

A. Budget Utilization

(₹ in Lakhs)

Name of the Scheme	Total BE 2020-21	Total R.E. 2020-21	Total Remittance Received 2020-21	Total Exp.	% of EXP. Against RE
ICAR-IIWBR, KARNAL	3156.17	2951.89	2951.89	2833.91	96.00
AICRP on Wheat & Barley	1673.15	1723.25	1723.25	1723.25	100.00

Expenditure Statement for the year 2020-21 in respect of ICAR-IIWBR, Karnal

(₹ in Lakhs)

Name of Scheme	HEAD	BE 2020-21	RE 2020-21	EXPENDITURE				TOTAL EXP.	% of EXP. Against Net RE
				Other than NEH & TSP	TSP	NEH	SCSP		
ICAR-IIWBR, KARNAL	Grants in Aid - Capital	230.00	32.20	19.63	0.0	0.0	0.0	**19.63**	60.96
	Grants in Aid - Salaries	1971.17	1956.00	1956.00	0.0	0.0	0.0	**1956.00**	100.00
	Grants in Aid - General								
	(1) Pension	210.00	197.20	197.20	0.0	0.0	0.0	**197.20**	100.00
	(2) Others	745.00	766.49	643.00	3.57	11.49	3.02	**661.08**	86.25
TOTAL		**3156.17**	**2951.89**	**2815.83**	**3.57**	**11.49**	**3.02**	2833.91	**96.00**

(₹ in Lakhs)

Name of Scheme	HEAD	BE 2020-21	RE 2020-21	EXPENDITURE				TOTAL EXP.	% of EXP. Against Net RE
				Other than NEH & TSP	TSP	NEH	SCSP		
AICRP (Wheat & Barley)	Grants in Aid - Capital	0.0	0.0	0.00	0.0	0.00	0.0	**0.00**	0.00
	Grants in Aid - Salaries	1385.15	1435.15	1435.15	0.0	0.00	0.0	**1435.15**	100.00
	Grants in Aid - General								
	(1) Pension	0.0	0.0	0.00	0.0	0.0	0.0	**0.00**	0.00
	(2) Others	288.00	288.10	258.10	20.0	10.00	0.0	**288.10**	100.00
TOTAL		**1673.15**	**1723.25**	**1693.25**	**20.00**	**10.00**	**0.00**	**1723.25**	**100.00**

B. Revenue Generation for the year 2020-21

(₹ in Lakhs)

S.N.	Year	Target	Revenue Generated as per Schedule 8, 10 & 12 of Balance Sheet 2020-21
1	2020-21	44.40	252.11

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

S.N.	Year	Number of outstanding Paras	Position of submission of reply as on31.7.2021
1	2017-20	10	Replies of audit paras have been submitted vide letter No. 8-3/ Fin/IIWBR/20-21/9288-89 Dated 19.2.2021.
2	2020-21		External Audit for the year 2020-21 is awaited.

D. Status of ICAR Inspection Report as on 31.07.2021

S.N.	Year	Number of outstanding Paras	Position of submission of reply as on 03.08.2020
1	2018-19	Nil	Internal Audit for the year 2019-20 and 2020-21 is awaited.

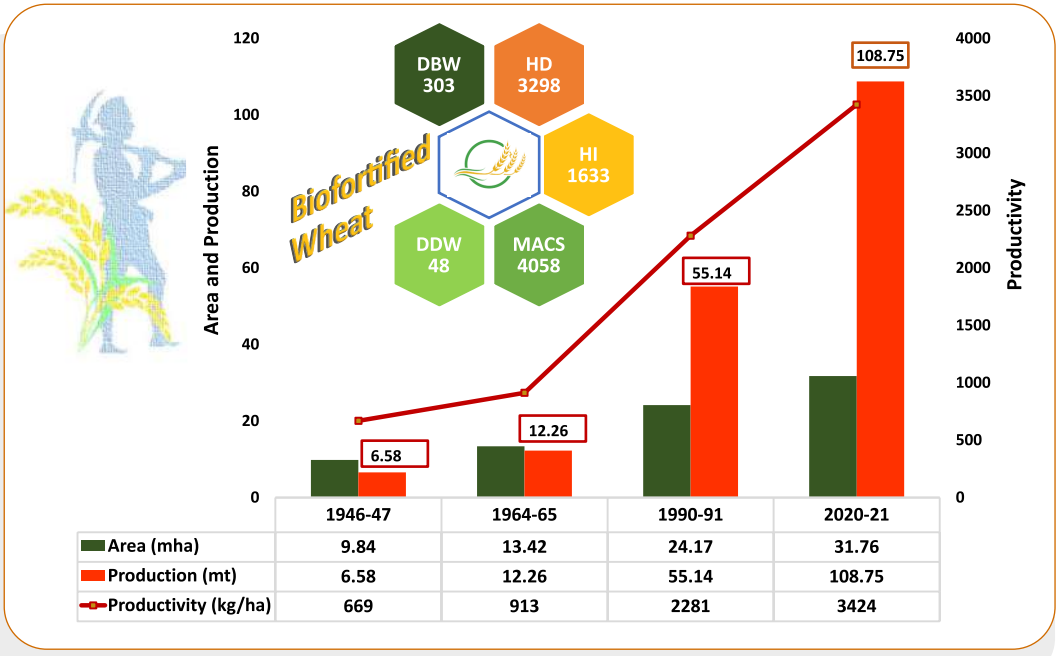
STATEMENT SHOWING NET GRANT RELEASED TO AICRP ON WHEAT & BARLEY CENTRES DURING THE YEAR 2020-21

(Amount in ₹)

S.N.	Name of the Centre	Pay & Allowances	TA	Rec. Cont.	Total
1	BAJAURA	1875000	7500	600000	2482500
2	BILASPUR	4174500	45000	450000	4669500
3	COOCHBEHAR	1725000	22500	600000	2347500
4	DHARWAD	4299750	30000	1125000	5454750
5	DURGAPURA	15900000	270000	1500000	17670000
6	FAIZABAD	6375000	52500	900000	7327500
7	GWALIOR	4935000	0	600000	5535000
8	HISAR	7429500	45000	1350000	8824500
9	IMPHAL-NEH	0	60000	180000	240000
10	JABALPUR	1837500	90000	600000	2527500
11	JAMMU	4650000	0	600000	5250000
12	JUNAGADH	2482500	90000	600000	3172500
13	KALYANI	2505000	67500	562500	3135000
14	KANPUR	8776500	97500	997500	9871500
15	LUDHIANA	10461000	0	1230000	11691000
16	MAHABALESWAR	2004000	63000	675000	2742000
17	NIPHAD	5231250	197874	492126	5921250
18	PALAMPUR	8400000	11250	900000	9311250
19	PANTNAGAR	9975000	315812	674188	10965000
20	POWARKHEDA	6000000	60000	600000	6660000
21	PUNE	6844750	90000	840000	7774750
22	RANCHI	1733250	45000	600000	2378250
23	SABOUR	5720250	0	600000	6320250
24	SAGAR	0	0	375000	375000
25	SHILLONGANI-NEH	7460250	37500	510000	8007750
26	SRINAGAR	1372500	45000	450000	1867500
27	UDAIPUR	4275000	73500	600000	4948500
28	VARANASI	3979500	90000	900000	4969500
29	VIJAPUR	3093000	138000	945000	4176000
	TOTAL	143515000	2044436	21056314	166615750
	Cont. to voluntary centers	0	0	3709250	3709250
	TSP	0	0	2000000	2000000
	Grand Total	**143515000**	**2044436**	**26765564**	**172325000**

STATUS OF AUC/ UC FOR THE YEAR 2020-21 IN R/O CENTRES UNDER WHEAT & BARLEY

S.N.	Name of centre	Name of University/SAU's	Position of AUC
1	BAJAURA	HPKV, PALAMPUR	AUC received
2	BILASPUR	IGKV, RAIPUR	AUC received
3	COOCHBEHAR	UBKV, COOCHBEHAR	Only UC received
4	DHARWAD	UAS, DHARWAD	AUC received
5	DURGAPURA	RAU, BIKANER	AUC received
6	FAIZABAD	NDUA&T, FAIZABAD	Only UC received
7	GWALIOR	RVS KV, GWALIOR	Not received
8	HISAR	HAU, HISAR	Only UC received
9	IMPHAL	CAU, IMPHAL	Only UC received
10	JABALPUR	JNKVV, JABALPUR	Not received
11	JAMMU	SKUAS & T, JAMMU	Only UC received
12	JUNAGADH	JAU, JUNAGADH	AUC received
13	KALYANI	BCKV, NADIA	AUC received
14	KANPUR	CSAUAST, KANPUR	Only UC received
15	LUDHIANA	PAU, LUDHIANA	Only UC received
16	MAHABALESWAR	MPKV, RAHURI.	AUC received
17	NIPHAD	MPKV , RAHURI	AUC received
18	PALAMPUR	HPKV , PALAMPUR	AUC received
19	PANTNAGAR	GBPUA & T, PANTNAGAR	AUC received
20	POWARKHEDA	JNKVV, JABALPUR	Only UC received
21	PUNE	ARI, PUNE	AUC received
22	RANCHI	BAU, RANCHI	Only UC received
23	SABOUR	BAU, SABOUR	AUC received
24	SAGAR	JNKV, JABALPUR	Not received
25	SHILLONGANI	AAU, JORHAT	Not received
26	SRINAGAR	SKUAS & T, SRINAGAR	AUC received
27	UDAIPUR	MPUAT, UDAIPUR	AUC received
28	VARANASI	BHU, VARANASI	Not received
29	VIJAPUR	SDAU, SARDAR, KRUSHI NAGAR	AUC received



	1946-47	1964-65	1990-91	2020-21
Area (mha)	9.84	13.42	24.17	31.76
Production (mt)	6.58	12.26	55.14	108.75
Productivity (kg/ha)	669	913	2281	3424

60th All India Wheat & Barley Research Workers' Meet
(August 23-24, 2021)

60वीं अखिल भारतीय गेहूँ एवं जौ अनुसंधान कार्यशाला में आयोजित गोष्ठी के दौरान जारी किया गया