प्रगति प्रतिवेदन

PROGRESS REPORT
2021-22

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

Azadi Ka Amrit Mahotsav

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ALL INDIA COORDINATED RESEARCH PROJECT (AICRP) ON WHEAT & BARLEY

DIRECTOR'S REPORT 2021-22

G.P. SINGH
DIRECTOR

भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल
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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.

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

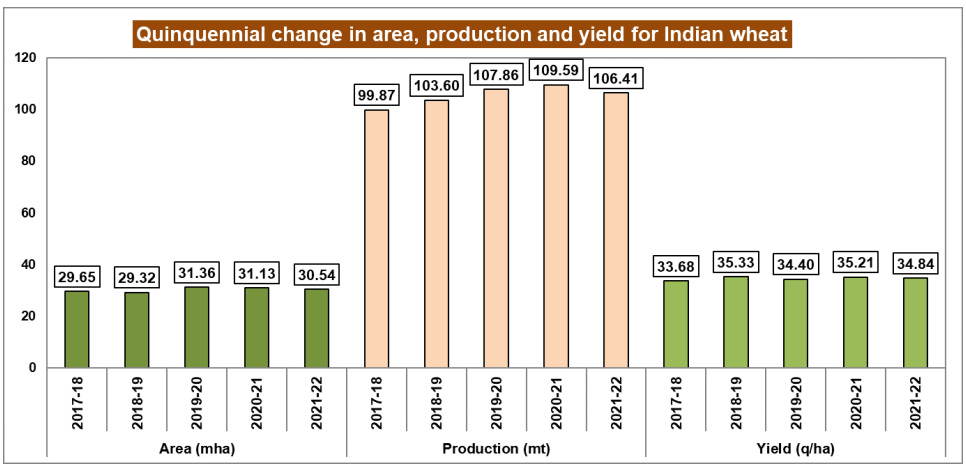
(G.P. Singh)
Director

Place : Karnal
Date : August 18, 2022

DIRECTOR'S REPORT (2021-22)

Globally, wheat and barley serve as an important source of calories and energy for humans and account for a prominent share in the consumption basket. These nutri-rich cereals have been under cultivation in 270.8 million hectares, of which wheat is grown in 222.21 million hectares and barley in 48.59 million hectares of area. The combined annual production of wheat and barley registered an all-time highest output, estimated at 924.11 million tonnes. Of them, wheat accounts for 779.03 million tonnes, and barley output is estimated at 145.08 million tonnes (Source: USDA). Further, wheat and barley respectively hold the first and fourth position in terms of global cereals' acreage for the period 2021-2022. In India, these *Rabi* cereals are grown in 31.09 million hectares (23.78% of total crop acreage) contributing 34.34% of the total foodgrains produced during 2021-2022. Wheat has been under cultivation in 30.54 million hectares and barley covered 0.54 million hectares during the 2021-2022 *Rabi* season (Source: 4th Advance Estimate, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India). In the current production season (2021-2022), the wheat output is pegged at 106.84 million tonnes with national average productivity of 3484 kg per ha. Similarly, the output from barley registered 1.59 million tonnes during 2021-2022 from 0.54 million hectares area with average national productivity of 2930 kg/ha.

Wheat Scenario in India



In India, the production of wheat has been increasing consistently in the recent past, despite the adverse effects of climate change. However, in 2021-22, the wheat output has witnessed a fall in comparison to the past year and is

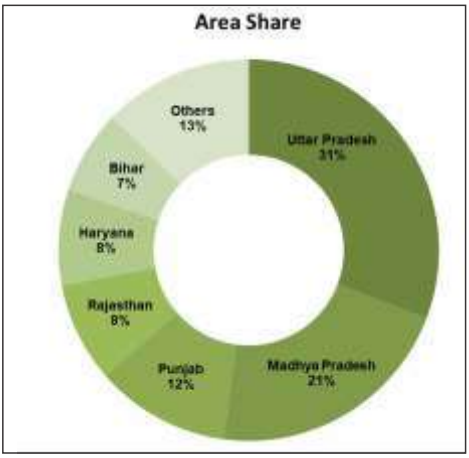
estimated at 106.84 million tonnes as per the 4th Advance Estimate, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India. The fall in production is attributed to the decline in the area by 1.87% and overall productivity by 1.05%. Reduced area (switching to other competing crops) and crop productivity (owing to a rise in day temperature during the crop season) in major wheat-growing states led to a decrease in the overall production. Madhya Pradesh has shown a significant increase in the crop area. However, in 2021-22, there existed variation in area, production, and productivity across states in comparison to the previous year's final estimates.

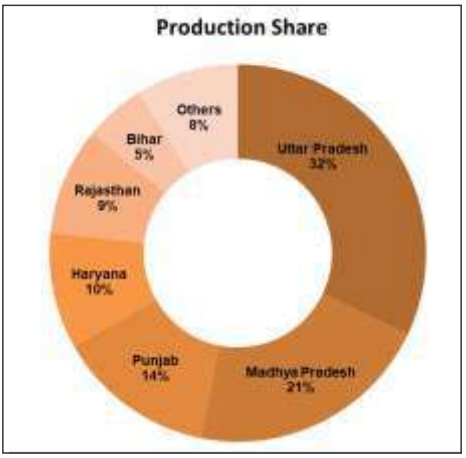
Quantum change in the area, production, and yield of wheat

State	2020-21 (Final Estimate)			2021-22 (Third Estimate)			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	9	13	1379	13	18	1359	3.66	4.78	-20
Bihar	2223	6150	2767	2176	5600	2573	-46	-550	-194
Chhattisgarh	160	248	1551	159	238	1494	-1	-11	-57.00
Gujarat	1017	3259	3205	1040	3364	3235	23	105	30
Haryana	2564	12394	4834	2471	10620	4298	-93	-1774	-536
Himachal Pradesh	333	570	1712	333	570	1712	0.01	0.02	0.00
Jharkhand	233	544	2337	225	469	2085	-8	-75	-252
Karnataka	203	262	1291	157	203	1291	-46	-59	0
Madhya Pradesh	6083	18182	2989	6500	22419	3449	417	4236	460
Maharashtra	1126	2071	1839	1169	2279	1950	42	207	111
Odisha	0.18	0.30	1640	0.20	0.30	1508	0.02	0.01	-132
Punjab	3530	17186	4868	3502	14456	4128	-28	-2730	-740
Rajasthan	3002	11035	3676	2580	9819	3806	-422	-1216	130.00
Telangana	6	15.84	2640	6.00	15.84	2640	0.00	0.00	0
Uttar Pradesh	9852	35507	3604	9420	34157	3626	-432	-1350	22.00
Uttarakhand	312	955	3062	298	867	2909	-14	-88	-153
West Bengal	193	595	3077	220	660	3000	26.73	65.31	-77
Others	278	598	2150	275	657	2394	-4	59	244
INDIA	31125	109586	3521	30544	106413	3484	-581	-3174	-37

Source: DES, MoA&FW, India.

Among the wheat-producing states, Uttar Pradesh accounted for the highest share of crop output estimated at 34.16 million tonnes (32%), followed by Madhya Pradesh (22.42 million tonnes: 21%), Punjab (14.46 million tonnes: 14%), Haryana (10.62 million tonnes: 10%), Rajasthan (9.82 million tonnes: 9%) and Bihar (5.60 million tonnes: 5%).





The aforementioned six states hold a share of about 91% of total wheat production in India. Barring Assam, Gujarat, Madhya Pradesh, Maharashtra, and West Bengal, the rest of the states registered a decline in production during the *Rabi* 2021-22 in comparison to 2020-21.

Overall production from all these states has declined by 7.85 million tonnes owing to the fall in yield levels and/or acreage. The highest fall in production was noticed in Punjab (-2.73 million tonnes: -15.88%). Among wheat-growing states, the increase in production was maximum in Madhya Pradesh (+4.24 million tonnes: +23.3%). In percentage terms, the observed change in production was highest in Assam (37.14%).

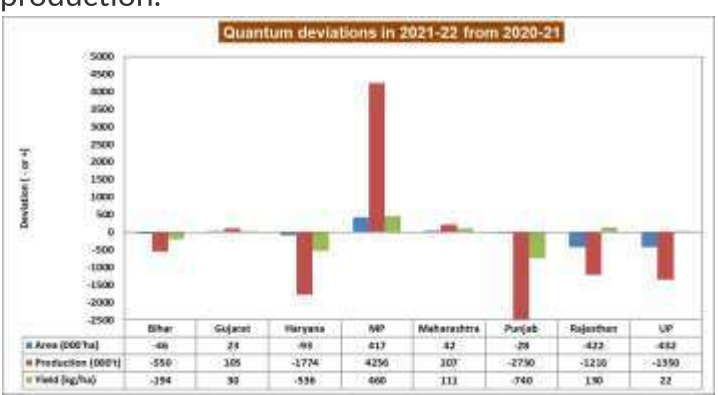
State-wise area under wheat exhibited regional differences and it has decreased by 0.58 million hectares (-1.87%) during the current season in comparison to the recent past. The highest fall in acreage was observed in Uttar Pradesh (-4.32 lakh hectares: -4.38%) whereas the maximum increase in acreage was noticed in Madhya Pradesh (+4.17 lakh hectares: +6.86%). As usual, Uttar Pradesh holds the top slot in wheat acreage (9.42 million hectares: 31%), followed by Madhya Pradesh (6.50 million hectares: 21%), Punjab (3.50 million hectares: 12%), Rajasthan (2.58 million hectares: 8%), Haryana (2.47 million hectares: 8%) and Bihar (2.18 million hectares: 7%). The aforementioned states altogether comprise 87 per cent of the total area and produce 91 per cent of the total wheat.

Contribution of yield and/or area to wheat production (2021-22)

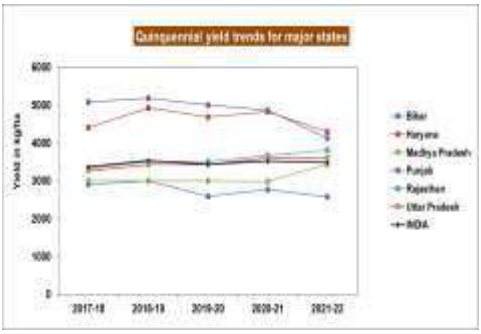
State/Country	Change in production in 2021-22 over 2020-21		% contribution by	
	Quantity (in '000 tonnes)	Deviation (in %)	Area	Yield
Assam	4.78	37.14	39.16	-1.45
Bihar	-550	-8.94	-2.07	-7.01
Chhattisgarh	-11	-4.24	-0.59	-3.68
Gujarat	105	3.22	2.26	0.94
Haryana	-1774	-14.31	-3.63	-11.09
Himachal Pradesh	0.02	0.00	0.00	0.00
Jharkhand	-75	-13.72	-3.30	-10.78
Karnataka	-59	-22.66	-22.66	0.00
Madhya Pradesh	4236	23.30	6.86	15.39
Maharashtra	207	10.02	3.76	6.04
Odisha	0.01	2.17	11.11	-8.05
Punjab	-2730	-15.88	-0.80	-15.20
Rajasthan	-1216	-11.02	-14.06	3.54
Telangana	0.00	0.00	0.00	0.00
Uttar Pradesh	-1350	-3.80	-4.38	0.61
Uttarakhand	-88	-9.26	-4.49	-5.00
West Bengal	65	10.98	13.83	-2.50
Others	59	9.92	-1.30	11.37
INDIA	-3174	-2.90	-1.87	-1.05

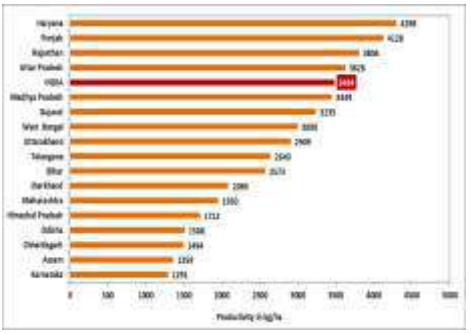
*Note: * indicate the third advance estimate from the DES, MoA&FW, India.*

Assam, Gujarat, Himachal Pradesh, Madhya Pradesh, Maharashtra, Odisha, and West Bengal have shown a positive change in crop acreage. In percentage terms, the decline in crop acreage was highest in Karnataka (-22.66%: 0.46 lakh hectares). Further, the state wise analysis indicated that Gujarat, Himachal Pradesh, Madhya Pradesh, Maharashtra and Telangana have exhibited an increase or sustained in both area and yield which resulted in the incremental national output in wheat production.



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 1.05% (-37 kg/ha) in 2021-22. State wise estimates indicated that Assam, Gujarat, Himachal Pradesh, Madhya Pradesh, Maharashtra, Odisha, Telangana, and West Bengal witnessed a positive change in the crop output for the *Rabi* season 2021-22. Similarly, with the exception of Gujarat, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Telangana and Uttar Pradesh, the rest of the states have witnessed a fall in their productivity levels during the current season (2021-22) in comparison to the recent past. The crop yield varied across states and it ranged from as high as 4298 kg/ha in Haryana to the lowest 1291 kg/ha in Karnataka. Haryana, Punjab, Rajasthan, and Uttar Pradesh have registered yield levels much higher than the national average (3484 kg/ha). The increase in productivity during 2021-22 over the previous year was highest in the case of Madhya Pradesh (+460 kg/ha: +15.39%) and the highest reduction was noticed in the case of Punjab (-740 kg/ha: -15.20%).



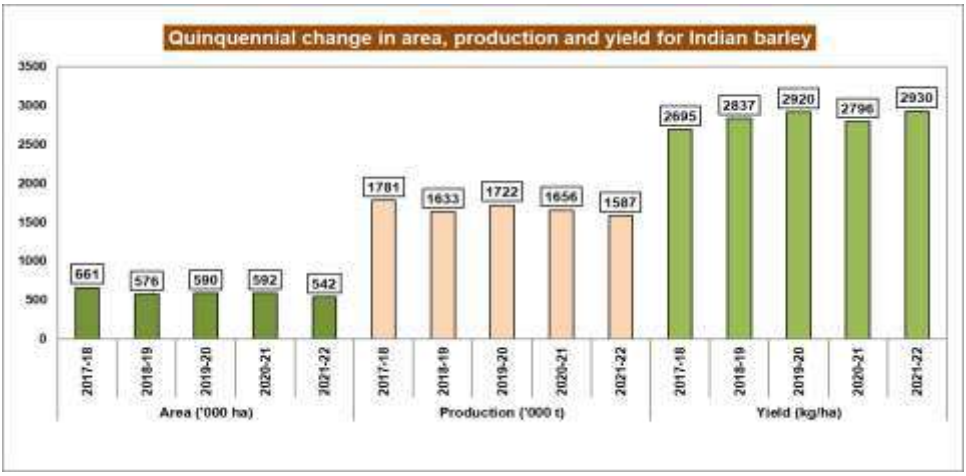


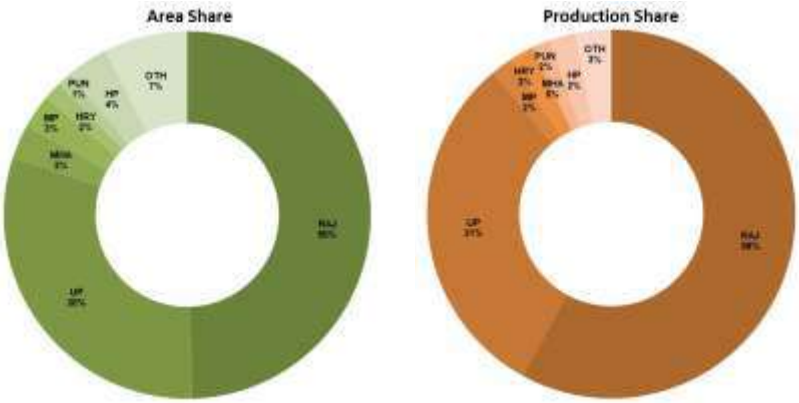
Scenario for Barley in India

Barley, a competing crop to wheat, has shown a similar pattern in area and production scenario with regional diffrences across states. For the *Rabi* 2021-22 crop season, barley production witnessed a decline by 0.69 lakh tonnes and the output was estimated at 1.59 million tonnes (Source: III Advance Estimate from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare, India).

The fall in production is attributed to the area decline by 8.55% (-0.51 lakh hectares) despite increase in the yield level by 4.80% (+134 kg/ha). 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 competing *Rabi* crops.





Quantum change in area, production and yield of barley

State/Country	2020-21 (Final Estimate)			2021-22 (Third Estimate)			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	7.6	14.4	1903	9.8	17.1	1754	2.20	2.73	-149
Chhattisgarh	1.4	1.0	694	0.7	0.6	820	-0.72	-0.41	126
Haryana	9.3	31.0	3343	9.0	32.9	3649	-0.24	1.96	306
Himachal Pradesh	20.4	32.1	1573	20.1	36.4	1810	-0.32	4.26	237
Madhya Pradesh	25.0	48.0	1919	16.0	30.7	1921	-9.00	-17.24	2
Maharashtra	63.0	48.1	764	16.4	3.3	199	-46.55	-44.83	-565
Punjab	5.9	22.3	3777	7.0	22.9	3275	1.10	0.64	-502
Rajasthan	269.7	935.7	3469	268.5	920.2	3427	-1.22	-15.50	-42
Uttar Pradesh	157.0	488.1	3109	165.0	490.9	2975	8.00	2.76	-134
Uttarakhand	22.0	28.0	1272	20.0	24.2	1208	-2.00	-3.82	-64
West Bengal	0.3	0.5	2139	0.5	1.1	2100	0.25	0.51	-39
Others	10.9	7.1	652	8.8	7.1	815	-2.18	0.00	163
INDIA	592	1656	2796	542	1587	2930	-51	-69	134

Source: DES, MoA&FW, India.

Among barley growing states, Rajasthan holds the top slot in production (0.92 million tonnes: 58%), followed by Uttar Pradesh (0.49 million tonnes: 31%) and equally by Haryana and Madhya Pradesh (0.03 million tonnes: 2%). The aforementioned four states altogether accounted for about 93% of the total barley produced in the country. Rajasthan consecutively ranks first in terms of barley acreage (0.27 million hectares: 50%) during 2021-22, and it may be a plausible reason for its high share in production (58%). During 2021-22 *Rabi* season, the average productivity in barley was highest in the case of Haryana (3649 kg/ha), followed by Rajasthan (3427 kg/ha), Punjab (3275 kg/ha), and Uttar Pradesh (2975 kg/ha). The aforementioned states registered the productivity levels more than the national average (2930 kg/ha).

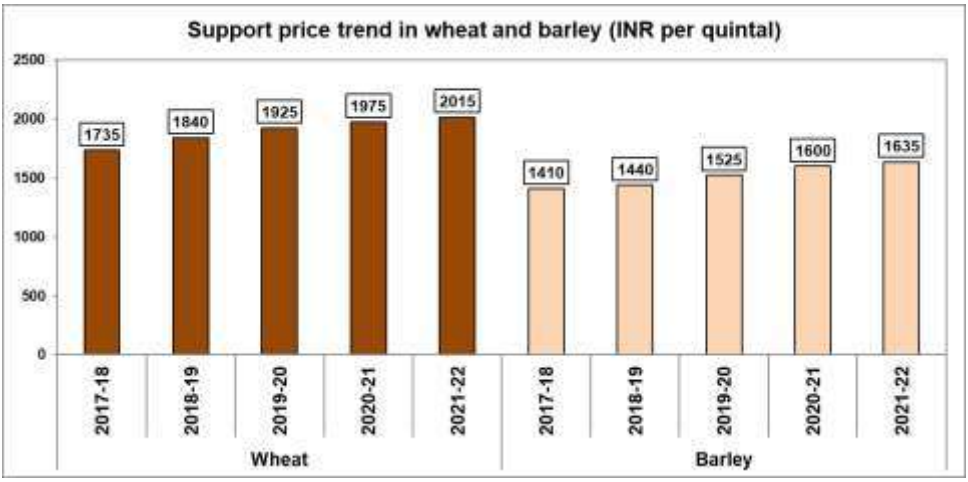
A wide range of variation has been noticed in crop acreage, production and productivity levels. Productivity has declined in states like Bihar, Maharashtra, Punjab, Rajasthan, Uttar Pradesh, Uttarakhand and West Bengal ranging from 39 to 565 kg/ha. Maharashtra is the only state to show an apparent negative change in both area and yield during the current season in comparison to the recent past.

	Bihar	Haryana	HP	MP	Maharashtra	Punjab	Rajasthan	UP	INDIA
Area ('000'ha)	2.20	0	-0.52	-9	-47	1	-1	8	-51
Production ('000't)	2.73	2	4.26	-17	-45	1	-15	3	-69
Yield (kg/ha)	-149	306	237	2	-565	-502	-42	-134	134

The crop acreage has witnessed a decline in a majority of the states barring Bihar, Punjab, Uttar Pradesh and West Bengal. Surprisingly, none of the states have exhibited a positive change in all the three variables *viz*., area, production and productivity of barley, and all have

shown a decline either in area and/or crop yield which is a serious concern. The decline in barley output was highest in the case of Maharashtra and the fall is estimated at 0.45 lakh tonnes (-93.21%) in comparison to previous year, which is attributed to the fall in both crop acreage (-73.95%) and productivity (-73.95%).

Price Scenario for Wheat and Barley



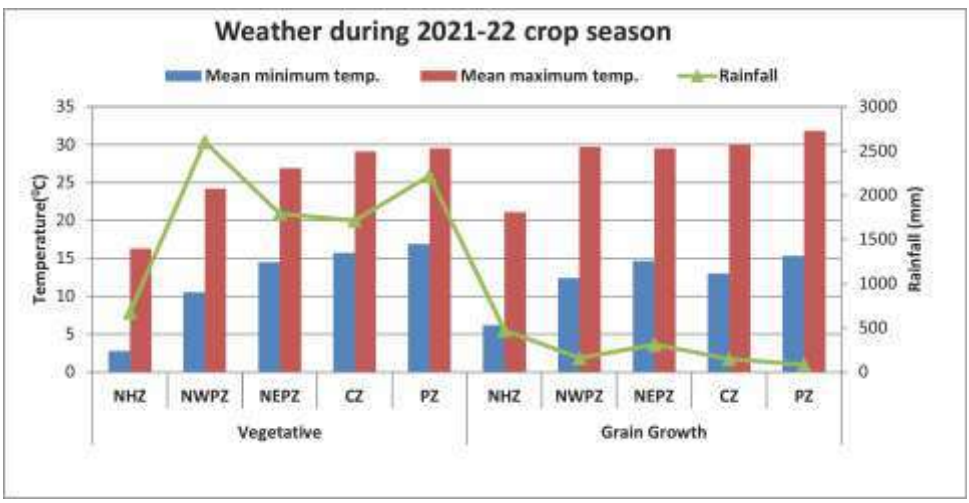
A comparison of the minimum support price for wheat and barley (in nominal terms) for the recent five years indicated a positive change over time. Government's policy decision on increasing the wheat procurement price by 2% and barley by 2.2% in comparison to the past year's support price helped farmers to take prior sowing decision. However, the extent of change in the support prices didn't have a positive impact on either of the crops acreage. The area under wheat has declined by 0.58 million hectares, and, barley acreage fell by 0.51 lakh hectares. It is also clear from the quinquennial data that the support price difference between wheat and barley hovers around ₹400 to ₹ 325 per quintal and the divergence increased in 2021-22 in comparison to 2020-21.

Weather Scenario 2021-22

Meteorological data were received by 63 centres across NHZ (6), NWPZ (14), NEPZ (14), CZ (18) and PZ (11). The mean minimum temperature (min.T) and mean maximum temperature (max.T) were

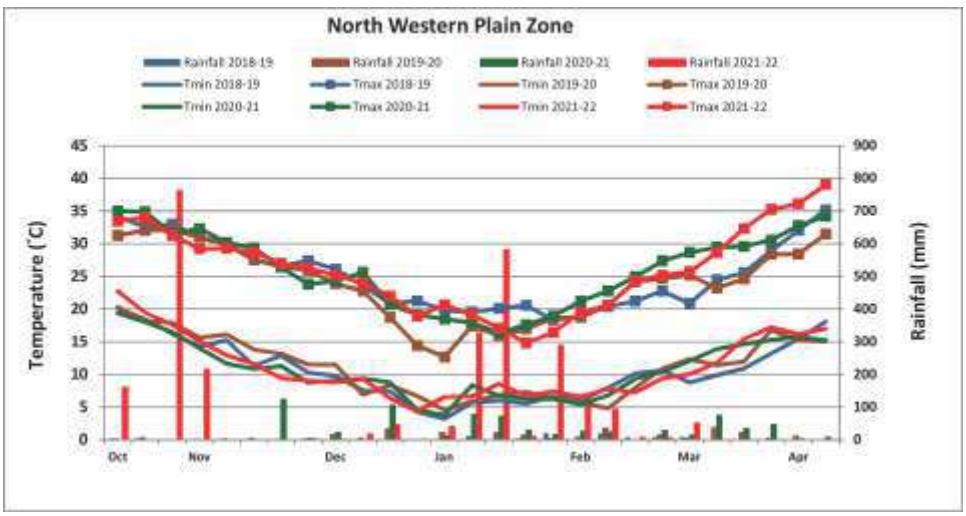
6.2^{0}C and 21.1^{0}C in NHZ, 12.4^{0}C and 29.7^{0}C in NWPZ, 14.7^{0}C and 29.5^{0}C in NEPZ, 13^{0}C and 30.2^{0}C in CZ and 15.3^{0}C and 31.8^{0}C in PZ during grain filling period. Compared to previous crop season, the mean min.T was lower in NHZ, NWPZ, CZ and PZ and was higher by 0.4^{0}C in NEPZ. The mean max.T was lower in NHZ, NEPZ, CZ and PZ and was higher by 0.8^{0}C in NWPZ during grain filling period. In NHZ, the max.T remained <28°C in most of the grain filling period, in NWPZ the max.T was >35°C from the mid of March till the crop maturity. In NEPZ the max.T remained <35°C during grain filling period and In CZ and PZ, the max.T was > 35°C during crop maturity.

All zones received rainfall during the crop season. Maximum rainfall of 2763mm was recorded in NWPZ followed by 2305 mm in PZ, 2103 mm in NEPZ, 1860 mm in CZ and 1155 mm in NHZ. Compared to previous year, significantly higher rainfall was received in all the zones. But, the rainfall distribution was unequal across crop season, wherein >80% of rainfall was received during vegetative stage and very meager rainfall was seen during grain filling period across all the zones.

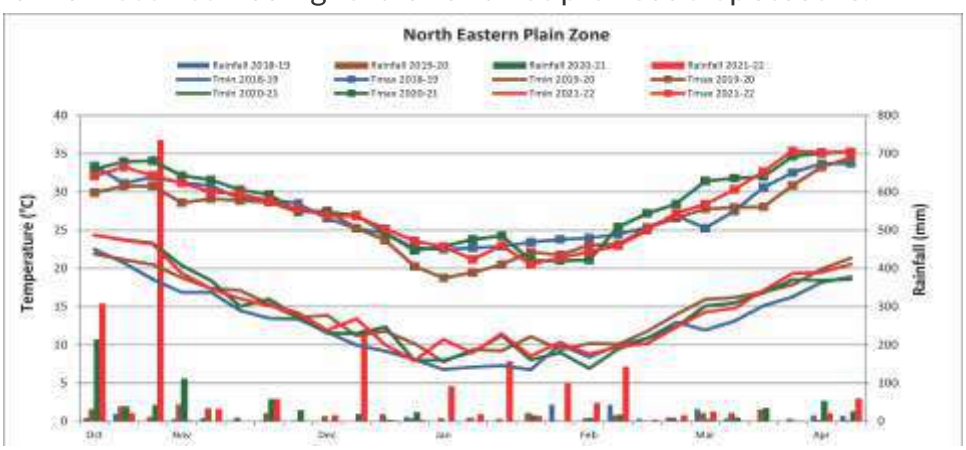


The weekly average weather data of cropping duration for all four major wheat growing zones (NWPZ, NEPZ, CZ and PZ) were compared with previous 3 years (2018-19, 2019-20, 2021-22) and the trend of min.T, max.T and rainfall being discussed here.

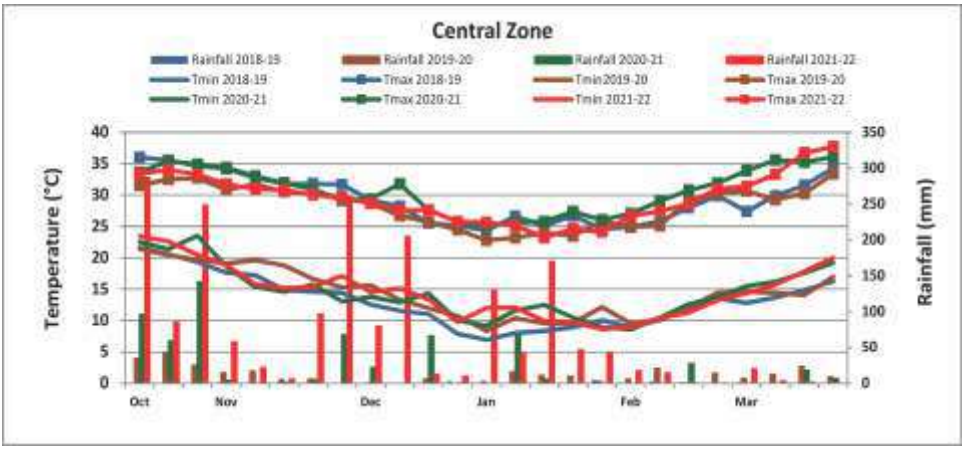
In NWPZ, the weekly average min.T was 0.6^0 and 0.3^{0}C higher than 2018-19 and 2020-21 crop seasons respectively, and it showed similar trend as that of 2019-20 crop season. The weekly average max.T was 0.8^{0}C and 2.1^{0}C higher than 2018-19 and 2019-20 crop seasons respectively, and it was in similar range as that of 2020-21 crop season. The rainfall received was significantly higher than all three previous crop seasons.



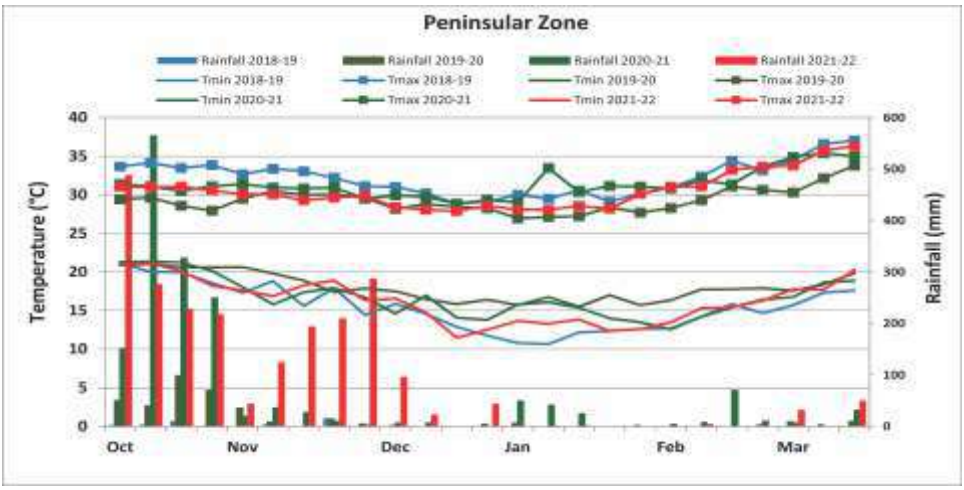
In NEPZ, The weekly average min.T was 1.6^{0}C and 0.3^{0}C higher compared to 2018-19 and 2020-21 crop seasons respectively, but was in the similar range as that of 2019-20 crop season and the max.T was 0.2^{0}C and 1.4^{0}C higher than 2018-19 and 2019-20 crop seasons respectively, and was 0.7^{0}C lower than 2020-21 crop season. The rainfall received was higher than all three previous crop seasons.



In CZ, the weekly average trend of min.T was 1.5^{0}C, 0.2^{0}C and 0.1^{0}C higher than 2018-19, 2019-20 and 2020-21 crop seasons respectively. The max. temperature was 0.2^{0}C and 1.3^{0}C higher than 2018-19 and 2019-20 crop seasons respectively, and was 1.1^{0}C lower than 2020-21 crop season. The rainfall received was significantly higher than all three previous crop seasons.



In PZ, the weekly average trend of mean min.T was 0.8^{0}C higher than 2018-19 crop season and was lower by 1.8^{0}C and 0.5^{0}C in 2019-20 and 2020-21 crop seasons respectively. The mean max. temperature was 1.7^{0}C higher than 2018-19 crop season and was 1.2^{0}C and 0.8^{0}C lower than 2019-20 and 2020-21 crop seasons respectively. The rainfall received was significantly higher than all three previous crop seasons.



Overall weather data analysis indicates that, there is no much significant variation in weather parameters were observed in NEPZ, PZ and CZ over the analysis years. But only significant variation was observed in max. temperature of NWPZ especially during the second fortnight of March with sudden rise in max. temperature which went upto 40^0C.

Heat Tolerance of Most Prevailing Wheat Varieties During 2021-22 Crop Season

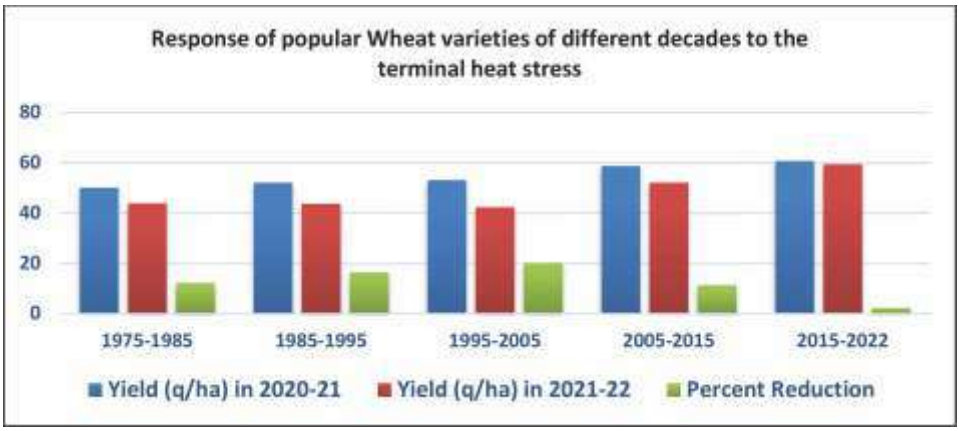
ICAR-IIWBR started programme for validating the heat tolerance of final year Advanced Varietal trail (AVTII) entries before their release as varieties. Multilocation heat tolerance trial (MLHT) was carried out in AICRP every year in which AVT II entries were tested in 15 different hot spot locations for heat stress across India. It was noted that, most of the varieties which have covered maximum share in area coverage across India during 2021-22 crop season had lower heat sensitivity index showing their resilience to heat stress, thus shielding from significant yield reduction during 2021-22 crop season under severe temperature stress.

Most prevailing wheat varieties at national level and their HSI values

Rank	Variety	% Share	HSI
1	DBW 187 (Karan Vandana)	14.36	0.8
2	DBW 303 (Karan Vaishnavi)	9.27	0.9
3	HD 2967	8.36	1.1
4	HD3226 (Pusa Yashasvi)	6.57	1.2
5	HD 3086 (Pusa Gautami)	6.5	1.3
7	DBW 222	4.48	1.0

Assessing the heat stress resilience of varieties released over decades

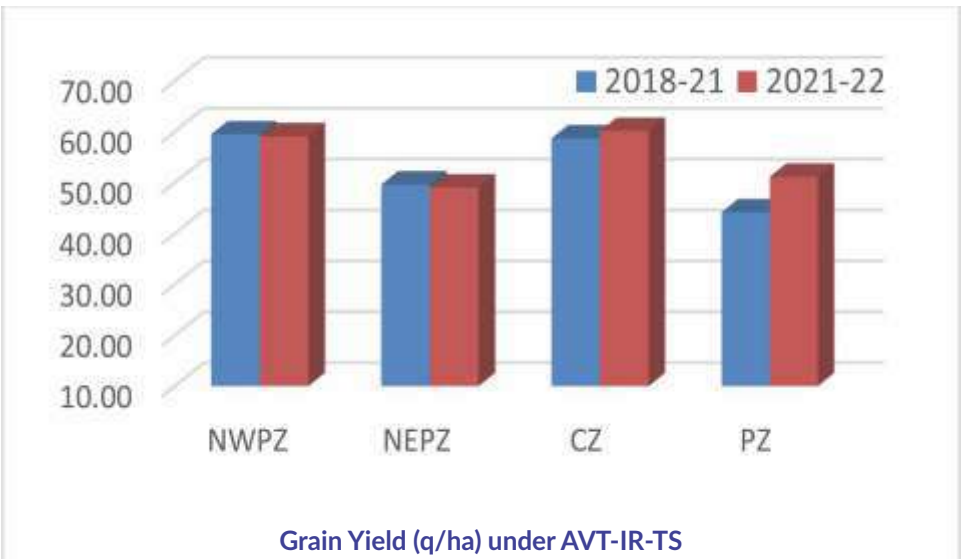
In a trial conducted at Karnal, involving popular wheat varieties of different decades starting from 1975-85 to 2015-2022, there has been continuous increase in the yield potential of varieties from different decades. Recently released varieties showed better resilience towards the high temperature stress encountered during the grain filling period in the Indo-Gangetic Plains of India during 2021-2022. A major role in this was played by varieties such as DBW187, DBW303, HD3226, which with the concerted efforts of ICAR and IIWBR have covered substantial area during the crop season 2021-22.



Yield and percent reduction of wheat varieties released in different decades during 2020-21 and 2021-22 crop seasons.

AVT level yield comparison against 2021-22 crop season

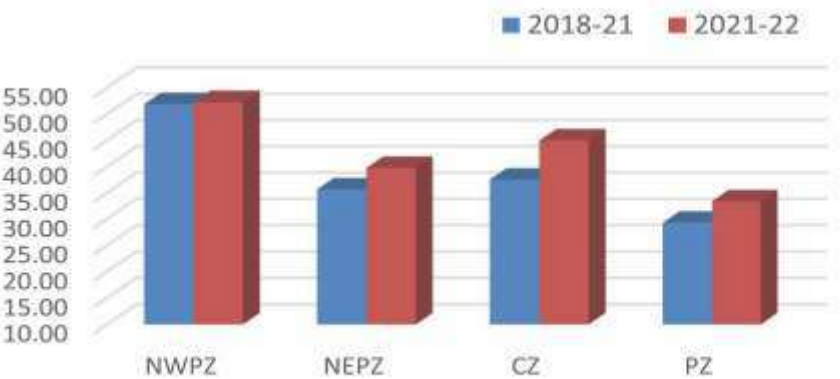
Grain yield average (site means) of last three years (2018-21) were compiled from coordinated advance varietal trials (TS, LS and RI) and compared with the yield data of the year 2021-22. Across zones, locations mean for condition wise trials (TS, LS and RI) were compiled and it was observed that almost all the trials had either similar yield levels or better except late sown trial of NWPZ (IR-LS), which showed decrease in site mean.



Grain Yield (q/ha) under AVT-IR-TS

Under timely sown conditions, the grain yield reduction of 0.67 and 1.13 % was observed in NWPZ and NEPZ, respectively, whereas, the yield enhancement of 2.48 and 15.83 % was observed for CZ and PZ, respectively. Under late sown conditions, the yield advantage of 7.31 % and 10.45 % was recorded in NEPZ and PZ, respectively, whereas the yield reduction of 7.11 % was exhibited in NWPZ. Similarly, yield gain of 0.75, 11.51, 14.03 and 19.91 % was estimated for NWPZ, NEPZ, PZ and CZ, respectively under RI condition (Fig. 3) AVT yield trials under AICRP.

Grain Yield (q/ha) (under AVT-IR-LS)



Grain Yield (q/ha) (under AVT-RI-TS)

The above statistics is based on AVT level yields as presented trials site mean only, whereas, it is very likely that situation may vary for farmers field yield realization across zones and conditions.

MAJOR RESEARCH ACHIEVEMENTS

CROP IMPROVEMENT

Development and release of new wheat varieties

Central released varieties

The year 2020-21 was very fruitful as the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops in its 87th meeting, recommended the release and notification of eight bread wheat and one durum varieties. On the basis of yield in adapted trials and the farmers' demand, the Sub-Committee in the same meeting also recommended the extension of area for cultivation for DBW 222 in NEPZ while that of DBW 187 for early sown, high fertility, irrigated condition of Central Zone.

Wheat varieties released by CVRC during 2021-22

Variety	Area and Production condition	Grain yield (q/ha)		Special features
		Pot.	Avg.	
JKW261	NWPZ-LS, IR	66.6	51.7	Drought & heat tolerant
DBW296	NWPZ-TS, RIR	83.3	56.1	Climate resilient
DBW327	NWPZ-IR-ES-HF	87.7	79.4	Tolerant to heat & drought
DBW332	NWPZ-IR-ES-HF	83.0	78.3	High protein (12.2%)
HUW838	NWPZ-TS-RIR	77.7	51.3	Resistant to wheat blast
HI1636	CZ-TS-IR	78.8	56.6	High zinc (44 ppm)
GW513	CZ-TS- IR	77.4	58.5	Good chapati score (8.36)
MP1358	CZ-TS- RIR	43.6	30.9	Tolerant to heat & drought
HI8823(d)	PZ-TS-RIR	65.6	38.5	Wider adaptability
DBW222 (AE)	NEPZ-TS- IR	62.0	48.9	Chapatti score (7.5), bread score (8.24)
DBW187 (AE)	CZ-IR- ES-HF	75.4	60.3	Resistant to yellow & brown rust

During the year 2021-22, the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops in its 87th meeting recommended the release and notification of eight bread wheat varieties and one durum wheat variety for different production conditions in various zones. The Sub-Committee in its 87th meeting also recommended the area extension of DBW 222 and DBW 187 to NEPZ and CZ, respectively.

State Released Varieties

The state recommended seven wheat varieties were also notified 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 SVRC during 2021-22

Variety	Developed by	State	Production condition	Potential yield (q/ha)	Average yield (q/ha)
PBW 1 (chapati)	PAU, Ludhiana	Punjab	TS, IR	48.4	45.1
PBW766			TS, IR	79.2	64.3
PBW 803			TS, IR	90.2	62.0
PBW 824			TS, IR	92.1	63.0
PBW 869			TS, IR	80.2	63.1
MP1323	JNKVV, Powarkheda	MP	TS, IR	76.1	61.5
HUW 711	BHU, Varanasi	UP	TS, RF/ RIR	43.2	21.9

Registration of genetic stocks: Forty two new genetic stocks of wheat were registered during 2021-22, for novel traits (disease resistance to rusts and spot blotch, higher protein content, water use efficiency, heat tolerance, drought tolerance, high grain iron and zinc content, soft wheat, CMS lines etc.). The ICAR-IIWBR, Karnal multiplies the seed of these registered genetic stocks so that it is supplied to breeders across the country for use.

Registration of Varieties with PPV&FRA

Registration proposals of four bread wheat varieties DBW303, MPO1255, DBW93, MP3382 and one durum wheat variety DDW48 were submitted to PPV&FRA, for registration under extant category.

Conduction of Coordinated Trials

The wheat coordinated varietal evaluation programme is the largest multilocation testing programme, and was undertaken with the help of 28 funded and 68 voluntary cooperating centres spread in five wheat growing zones across the country. A total of 35 trial series including AVTs (15), NIVTs (10), IVTs (2) and SPLs (8) were laid out during 2021-22 in different zones under six major production conditions namely early-sown irrigated, timely-sown irrigated, late-sown irrigated, timely-sown restricted irrigation, late-sown restricted irrigation and timely-sown rainfed. This year 433 test entries were evaluated with 67 check varieties in different trials. In all, 517 trial sets were supplied to 96 centers and all the trials were conducted successfully at all the centers.

Genetic stocks registered during 2021-22

Name	Developed by	Traits
DT-RIL110	ICAR-IIWBR, Karnal	Drought tolerance
QLD121	ICAR-IIWBR, Karnal	Soft grains and low sedimentation value
QLD120	ICAR-IIWBR, Karnal	Soft grain with high Zn, Fe and protein
QLD118	ICAR-IIWBR, Karnal	High grain zinc
QLD122	ICAR-IIWBR, Karnal	High grain iron and zinc
BNSR6	ICAR-IIWBR, Karnal	High iron, zinc and protein content
RWP-2018-32	ICAR-IIWBR, Karnal	Heat tolerant, grain number and grain weight
DBW302	ICAR-IIWBR, Karnal	Resistant to black, brown rust, KB and flag smut
IIWBR DN 502	ICAR-IIWBR, Karnal	Glu-D1 double null with lowest sedimentation
DBW308	ICAR-IIWBR, Karnal	Resistant to wheat blast, brown, black and yellow rust
DCMS22A & B		CMS line - MTSA 2A
DCMS44A & B		CMS line - MTSA 2A
DCMS52A & B		CMS line - MTSA 2A
DCMS23A & B		CMS line - Chuan 13A
DCMS9A & B		CMS line - Chuan 13A
DCMS35A & B		CMS line - Chuan 13A
WAPD1508		Triple gene dwarf, bold seeds and longer spikes
DWAP18-07		Highly tolerant to water stress conditions
IC212176		Gigas plant type
DWAP18-12		Tolerant to water stress
Hango-2		Leaf rust resistance gene Lr80
HD3304	ICAR- IARI, New Delhi	High sedimentation value
QBP18-8	ICAR- IARI, New Delhi	High hectoliter weight
QBI20-14	ICAR- IARI, New Delhi	High grain zinc concentration (57mg/kg)
QBP18-10	ICAR- IARI, New Delhi	High hectoliter weight
QBP17-7	ICAR- IARI, New Delhi	High grain iron concentration (48.1ppm).
HD3241	ICAR- IARI, New Delhi	High sedimentation value
QBI19-09	ICAR- IARI, New Delhi	High grain zinc concentration
QBI20-20	ICAR- IARI, New Delhi	Low hardness Index
IC252458	ICAR- IARI, Wellington	Resistant to rusts and powdery mildew
IC290150	ICAR- IARI, Wellington	Resistant to rusts and powdery mildew
IC279875	ICAR- IARI, Wellington	Resistant to rusts and powdery mildew
HW5073	ICAR- IARI, Wellington	Resistant to rusts and powdery mildew
DH-1	ICAR- IARI, Shimla	Resistant to yellow rust and brown rust
HS661		Resistant to all the pathotypes of yellow rust
HI8807	ICAR- IARI, Indore	Resistant to all the three rusts and Karnal Bunt.
HI8812		Resistant to all three rusts and Flag smut
PAU16071	PAU, Ludhiana	Leaf rust resistance
PAU16068		Resistant to powdery mildew
IC290156	ICAR- NBPGR, New Delhi	Resistant to stripe rust pathotypes
IC321906		Terminal heat tolerance.
TAW 33	BARC, Mumbai,	High grain hardness

Out of 517 trials conducted, the data of only 393 trials (76.0%) have been reported based on the norms for disease resistance and yield performance. Non-reporting due to low site mean was the primary reason (84), followed by rejection of 23 trials by the zonal monitoring teams.

Genetic stocks registered during 2021-22

Zone	Proposed	Conducted	Reported
NHZ	25	25	21
NWPZ	140	140	105
NEPZ	122	122	77
CZ	129	129	110
PZ	101	101	80
Total	517	517	393

Entries in the Final Year of Testing in AVTs

A total of 28 entries were tested in the final year of yield evaluation in various AVTs and SPL trials of different zones. Three entries namely, PBW826, HD3406 and DBW372 were tested in two zones.

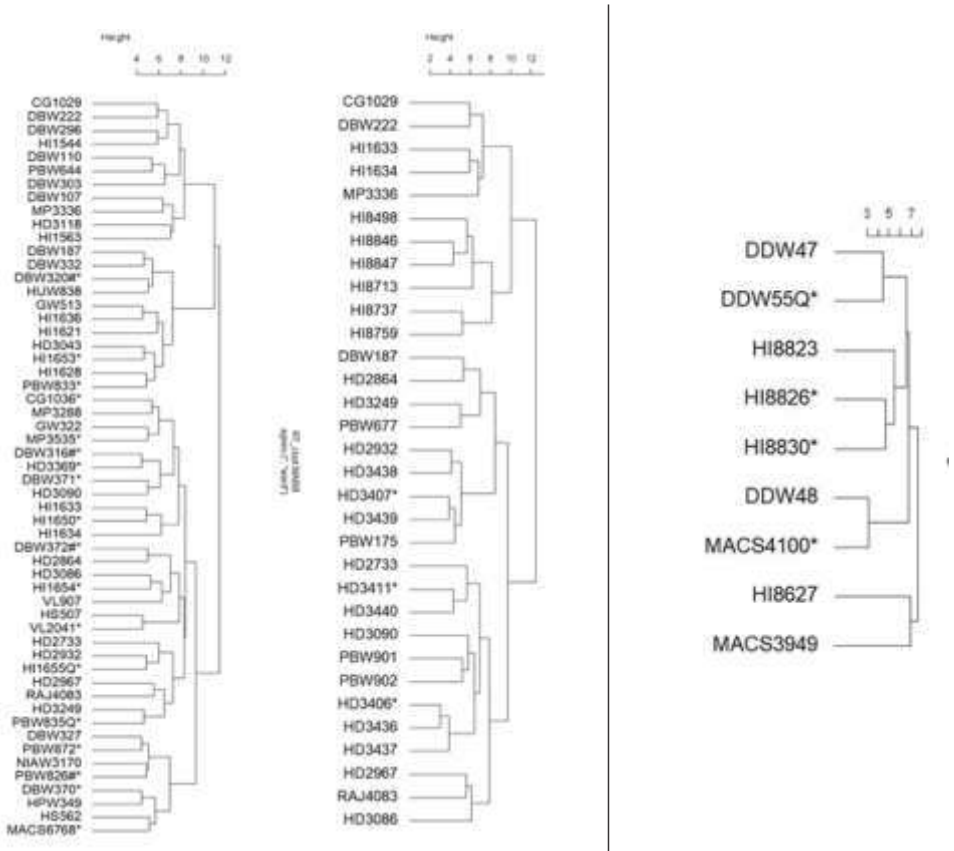
Entries in the final year of evaluation in AVTs and SPL trials during 2021-22

Zone	Zone/ Trial	Final year entries
NHZ	AVT-RF-TS-TAS	VL2041
NWPZ	AVT-IR-TS-TAS	PBW826, HD3406^{M}
	AVT-RI-TS-TAS	HD3369, HI1653, HI1654
NEPZ	AVT-IR-TS-TAS	PBW826, HD3406^{M}, HD3411^{M}
	AVT-IR-LS-TAS	DBW316, PBW833, PBW835
CZ	AVT-IR-TS-TAD	HI1650, MP3535, MACS6768
	AVT-IR-LS-TAS	HD3407^{M}
	AVT-RI-TS-TAD	HI8830(d), CG1036, HI1655, DDW55(d)
PZ	AVT-IR-TS-TAD	HI8826(d), MACS4100(d)
	AVT-IR-LS-TAS	DBW320
NW/NEPZ	SPL-HYPT	DBW370, DBW371, DBW372, PBW872
CZ/PZ	SPL-HYPT	DBW372

Marker Assisted Gene Prospecting in AVT entries of wheat

AVT final year (2021-22) entries and checks were screened using various STS/ AS-PCR markers linked to the gene(s) of Waxiness (*WxB1*), abiotic (drought) stress related (*DREB*), vivipary (*Vp1B3*), leaf rust resistance (*Lr*), Photoperiod response (*Ppd1*) and vernalization (*Vrn*). The dendrogram

constructed using these STS and more than 40 SSR markers depicted the genetic relationships among genotypes.



Bread wheat (AVT & MABB entries and Checks)

Durum wheat

Dendrogram showing diversity among AVT final year entries and checks

As regards durum wheat varieties, the dendrogram generated using the molecular marker data shows that the final year test entries MACS4100 and DDW55 are quite distinct as compared to HI8826 and HI8830, which are grouped together. In case of bread wheat, except for DBW316 and HD3369 which get clustered in the same group, other final year entries fall in distinct resolvable groups. This shows that wheat improvement programme of our country is developing diverse wheat varieties avoiding monoculture.

Promising Entries in Advanced Varietal Trials

The criteria for promotion of Entries in AVTs were based on significant superiority of genotypes over the best zonal check of the trials. Out of 68 genotypes evaluated in AVTs of different zones during this crop season, nine genotypes were identified to be superior on the basis of their yield performance and response to the incidence of rusts. These promising entries were under irrigated timely sown (1), restricted irrigation late sown (2) and restricted irrigation timely sown (6). DBW359 has been found promising in both Central and Peninsular Zone.

Promising Entries in Initial Varietal Trials

Among the total 276 new entries evaluated for their performance in different NIVTs/IVTs, 58 entries were found promising on the basis of high yielding ability and disease resistance. Out of total 58 promising entries, 55 were of bread wheat and 03 of durum wheat. Eighteen entries were observed to be promising for timely sown irrigated condition, 26 for late sown irrigated condition, 10 for restricted irrigation condition and 5 for early sown conditions.

Special Trials for Marker Assisted Back Cross Breeding (MABB) Derived Genotypes

Five special trials for entries derived through MABB approach were conducted, to evaluate performance for yield, DUS traits and trait transferred. In these SPL-MABB trials a total of twelve entries were tested along with their respective recurrent parent(s) and high yielding checks as per the production condition of recurrent parent in respective zones. Most of the MABB derived genotypes differed from recurrent parents for DUS traits (03-17). Based on the performance of these MABB genotypes, genotypes HD3438 (SPL-MABB-CZ-IR-LS) and HD3439 (SPL-MABB-PZ-IR-LS) were found significantly superior but their expression was showing variation for more than two DUS traits. All the final year entries (HD3406, HD3407 and HD3411) showed difference for more traits than the acceptable limit.

Most promising entries in NIVTs and IVTs

Zone	Condition	Entries
NHZ	RF-TS	HS691, HPW484
NWPZ	IR-TS	HI1668, PBW887, PBW889, DBW386, UP3102#
	IR-LS	K2108, HD3428, PBW893#
	RI-TS	WH1311, PBW899, DBW397, DBW398, UP3111#
	SPL-HYPT	PBW878
NEPZ	IR-TS	DBW386#
	RI-TS	DBW398
CZ	IR-TS	UAS3020, HI1669
	IR-LS	HI1673, HI1674, HI1675, AKAW5104, MP3557#
	SPL-HYPT	GW543, CG1044
PZ	IR-TS	UAS3021, NWS2222, MACS6811, UAS3020, WH1306, NIAW4183, AKAW5314, NIAW4153, MACS6809, AKAW5100#, PWU15#, MP1386#, HI8841(d), PBW891
	IR-LS	MACS6814, NIAW4114, AKAW5104, UAS3022#, HI1674#, DBW395#, HI1672#, HI1673#, MP3557, NIAW4120, UAS3023, GW538, HI1675, MP1388, MACS6805, WH1310, GW542, DBW394, LOK79
	RI-TS	UAS481(d), DDW61(d)

Screening against wheat blast

A set of 350 wheat lines (test entries, pipeline materials and new checks) were screened against wheat blast in Bangladesh during 2021-22 through CIMMYT. Among these 350 total lines, 268 were new AICRP test entries while remaining 82 were contributed from ICAR-IIWBR breeding programmes. Based on the disease score (score <10) across two dates of sowings, 91 resistant genotypes were shortlisted. It is important to note here that this season only 06 entries were found highly resistant (0, 0 score), and 36 entries from ICAR-IIWBR pipeline material were found resistant (maximum score up to 10 only), thereby indicating that anticipatory breeding work at ICAR-IIWBR is effective and will be useful at national level.

Wheat Blast resistant genotypes identified in 2021-22

Wheat Blast reaction	AICRP /IIWBR	Genotypes	Total
0, 0 (Free)	AICRP	NW8045, PBW879, UP3116	3
	IIWBR	DWAP2174, DWAP2175, GRU25	3
Upto 10 (Resistant)	AICRP	HD3421, DBW379, DBW380, DBW381, RAJ4567, NW8046, WH1301, K2101, UP3101, UP3102, HUW849, UBW16, DBW386, RAJ4570, NW8044, PBW890, TAW142, DBW387, DBW388, UAS302, PBW891, MP1387, NWS2222, HD3427, HD3428, RAJ4572, NW8040, WH1309, K2108, PBW892, PBW896, UP3109, JKW298, HUW852, DBW394, DBW395, WH1310, MP3556, MP3557, WH1312, HD3431, HD3432, HI1682, PBW878, PBW880, DBW404, WH1313, WH1314, UP3115, RAJ454, K2001, DBW401, DBW405, DBW406, GW543	55
	IIWBR	RWP1267, QYT2031, QYT2030, QYT2049, QYT2050, QYT2047, QYT2032, QYT2073, QYT2034, QYT2036, PBS21-08, PBS21-09, DWAP2168, DWAP2171, DWAP2176, DWAP2178, LBP2020-11, LBP2020-22, LBP2020-28, LBP2020-34, LBP2020-50, LBP2020-51, LBP2020-52, GRU24, GRU26, GRU27, GRU28, GRU29, GRU30, CRP-45	30
Total			91

Evaluation of International and National Nurseries Trials/ Nurseries International Germplasm

The ICAR-IIWBR, Karnal being nodal centre, procured 1375 lines (1181 bread wheat and 194 lines of durum wheat) from CIMMYT, Mexico and 420 lines (300 bread wheat and 120 lines of durum wheat) from ICARDA, Morocco in the form of different nurseries/trials. These were evaluated at various wheat breeding centres during the crop season 2021-22. One set of each nursery/trial was planted at ICAR-IIWBR, Karnal for evaluation to diseases particularly stripe rust and also to facilitate in-situ selections.

IIWBR Karnal organized a visitor's week (21-31, March 2022) and a large number of wheat breeders/pathologists, made selections and the indented seed in limited quantity is being supplied to selectors as per their requirement.

National Nurseries: During 2021-22 crop season, two national nurseries and one segregating stock nursery were constituted by the institute and supplied to different co-operators located across various zones in the country for evaluation and utilization.

Nursery	Genotypes +Checks	Centres
National Genetic Stock Nursery (NGSN)	82+4	33
Quality Component and Wheat Biofortification Nursery (QCWBN)	50+4	18
Segregating Stock Nursery (SSN)	200 F2 and F3	25

National Genetic Stock Nursery (NGSN): The NGSN comprising 82 genotypes including *T. aestivum* (69), *T. durum* (10), and *T. dicoccum* (3) was provided to 33 centres. The researchers used these lines intensively. The utilization report indicated 24 centres out of 32 utilized the NGSN entries. On the basis of utilization report received, it was found that 20.27% genotypes in the NGSN were utilized in hybridization as the donor parents.

Quality Component and Wheat Biofortification Nursery (QCWBN): The QCBWN of 50 entries alongwith four check varieties (DBW187, DBW222, GW322 and WB02) was evaluated at 18 centers and data were recorded on grain yield and three nutritional quality traits (Protein, Fe and Zn content). Entries better than checks, having disease resistance and nutritional traits are suggested for promotion to respective AVTs. Out of 50 entries tested, only 04 entries (QBI21-1, NEQ2021-2, QLD125 and UP3083 were found promising in PZ and recommended for evaluation in advance varietal trials.

Segregating Stock Nursery: 25th Segregating Stock Nursery (SSN) comprised 200 segregating populations (F2/F3) was shared with 25 wheat breeding centres to select superior plants/material as per the breeding objectives and cultural conditions. The utilization report indicated that the nursery could achieve 34.5 percent utilization across the centres.

Setting Priority Traits for AICRP Centres

A meeting was held on 22.02.2022 under the Chairmanship of Director ICAR-IIWBR, Karnal to discuss the prioritized trait specific breeding programmes across the centers under AICRP on Wheat & Barley as the resources are becoming limited. Also there is a need to focus on region specific problems. This approach will help in strengthening the centres under the AICRP network across the country. Based on deliberations, with each centre, priority traits were identified. These traits have to be addressed by specific centre(s) along with other breeding objectives for the region.

Zone-wise and centre-wise priority traits

Zone	Centre	Priority Trait(s)
NHZ	Khudwani	Short duration, Yellow rust, Biofortification for Fe & Zn
	Wadura	Yellow rust, Leaf blight, Biofortification for Fe & Zn
	Malan	Yellow rust, Powdery mildew, Karnal bunt, Soft wheat
	Almora	Biofortification (Fe, Zn), Wheat blast, Soft wheat
	ICAR-IARI, Shimla	Yellow rust, Soft wheat, Water Use Efficiency
NWPZ	Pantnagar	Heat & Drought tolerance, Brown rust, Karnal bunt, Grain quality (soft)
	Jammu	Yellow rust, Terminal heat tolerance
	ICAR-IARI, Delhi	Nitrogen & Phosphorus use efficiency, Lodging tolerance Soft and Hard wheat, Biofortification and Bioavailability, Wheat rusts
	ICAR-IIWBR, Karnal	Grain quality (hard and soft), Biofortification, Yellow rust & Karnal bunt, Wheat blast, Nitrogen use efficiency
	Ludhiana	Karnal bunt, Yellow rust, Terminal heat tolerance, Grain quality (soft and hard), Nitrogen use efficiency, Lodging tolerance
	Hisar	Hard Wheat, Brown rust, Heat tolerance, Salinity tolerance
	Durgapura	Water use efficiency, Brown rust, Heat tolerance
	ICAR-CSSRI, Karnal	Salt tolerance, Element toxicity
NEPZ	Kanpur	Hard grain quality, Brown rust, Water Use Efficiency, Fe and Zn
	Ayodhya	Spot blotch, Water logging, Salinity tolerance
	Varanasi	Spot blotch, Heat tolerance, Biofortification (Fe, Zn)
	Kalyani	Spot blotch, Wheat blast, Heat tolerance, short duration
	Coochbehar	Spot blotch, Wheat blast, Water use efficiency, Al toxicity
	Shillongani	Short duration, Heat tolerance, Pre-Harvest sprouting
	RPCAU, Pusa	Short duration, Waterlogging, Heat tolerance, Aphid resistance
	Sabour	Spot blotch, Wheat blast, Heat tolerance, Earliness, Grain quality
	Ranchi	Heat tolerance, Water-use efficiency

Zone	Centre	Priority Trait(s)CZ
CZ	ICAR-IARI Indore	Hard wheat (bread) & durum wheat for yellow pigment, Biofortification
	Udaipur	Heat tolerance, Grain quality
	Vijapur	Black and brown rusts, Grain quality (durum for yellow pigment), End product quality
	Junagadh	Black and brown rusts, Heat tolerance, Water use efficiency, Hard wheat
	Gwalior	Heat tolerance, Lodging tolerance, Nitrogen use efficiency
	Powarkheda	Heat tolerance, Black and brown rust
	Jabalpur	Nitrogen use efficiency, Drought tolerance
	Bilaspur	Heat tolerance, Water use efficiency
PZ	Pune	Heat & Drought tolerance, hard grain quality, Black and Brown rusts, Biofortification (Fe and Zn)
	Niphad	Water use efficiency, Heat tolerance, Aphid resistance
	Akola	Water use efficiency, Heat tolerance, Black rust
	Dharwad	Black and Brown rusts, Drought tolerance, Grain quality, Biofortification (Fe and Zn), Root traits

Note: New Delhi, Karnal, Ludhiana, Hisar, Pantnagar, Durgapura, Kanpur, Sabour, Indore, Vijapur, Jabalpur, Pune, Niphad, Dharwad etc. will take up most of traits of national/regional importance.

Exploratory Trial of Wheat Varieties in Ladakh Region

As per recent deliberations during regional committee meeting (22.04.2022), a trial of released wheat varieties was recommended to be conducted during summer season in UT of Ladakh. The purpose of this trial is to explore the possibility of encouraging wheat cultivation in the region and also to check the performance of wheat varieties from NHZ and NWPZ in the region. Twelve wheat varieties released for cultivation in NHZ (Shalimar Wheat-1, Shalimar Wheat-2, Shalimar Wheat-3, HS490, HS562, HPW349, VL829 & VL907) and NWPZ (HD2428, HD2967, DBW187 & DBW222) were used to constitute one special trial to be conducted during summer 2022 at six locations across Leh and Kargil divisions.

Seed Production Programme

During 2021-22, a total indent of 14306.80q breeder seed of 152 wheat varieties was received from DAC&FW, New Delhi for total 22 indenting agencies. Among the indenting agencies, UP has maximum indent of 2980.00q followed by NSAI (2742.30q) for private seed companies, Madhya Pradesh (2011.30q) and NSC (1448.00q).

Breeder Seed Allocation & Production

Total allocation of 14053.80q breeder seed of 115 varieties was made to 34 BSP centres for the production during 2021-22 against 14306.80q total indent. The indent of 856.55q breeder seed of 37 varieties including PBW373, PBW154, Raj3077, Raj 1482, etc. was not allocated to the BSP centre due to insufficient nucleus seed (14) and rest 23 varieties were not notified. The total breeder seed production was 20114.84q during the season with surplus production of 6061.44q. Among the BSP centres, ICAR-IIWBR, Karnal, produced maximum quantity i.e., 4350.00q (21.62%) of breeder seed followed by IARI-RS- Indore (2020.00q). The highest quantity of breeder seed was produced for DBW187 (2623.10q) followed DBW303 (1595.0q). Only two BSP centres viz., SVPUA&T, Meerut (-80.65q) and SKAUST, Jammu (-0.50q) produced deficit breeder seed against their allocation.

Top ten indented wheat varieties and their breeder seed production 2021-22

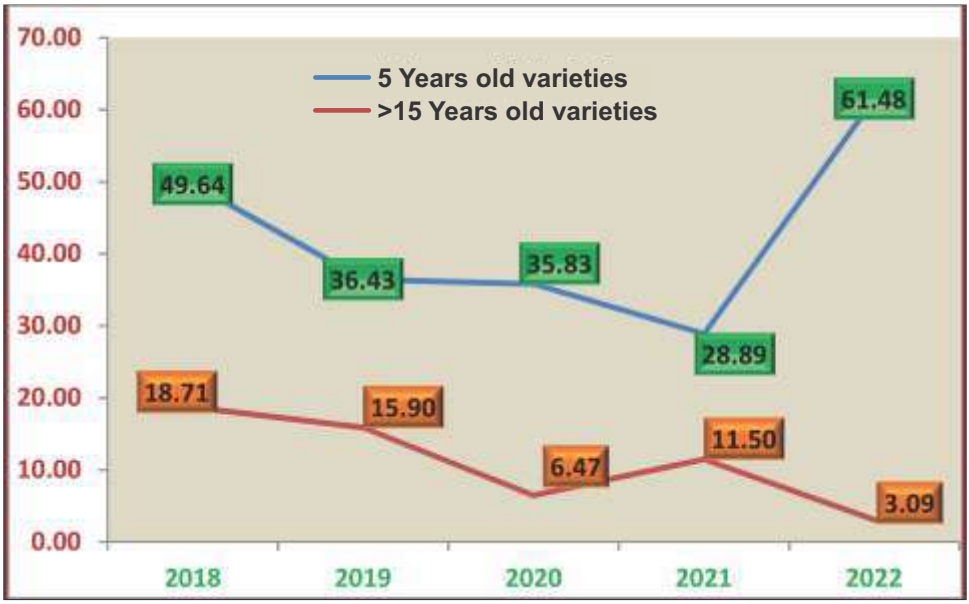
Variety Name	Year of Notification	DAFW Indent(q)	Breeder Seed Production (q)	Surplus (q)
DBW187	2020	2055.10	2623.10	568.00
DBW303	2021	1326.30	1595.00	268.70
HD2967	2014	1196.20	1414.20	218.00
HD3226	2019	939.70	960.00	20.30
HD3086	2014	929.30	979.50	50.20
RAJ4238	2016	750.20	1140.65	390.45
DBW222	2020	640.80	985.00	344.20
HI8759	2017	638.80	800.00	161.20
JW3382	2016	372.40	380.68	8.28
PBW723	2017	364.40	460.00	95.60

Nucleus Seed Allocation & Production

Against an allocation of 387.75q nucleus seed of 115 wheat varieties was made available to the 32 BSP centres except SVPUA&T, Meerut and SKAUST, Jammu, a total of 840.85q of nucleus seed was produced with a surplus of 453.10q by 32 Centres out of total 34 centres.

Phasing out of >15 years old varieties from the Breeder Seed Indent

With the continuous efforts of the Ministry of Agriculture and Farmers Welfare (Govt. of India), Council and ICAR-IIWBR, Karnal, to discourage more than 15 year old varieties from the breeder seed indent, the per cent share of >15 year old varieties has been reduced drastically from 18.71 % (2018) to 3.09 % (2022) during last five years. The varietal replacement rate (VRR) has also reached on record point of 61.48 % (5 years old varieties) and 92.34 % (10 years old varieties) of wheat as compared to the other crops.



CROP PROTECTION

The crop protection programme aimed to minimize yield losses of wheat and barley caused by biotic stresses through keeping 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

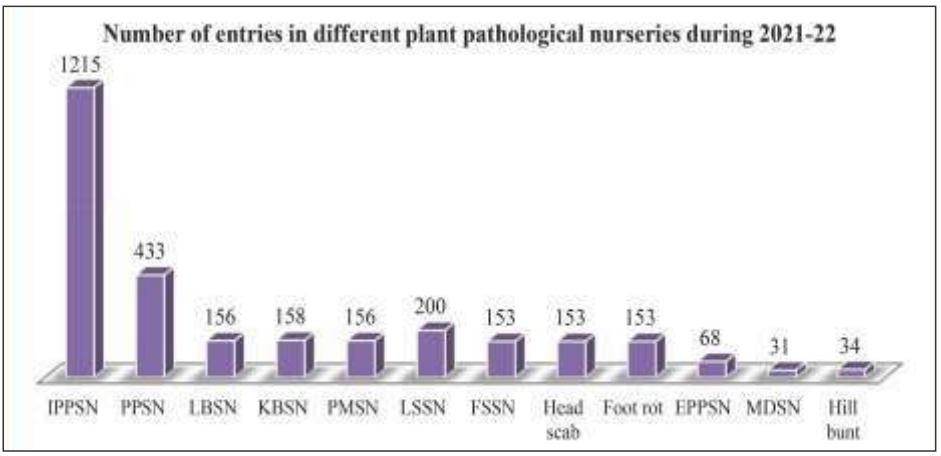
Survey and surveillance for diseases

Wheat and barley crop health was monitored by regular surveys conducted with major emphasis on occurrence of yellow rust in NWPZ and surveillance for wheat blast near Bangladesh border. The surveys were conducted by the wheat crop protection scientists of different cooperating centres including ICAR-IIWBR Karnal and information was shared through the "Wheat Crop Health Newsletter", Vol. 27 (Issues 1 to 5) issued during the crop season and also uploaded on ICAR-IIWBR website (www.iiwbr.icar.gov.in). The first appearance of yellow rust of wheat was reported from village Nikku Nangal at Sh. Anandpur Sahib block of Rupnagar district of Punjab on 14.1.2022 on varieties HD2967 and HD3086. Leaf rust infection was first recorded at very low incidence in few farmers' fields in the Dharwad and Belagavi districts of Karnataka during the surveys conducted on 22.12.2021. No wheat blast like symptoms were noticed at farmer's field but incidence of leaf rust, Fusarium head blight and leaf blight in some varieties was noticed in farmer's field of Raiganj, Gangarampur, Hili, Gazole, Samsi, Ratua, Manikchak, Chopra, Kharibari and Cooch Behar of West Bengal. Infestation of aphids was low in the initial stages of crop growth which increased in the months of February and March in some areas. Infestation of stem borer was also observed in some fields in Karnataka. Besides these few instances of disease and pest occurrence, no major report of disease and insects infestation was observed. Overall the wheat crop health was good in all the wheat growing areas.

Host resistance

Wheat germplasm and advance breeding materials were evaluated against disease and insect pests resistance at various hot spot locations under artificially inoculated conditions. The major plant pathological nurseries

were: Initial Plant Pathological Nursery (IPPSN), Plant Pathological Nursery (PPSN), Elite PPSN (EPPSN), Multiple Disease Screening Nursery (MDSN), and disease specific nurseries like Leaf Blight Screening Nursery (LBSN), Karnal Bunt Screening Nursery (KBSN), Powdery Mildew Screening Nursery (PMSN), Loose Smut Screening Nursery (LSSN), Flag Smut Screening Nursery (FSSN), Head Scab Screening Nursery, Foot rot Screening Nursery and Hill Bunt Screening Nursery. The numbers of entries tested under different plant pathological nurseries are given in Figure.



Constitution of different plant pathological nurseries during 2021-22

Entries identified resistant against rusts in advance breeding lines

Rust resistance materials in AVT entries (2021-22) with ACI upto 10.0 are given below:

Stem, Leaf and Stripe rusts

HD3402, HS692, HS693, VL3029, HS691, PBW870, DBW318, HI8840(d), PBW835^{Q*}, WH1402, WH1403, HI8759(C), HI8846, HD3437 and PBW902

Stem and leaf rusts

HD3402, HPW481, HS692, HS693, VL3029, HS691, UP3113, VL892(C), DBW377, PBW870, DBW318, HD3090(C), HI1633(C), MP1380#, HI8826(d)*, MP1378, HI8839(d), HI8840(d), MP1358(I)(C), NIAW3922, NIDW1149(d)(C), DBW352#, GW513(I)(C), GW547^{B}, HI1636(I)(C). HI1650*, NWS2194#, HI1665, NIAW4028 , CG1036*, GW532, HI1655^{Q*} ,

HI1666, HI8823(d)(I)(C), HI8830(d)*, MACS6795, PBW835^{Q}*, DBW353, PBW771(C), HD3386, NIAW3170(C), HD3397, HI1628(C), HI1654*, HUW838(I)(C), WH1402, WH1403, DBW402, KRL2021, RAJ4565, HD3438, HD3439, CG1029(C), HD3407*, HI1634(C), HI8759(C), HI8846, HI8847, HD3437, PBW677(C) and PBW902

Stem and Stripe rusts

VL2043, HD3402, HPW487, HS692, HS693, VL3029, HS690, HS691, HPW349(C), PBW870, DBW318, HI8840(d), HD3392, PBW835^{Q}*, DBW359, HD3369*, HD3400, WH1402, WH1403, HI8759(C), HI8846, HD3437 and PBW902

Leaf and Stripe rusts

VL2044, HD3402, HS692, HS693, VL3029, HPW484, HS691, VL2047, PBW870, DBW318, DDW48(d)(C), HI8840(d), UAS478(d), DDW47(d)(C), PBW833*, PBW835^{Q}*, HD3249(C), WH1402, WH1403, HI8759(C), HI8846, HD3440, HD3437 and PBW902

Identification of multiple diseases resistant entries:

The entries found resistant against rusts were again tested for other diseases also under Multiple Diseases Screening Nursery (MDSN) at multilocations. The following genotypes have been identified as conformed source of resistance for multiple diseases that may be used as resistant donor in breeding programme:

- **Resistant to all three rust:** MPO 1357 (d)
- **Resistant to stem and leaf rust:** HS 679,HS 681,DDK 1058 (dic.), HUW 838, RAJ 4541,HI 8823(d), DDK 1059 (dic.),GW 513,HD 2864,HI 1544, HI 1633,HI 8627(d),HI 8818(d),VL 3024
- **Resistant to stem and leaf rust +PM:** HD 2733
- **Resistant to leaf and stripe rust +PM+FS:** DDW 47(d)
- **Resistant to leaf & stripe rust +KB:** UAS 466(d)
- **Moderately Resistant to Leaf Blight:** HS 507, HI 1636

Incidence of wheat and barley rusts in India and Nepal during 2021-22

The crop season 2021-22 was largely wheat and barley rusts free as no major outbreak of these diseases was reported from any of the wheat growing areas of India and Nepal. Yellow (stripe) rust was observed sporadically in parts of Punjab, Haryana, Uttar Pradesh, Jammu and Kashmir, Himachal Pradesh, Delhi and Rajasthan. The earliest report of yellow rust was from Nikku Nangal village at Shri Anandpur Sahib block in Rupnagar district of Punjab on varieties HD2967 and HD3086 in the middle of January. Subsequently, yellow rust was reported from different villages in Rupnagar district. In Haryana, up to 20S yellow rust was observed on HD2967 and SW23 at Mamli village (Yamunanagar) on 17.02.22 and in Karnal district on some varieties on 26.02.22. A few foci of wheat yellow rust were observed on HD2967 (up to 40S) in Chalwara and other areas of district Kangra and on HD3086 (40S) in Jandniyan area in Sirmour district of Himachal Pradesh during February 2022. The natural infection of brown (leaf) rust of wheat was reported from 14 states of India and neighbouring country Nepal. Very low incidence of leaf rust was observed in few farmers' fields in the Dharwad and Belagavi districts of Karnataka on 22.12.2021. During January 2022 incidence of leaf rust (5S to 10S) was observed on some off types and local varieties at Sanghi, Satara, Nashik, Pune and Kolhapur districts and other areas including Dhule, Rahuri, Pravaranagar in Maharashtra. Similarly, up to 10S brown rust severity was reported from Fanda and Jagriya villages in Sehore district and Donta Jagir, Bhatuni and other villages in district Dewas in Madhya Pradesh. The natural infection of black rust was reported from Gujarat, Madhya Pradesh, Maharashtra and Wellington areas of Tamil Nadu. Barley rusts were not observed in nature anywhere in India during 2021-22.

Pathotype distribution of *Puccinia* species on wheat and barley

During 2021-22, a total of 565 samples of three rusts of wheat and stripe rust of barley from India and Nepal were pathotyped.

Stripe rust of wheat and barley (Puccinia striiformis)

Population of wheat stripe rust pathogen (*Puccinia striiformis* f. sp. *tritici*, Pst) was avirulent to *Yr5*, *Yr10*, *Yr15*, *Yr16*, *Yr32*, and *YrSp*. Six Pst pathotypes were identified in 126 stripe rust samples collected from freshly infected leaf of

wheat. The frequency of Pst pathotype 110S119 was maximum (34.9%) followed by 238S119 (31.0%). The frequency of pathotype 238S119 was higher in Himachal Pradesh, Punjab and Nepal. The frequency of 46S119 (virulent on *Yr2*, *Yr3*, *Yr4*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr17*, *Yr18*, *Yr19*, *Yr21*, *Yr22*, *Yr23*, *Yr25*, and *YrA*) increased to 20.6% from 15.12% in previous cropping season. Pathotypes 47S103, 46S103 and 79S68 were identified in 5, 3 and 1 samples, respectively.

Predominant pathotypes of *Puccinia* spp. on wheat in India

Wheat Rusts	Predominant pathotypes
Stem	79G31(11), 62G29(40A) and 58G13-3 (40-2)
Leaf	121R60-1(77-9), 121R63-1,7 and 121R63-1(77-5)
Stripe	110S119, 238S119, and 46S119

Only one pathotype 57 (0S0) of *Puccinia striiformis* f. sp. *hordei* (*Psh*) was identified in 8 barley yellow rust samples collected from barley disease screening nursery at Durgapura, Rajasthan.

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

Five pathotypes 11, 21, 34-1, 40-2 and 40A of *Puccinia graminis* f. sp. *tritici* (Pgt) were identified in 62 black rust samples received from Gujarat, Maharashtra, Madhya Pradesh and Tamil Nadu. The *Pgt* population was avirulent to *Sr26*, *Sr27*, *Sr31*, *Sr32*, *Sr35*, *Sr39*, *Sr40*, *Sr43*, *SrTt3* and *SrTmp*. Pathotype 11 (79G31=RRTSF), 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* and *Sr*McN, was recorded in 69.4% of the samples. Pathotypes 40-2 and 40A were in equal frequency.

Leaf rust of wheat (P. triticina)

A total of 377 samples of wheat leaf rust were pathotyped from 13 states and one UT of India and neighbouring country Nepal. Among the 18 pathotypes of *Puccinia triticina* that were identified in these samples, pathotype 77-9 (121R60-1) was the most widely distributed and occurred in 59.9% of the samples followed by 121R60-1,7 in 19.4% samples. Pathotype 77-5 (121R63-1), that remained the most predominant for more than 20 years was

observed in 9.5% samples only. The remaining 15 pathotypes were identified in only 11.1% samples. In Nepal, four pathotypes were identified in 31 samples. Pathotype 77-9 was the most predominant in Nepal also.

Seedling resistance test (SRT) to virulent pathotypes of wheat and barley rust pathogens and characterization of *Lr*, *Sr* and *Yr* genes in AVT material

For identifying rust resistance sources, ~5050 wheat and barley lines were evaluated at seedling stage under controlled conditions during 2021-22. Of these, 281 lines including 153 of AVT and 128 of NBDSN/EBDSN were subjected to multiple pathotypes screening under controlled light and temperature conditions. Advanced wheat lines (153) were evaluated at seedling stage against 59 pathotypes of stem rust (*P. graminis* f. sp. *tritici*), leaf rust (*P. triticina*) and stripe rust (*P. striiformis* f.sp. *tritici*) possessing different avirulence/virulence structures. Seedling (all-stage) rust resistance remains effective throughout the life of wheat plants.

Rust resistant wheat lines in AVT (2021-22)

Rusts	No. of lines	Variety/line
Brown, Black and Yellow	03	HD3407, HD3439, PBW835
Brown and Black	10	DBW352, GW532, GW547, HD3438, HI1665, HI1666, HS691, MACS6795, PBW870, PBW902
Black and Yellow	02	WH1402, WH1403
Brown only	14	CG1029, DDW55, GW513, HD3090, HD3249*, HI1633, HI1634, HI1636, HI1650, HS692, MACS6768, NIAW3922, PBW833, PBW901
Black only	11	CG1040, DBW318, DBW377, HD3400, HI1628(C), HI1655, HI8847, HPW481, MP1380, PBW868, VL2043
Yellow only HS694	06	HD3392, HD3402, HD3436, HD3437, HD3440,

Diversity for rust resistance genes in AVT lines (2021-22)

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Stripe	94	Four: Yr2, 9, A, 18
Leaf	113	Eight: Lr1, Lr3, Lr10, Lr13, Lr23, Lr24, Lr26, and Lr34
Stem	1133	Fourteen: Sr2, Sr5, Sr7a, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30 and Sr31

Rust Resistant Lines in AVT (Wheat)

Three AVT entries HD3407, HD3439, and PBW835 possessed resistance to all pathotypes of three rust pathogens. Resistance to black and brown rusts was observed in 10 entries. Entries WH1402 and WH1403 were resistant to black and yellow rusts. Fourteen lines were found resistant to leaf rust, whereas 11 to stem rust pathotypes. Only six entries HD3392, HD3402, HD3436, HD3437, HD3440, and HS694 conferred resistance to all yellow rust pathotypes. The wheat lines showing resistance to one or other rusts are presented in the Table.

Characterization of rust resistance genes

Yr-genes

Among the 153 lines of AVT, *Yr* genes were characterized in 94 lines. *Yr* genes were postulated in lines where differential interactions were observed and in some cases tight linkage of *Yr* genes to other *Lr* and *Sr* genes also implicated the presence of a resistance gene. Four Yr genes viz. *Yr*2, *Yr*9, *Yr*A and *Yr*18 contributed to yellow rust resistance in Indian wheat material. Among the postulated *Yr* genes, the frequency of *Yr*2 was maximum and it was characterized, alone or in combination, in 74 lines. *Yr*9, alone or in combination, was postulated in 16 entries. *Yr*18 along with *Yr*2 was characterized in only PBW175(C).

Sr-genes

Fourteen stem rust resistance genes (*Sr*2, *Sr*5, *Sr*7a, *Sr*7b, *Sr*8a, *Sr*8b, *Sr*9b, *Sr*9e, *Sr*11, *Sr*13, *Sr*24, *Sr*28, *Sr*30 and *Sr*31) were characterized in 133 entries. The frequency of Sr2 was maximum as it was postulated in 61 AVT entries followed by *Sr*11, *Sr*7b, and *Sr*30, which were characterized in 41, 38 and 27 entries, respectively. *Sr*31 linked with *Lr*26 and *Yr*9 and conferring resistance

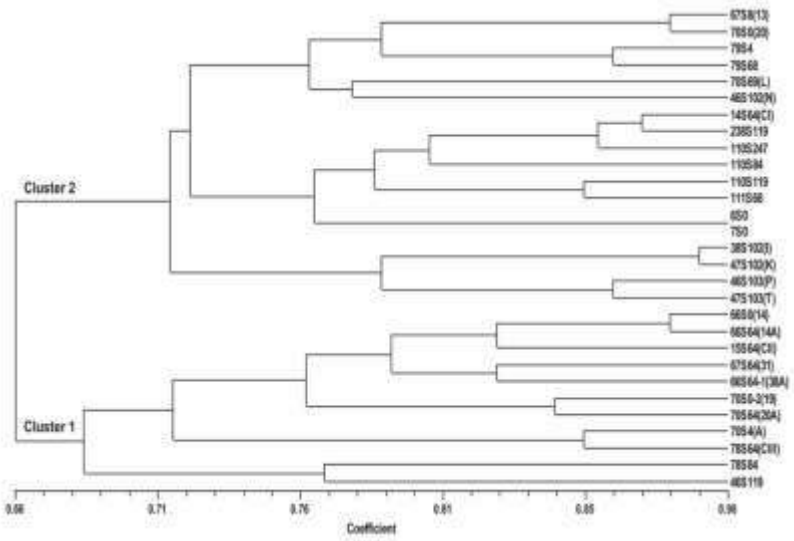
to all the known Pgt pathotypes in Indian subcontinent was postulated in 16 AVT entries. Whereas, *Sr*24 linked to *Lr*24 was characterized in 3 entries {CG1029 ©, GW513 (I)(C) and HI1636 (I)(C)}. *Sr*5 and *Sr*9b were characterized in 18 entries and Sr28 and Sr8b were postulated in two entries only. Other Sr genes i.e. *Sr*8a, *Sr*13, *Sr*9e, and *Sr*7a were postulated in 20, 15, 4 and 1 entries, respectively.

Lr-genes

Eight Lr genes *Lr*1, *Lr*3, *Lr*10, *Lr*13, *Lr*23, *Lr*24, *Lr*26, and *Lr*34 were characterized in 113 entries. *Lr*13 was the most commonly postulated leaf rust resistance gene that was characterized, alone or in combination, in maximum number of lines (65) followed by *Lr*10 (37 lines), and *Lr*23 (31 lines). *Lr*24 that is linked with *Sr*24 was postulated in 03 entries CG1029, GW513, HI1636. *Lr*26, tightly linked with Yr9 and *Sr*31, was characterized in 16 lines. *Lr*34 was postulated in only HD2733 and PBW175. Resistance to leaf rust in nine entries was based on a combination of three different genes.

Elucidating the population genetic structure of Indian *Puccinia striiformis* f. sp. *tritici* pathotypes based on microsatellite markers

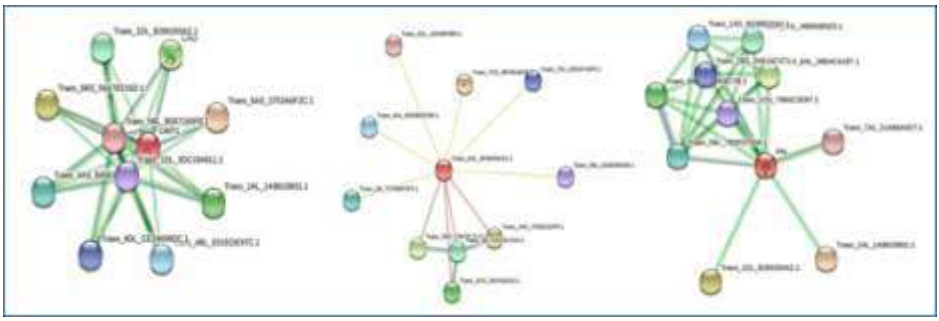
Population structure and genetic diversity of *Puccinia striiformis* f. sp. *tritici* (*Pst*) pathotypes was elucidated using 38 simple sequence repeat (38 SSR) primer-pairs. Bayesian assignment and discriminant analysis of principal components (DAPC) indicated the presence of two distinct *Pst* lineages. The unweighted pair-group method with arithmetic mean (UPGMA) also categorized these pathotypes into two major clusters (Fig.). Principal coordinates analysis (PCoA) explained 20.06% and 12.50% variance in horizontal and vertical coordinates, respectively. In total, 102 alleles were detected, the expected heterozygosity (H_{exp}) per locus ranged from 0.13 to 0.73, with a mean of 0.47. The average polymorphic information content (*PIC*) value of 0.40 indicated high genetic diversity among pathotypes. Analysis of molecular variance (AMOVA) revealed 12% of the total variance between sub-populations, 11% among the pathotypes of each sub-population, and 77% within pathotypes. The *Pst* virulence phenotypes showed a weak positive correlation ($R^2 = 0.027$, $p < 0.02$) with molecular genotypes



Similarity coefficient based UPGMA dendrogram revealing interrelatedness of 29 *Pst* pathotypes

Cross talk among defense responsive proteins during wheat-stripe rust interactions

An in-silico STRING analysis was performed to understand the crosstalk among defense responsive proteins during wheat stripe rust interactions. STRING analysis revealed the interplay of defense responsive proteins with other proteins during infection of *Pst* pathotype 78S84 on PBW343 and FLW-3 at different time points. This analysis showed a set of connections of defense related proteins with supplementary proteins, which are involved in the inhibition of pathogens (Fig.). COMT1 interacts with Traes_6DS_211935E65.2 (CAD-Cinnamyl alcohol dehydrogenase), which is involved in the lignin biosynthetic process. PR10 (1AS_0B9295A68.1) is homologous of AT2G37040.1, found in *Arabidopsis*, interacted with cinnamoyl-CoA reductase, 4-coumarate: CoA ligase and caffeoyl-CoA O-methyltransferase, which participate in cell wall synthesis and strengthening. Traes_5BL_628390692.1 (LTP) showed interactions with Traes_5BL_9BE35DEC71.1, Traes_2BL_490540C70.1 and Traes_4BL_AB3EBF1FD.2. These proteins are implied in the transfer of lipids across the membrane and the binding of actin in the cytoskeleton and thus proteins strengthen the cytoskeleton of cells and inhibit the entry of pathogens.



Crosstalk between different defense responsive proteins during wheat-stripe rust interactions (COMT1, LTP, PR-10)

Genetics of rust resistance and plant breeding

Mapping studies for rust resistance and gene pyramiding

Three wild species of wheat *Aegilops uristata*, *Aegilops multiflorata*, and *Aegilops ovata* were evaluated against all three rusts. All species were found resistant to black rust, and only one species *Aegilops multiflorata* was resistant to all three rusts. These species were sown along with susceptible durum wheat landrace local red for development of synthetic hexaploid wheat that will be targeted for rust resistance gene mapping. The brown rust resistant Indian landrace *Hango-2*, a source of newly mapped gene *Lr80* was crossed with brown rust susceptible Indian wheat varieties PBW752 and PBW757 to develop brown rust resistance version of PBW752 and PBW757.

Screening of salt tolerant advanced wheat lines for rust resistance

Forty-one salt tolerant advanced wheat lines were evaluated for rust resistance at seedling (ASR) and adult plant stage (APR) against different pathotypes of three rusts and screened for the presence of rust resistance gene using linked molecular markers. The SRT of these genotypes was conducted under controlled conditions of the glasshouses as per the described procedures and rust resistance genes were postulated using gene matching technique. The pathotypes used for screening are T, 8S84, 110S119, 110S119, P, K, 7S0, 46S119, 111S68, 79S68, 238S119 and 110S 84 (yellow rust pathogen), 11, 12A, 13-3, 12-5, 12-7,77, 77-1, 77-2, 77-5, 77-7, 77-8, 77-9, 77-10, 104-2, 107-1, 108-1, 106-1 (brown rust pathogen) and 11, 21A-2, 34-1, 40, 40A, 40-2, 40-3, 42B, 117A-1, 117-4, 117-6, 122,

184-1 (black rust pathogen). The adult plant resistance (APR) of these lines was evaluated under controlled conditions of polyhouses against yellow and brown rusts. A mixture of five pathotypes each of yellow (46S119, 110S119, 238S119, 47S103, and 110S84) and brown (12-5, 77-1, 77-5, 77-9, and 104-2) rust pathogens were used in the study.

Molecular characterization of salt tolerant lines

Lr19/ Sr25 present in fourteen wheat genotypes identified using molecular marker GB, while *Yr9/Lr26/Sr31* gene complex is present in six genotypes. Seven wheat genotypes showed the presence of *Yr17/Lr37/Sr38* gene complex identified through molecular marker Ventruip. *Yr36*, *Lr 32*, *Yr18*, *Yr5*, *Yr10* and *Yr15* showed negative results in these wheat lines. HD2851 and KRL2029 showed resistance to all pathotypes of black and brown rust pathogens at seedling stage and molecular marker analysis showed the presence of *Lr24/Sr24* in both of the lines along with *Yr9/Lr26/ Sr31* gene.

Details of salt tolerant wheat lines and rust resistance gene postulated by multi-pathotype data at seedling stage

S. No.	Line	Genes postulated		
		Yr	*Lr*	*Sr*
1	KRL283	*Yr*9+	*Lr*26+23+10	*Sr*31+
2	KRL210	*Yr*2+	*Lr*23+10	*Sr*28+
3	KRL213	*Yr*2+	*Lr*13+	*Sr*28+
4	KRL19	*Yr*2+	*Lr*13+	R
5	KRL1-4	*Yr*2+	*Lr*13+	*Sr*28+
6	KRL99	-	*Lr*13+	*Sr*28+
7	KRL3-4	-	*Lr*13+10+1+	*Sr*11+
8	KRL119	-	*Lr*13+10+1+	*Sr*11+
9	KRL238	-	*Lr*13+	*Sr*5+11+
10	KH65	-	-	-
11	HD2851	-	Lr24+R	*Sr*24+
12	KRL2001	-	*Lr*13+2a	*Sr*28+
13	KRL2002	*Yr*2+	*Lr*23+10	*Sr*30+
14	KRL2003	-	*Lr*23+10+	*Sr*28+
15	KRL2004	*Yr*2+	*Lr*23+10+	R
16	KRL2005	*Yr*2+	*Lr*23+10+	R
17	KRL2006	-	*Lr*13+3+	*Sr*28
18	KRL2007	*Yr*2+	*Lr*23+10+	-
19	KRL2008	*Yr*2+	*Lr*10+1+	*Sr*11+
20	KRL2009	*Yr*2+	*Lr*23+	*Sr*28+
21	KRL2010	*Yr*2+	*Lr*23+3+	*Sr*28+
22	KRL2011	*Yr*2+	*Lr*13+	*Sr*11+

S. No.	Line	Genes postulated		
		Yr	*Lr*	*Sr*35
23	KRL2012	*Yr*2+	*Lr*13+	-
24	KRL2013	*Yr*9+	*Lr*26+23+1+	*Sr*31+
25	KRL2014	*Yr*2+	*Lr*13+2a+1+	*Sr*30+
26	KRL2015	*Yr*2+	*Lr*10+1+	-
27	KRL2016	*Yr*2+	*Lr*13+	*Sr*11+
28	KRL2017	*Yr*9+	*Lr*26+1+	*Sr*31+
29	KRL2018	*Yr*A+	*Lr*13+1+	*Sr*57+11+
30	KRL2019	*Yr*2+	*Lr*13+	*Sr*11+
31	KRL2020	*Yr*2+	*Lr*13+	*Sr*7b+11+
32	KRL2021	*Yr*2+	*Lr*13+10+1	-
33	KRL2022	*Yr*2+	*Lr*10+3+13+	*Sr*28+
34	KRL2023	-	*Lr*13+3+	-
35	KRL2024	*Yr*A+	-	-
36	KRL2025	*Yr*2+	*Lr*13+10+	-
37	KRL2026	*Yr*2+	*Lr*13+1+	*Sr*7b+11+
38	KRL2027	-	*Lr*13+1+	*Sr*7b+11+
39	KRL2028	*Yr*2+	*Lr*13+10+1+	*Sr*7b+11+
40	KRL2029	*Yr*9+	*Lr*26+R+Lr24+	*Sr*31+24+
41	KRL2030	*Yr*A+	*Lr*13+10+	-

Details of salt tolerant wheat lines and rust resistance at adult plant stage.

S. No.	Line	Rust Score	
		P. striiformis	*P. triticina*
1	KRL283	0R	0
2	KRL210	0R	20S
3	KRL213	5MR	5R
4	KRL19	40S	0R
5	KRL1-4	60S	-
6	KRL99	10S	20MS
7	KRL3-4	30S	40S
8	KRL119	10S	40S
9	KRL238	0R	0R
10	KH65	60S	40S
11	HD2851	30S	0R
12	KRL2001	20S	10S
13	KRL2002	10S	10MR
14	KRL2003	TMR	0R
15	KRL2004	5MR	0R
16	KRL2005	0R	0R
17	KRL2006	0R	5R
18	KRL2007	0R	10R
19	KRL2008	TMR	0

S. No.	Line	Rust Score	
		P. striiformis	*P. triticina*
20	KRL2009	5MR	-
21	KRL2010	5S	-
22	KRL2011	5MR	5MS
23	KRL2012	0R	0R
24	KRL2013	TMR	0R
25	KRL2014	0R	0R
26	KRL2015	0R	5S
27	KRL2016	0R	10R
28	KRL2017	10MS	0R
29	KRL2018	0R	0R
30	KRL2019	10S	-
31	KRL2020	5MR	-
32	KRL2021	-	0R
33	KRL2022	-	0R
34	KRL2023	10S	5S
35	KRL2024	0R	0R
36	KRL2025	5MR	20MS
37	KRL2026	5MR	0R
38	KRL2027	10MR	0R
39	KRL2028	5S	0R
40	KRL2029	5S	0R
41	KRL2030	-	-

Utilization of resistance sources

The NGSN comprising 20 entries with confirmed sources of high level of disease resistance were shared with 20 breeding centres across different agro climatic zones of the country for their utilization in breeding for resistance to biotic stresses. The utilization was 12.5 to 50.0% by different centres. The entries utilized at most of the centres were UP 3043, PBW 821, PBW 752 and WH 1270. Khudwani centre, utilized maximum 15 entries in their breeding programme followed by Jabalpur and Durgapura.

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

A total of 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 48 scientists/researchers.

Management of diseases through chemicals

Field experimental trials for the evaluation of efficiency of three chemical fungicides viz., Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC (0.1%), Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC (0.1%), Azoxystrobin 11% + Tebuconazole 18.3% w/w SC (0.1%), along with standard recommended fungicide [Tebuconazole (0.1%) and Propiconazole (0.1%)] were performed in randomized block design with three replications for the management of powdery mildew of wheat during the crop season 2021-22 at four different locations i.e. Pantnagar, Malan, Dhaulakuan and Jammu. Multilocation evaluations of the efficacy of the tested fungicides clearly highlighted that Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 0.1% is the best performing fungicide across the locations followed by Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC (0.1%) and Azoxystrobin 11% + Tebuconazole 18.3% w/w SC (0.1%). No phytotoxicity was recorded with any of the tested concentrations of the fungicides on wheat plants.

Besides this, six different fungicides viz., Picoxystrobin 7.05% + Propiconazole 11.7% SC (0.1%), Pyraclostrobin 133g/l + Epoxiconaxole 50g/l SE (0.1%), Tebuconazole 50% + Trifloxystrobin 25% WG (0.06%), Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC (0.1%), Azoxystrobin 18.2% + Difenoconazole 11.4% w/w SC (0.1%) and Azoxystrobin 11% + Tebuconazole 18.3% w/w SC (0.1%) along with standard recommended fungicide [Tebuconazole (0.1%) and Propiconazole (0.1%)] were evaluated for the management of head scab, stem rust and brown rust at multilocations.

Advisory for stripe rust management

During the current season 2021-22 the weather remained congenial in the month of Feburary for yellow rust in NWPZ. However, disease severity remained low due to deployment of resistant cultivars. Need based advisories for stripe rust management and Karnal bunt were issued. Awareness among farmers for stripe rust management was created through mobile, internet, toll free number, newspapers, discussions and delivering lectures in farmers training programmes.

Preparedness to wheat blast

Survey was conducted during the cropping season 2021-22 in North and South West Bengal near Indo-Bangladesh border by team of scientists from ICAR-IIWBR, Karnal, UBKV, Cooch Behar and BCKV, Kalyani, Nadia and no wheat blast was observed. Awareness was also created in farmers to take all preventive measures available against blast and to grow the identified resistant varieties. 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 2020 screened against blast at Jessore, Bangladesh at two different dates of sowing during 2020-21 and out of that 283 were again tested at Jashore, Bangladesh at two different dates of sowing during 2021-22. Out of these 283, across the years, 3 entries found free from infection and 100 are categorised resistant on the basis of average disease upto 10% infection. Besides, 350 entries were sent in 2021 to screen against blast during 2021-22 at Jessore, Bangladesh at two different dates of sowing. Six entries (NW8045, PBW879, UP3116, DWAP 2174, DWAP 2175 and GRU 25) were found free from infection and 86 are categorised resistant on the basis of highest score upto 10% infection.

Post harvest surveys for Karnal bunt

A total of 7759 grain samples collected from various mandies in different zones were analyzed at cooperating centres. The overall 21.94% samples were found infected. The samples from Rajasthan showed maximum infection (37.10%). The average incidence of Karnal bunt infected grains was 0.227% ranging from 0 to 12.4%. The maximum grain infection of 12.4% was observed in a sample from Jammu. In general the samples fall in the category of less than 1% grains infected with Karnal bunt. In case of Madhya Pradesh the samples collected from Seoni Malwa, Harda mandi, Dolaria mandi, Itarsi mandi and Sagar had Karnal bunt infection in the range of 6.6 to 40.0 per cent but the average incidence level remained low (0.00079%) ranging from 0 to 1.1 per cent grain infection. However, the samples collected from Ujjain, Indore, Dhar, Dewas and Sehore were found free from Karnal bunt infection. This year the sample collected from Uttarakhand, Karnataka and Maharashtra were also found free from Karnal bunt infection.

Training for human resource development

To bring more uniformity in disease creation and data recording a training was organized on "Field trial conduction, data recording and reporting under wheat and barley crop protection programme" from 1st - 3rd February, 2022 through virtual mode at ICAR-IIWBR, Karnal for scientists working in crop protection under the coordinated system. The scientists and technical workers involved in disease and insect pest recording participated in the training programme.

ENTOMOLOGY

Survey and surveillance for insect pests

In Punjab, the aphid incidence was above economic threshold level in some places viz. village Tapa (Barnala) and Bhucho mandi (Bhatinda) during the second fortnight of March. The natural enemies viz. grubs and adults of coccinellid beetles, syrphid fly and chrysoperla were observed in most of the fields infested with aphids. Surveys were also 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 recorded during 2021-22 crop year except few minor infestations.

In Maharashtra state, survey was carried out in the villages of Nashik and adjoining district Ahemednagar and Aurangabad at different crop stages on farmers' field during the season (Dec 2021 to March 2022). Medium to heavy incidence of aphids was recorded during the survey. The Coccinellid & Crysoparla predator grubs and beetles feeding on the aphid were also observed. The incidence of jassids was recorded in low intensity.

In Gujarat state, the termite damage during the Rabi 2021-22 crop season in wheat fields was very low in the fields across the area surveyed. The incidence of aphid was observed to be low to moderate during ear head stage of the crop. The population of *H. 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 UP (Kanpur), survey was conducted in villages viz., Araul, Kannauj, Hardoi and Unnao during 2021-22. Incidence of shootfly was recorded to be 2 percent at all three locations. The incidence of termite was observed 10 per cent wheat variety HD2967 in Hardoi. However, it was 8% in Unnao and Araul on variety HD2967. Moderate infestation (25-30 aphid/tiller) of foliar aphid was 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 (2%) was observed in irrigated crop one per cent in variety HD2967.

In Haryana, survey was conducted in field from December -March in Ladwa, Yamunanagar, Kunjpura, Subhari, Racina and Hajwana, Karnal etc. This year incidence of aphids, termites, pink stem borer and army worm was reported to be low (1-3%). Termites and root aphid was reported to be around 2-4% during November and December. Aphid infestation started appearing in the month of January and the population in the beginning was around 4-5 aphids/tiller but in February, higher infestation of aphids (27-39 aphids/tiller on an average) 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 three locations viz., Ludhiana, Dharwad and Kanpur, the lowest infestation index (2.91 %) of shoot fly entry was reported in RAJ4083(C) and the highest index of 12.64 % in DBW371. At Ludhiana centre, maximum infestation index of 7.95 per cent was reported on HI8759(C) and minimum (3.60 per cent) on KRL19(C). Nine entries viz., SKW362, UP3113, RAJ4083(C), HI1665, HI8830(d)*, MACS6795, HI1621(C), HD3249(C) and HD3386 at Dharwad had zero infestation of shootfly while highest infestation (19.61 %) was observed on PBW175(C). At Kanpur location, lowest infestation 2.85 % was observed on HD3400 and highest infestation of 20% was recorded on entry PBW835^{Q}*.

Brown wheat mite: At Ludhiana, three entries HD3418, DBW365 and VL2044 recorded the minimum mite population of 7.7/10 cm^2 area while maximum mite population of 24.0 /10 cm^2 in entry PBW902. This seasonal 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 five locations; Ludhiana, Karnal, Niphad, Khudwani and Kharibari six entries; VL2041, VL2043, VL2044, HD3402, HPW481 and HPW487 scored 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, Durgapura and Pusa Bihar was recorded to very low and therefore data was rejected. Out of 280 tested NIVT entries, none of the entry showed the moderately resistance (grade 3) or resistance (grade 2) reaction based on average score of three locations i.e. Ludhiana, Niphad and Karnal. All the entries were found to be either in susceptible (grade 4) or highly susceptible (grade 5) category.

Root aphid: Out of total 153 entries, all entries were found to be either in susceptible (grade 4) or highly susceptible (grade 5) category. None of the entry showed the moderately resistance (grade 3) or resistance (grade 2) reaction at Ludhiana.

Screening against multiple pests

The average infestation index of shootfly recorded at three locations (Ludhiana, Dharwad & Kanpur) was to be lowest (3.97%) in entry HI8823 (d) and the maximum score of 11.55% was recorded for GW513. The lowest population of 5.67 brown wheat mites/10 cm^2 was recorded in entry HUW838 while entry HS 681 had highest population of 15.67 mites/10 cm^2 at Ludhiana. Based on average score of five locations (Ludhiana, Karnal, Khudwani, Kharibari and Niphad), 8 entries HS507, HS679, HD3334, VL2036, HI8823 (d), HD2864, NIAW3170 and VL3024 showed moderately resistance (grade 3) response to foliar aphid. At Ludhiana, all entries were found to be either in susceptible (grade 4) or highly susceptible (grade 5) category to root aphid.

Integrated pest management studies

Influence of sowing time on the incidence and population build-up of major insect pests of wheat was studied. The termite damage recorded at seedling stage in different dates of sowing indicated that early sown crop (first fortnight of Nov 2021) suffered more termite damage as compared to timely, late and very late sown crop. At earing stage, again termite damage was highest in early sown crop followed by timely and late sown and very late

sown crop. The root aphid appeared in the early growing season and its attack was observed on 3-5 week old crop. Foliar aphid incidence first appeared in first week of February in early, timely, late sowing dates and second week of February in very late sowing time. The data recorded indicated that the aphid incidence got delayed with the delay in sowing time. The peak of aphid incidence was recorded in 9th standard meteorological weeks (SMW) of 2022 in early sowing date. However, peak of aphid population was recorded in10th SMW for II sowing time and it was in 11th SMW for III & IV sowing time.

The effect of different sowing methods viz. Happy-Seeder, Super-Seeder, Rotavator along with conventional sowing in wheat was tested to study the population dynamics of major insect-pests and natural enemies in rice-wheat cropping system. Pink Stem borer incidence was highest in Rotavator sown wheat crop followed by Super seeder and Happy-Seeder sown crop at different observation time. However, there was no difference observed in foliar aphid incidence among all tillage conditions. All residue management conditions recorded significantly lower number of root aphids/tillers as compared to conventional tillage. Coccinellid population was higher in all residue managed wheat fields as compared to conventionally sown wheat crop.

Effect of silicon application in the form sodium meta-silicate was tested to determine its effect on aphid abundance and their coccinellid predators in wheat. The observations indicated that one or two foliar applications of sodium meta-silicate have little effect on aphid population. Although some reduction in aphid control was recorded in foliar application of sodium meta-silicate but it remained above economic threshold level of 5 aphids /earhead. However, application of thiamethoxam 25WG significantly reduced the aphid population. Coccinellid population was statistically at par with each other in all sodium meta-silicate application and it was significantly lower than foliar application of thiamethoxam 25WG. The grain yield recorded in all silicon treatment was also significantly lower than foliar application of thiamethoxam 25WG.

Evaluation of biodegradable insecticide loaded hydrogels for management of termites in wheat was done during 2021-22. Insecticides recommended for termites control viz. thiamethoxam 70WS @ 1 g/kg of seed, chlorpyriphos @ 4 ml/kg of seed and Neonix @ 2 ml/kg of seed, were loaded with commonly available Hydrogel (Goond Katira along with Jaggery) and tested for their

efficacy along with seed treatments without hydrogels and untreated control. Fipronil 0.3 G @ 7 kg/ac and chlorpyriphos 20 EC @ 1.2 litres/ac alone or in combination with hydrogels were also applied before first irrigation and tested for their efficacy. The data revealed that plant population/m row recorded after 3 weeks of germination was non-significant among all the treatments. Hence, none of treatment used, affected the seed germination. Per cent damaged effective tillers/m row after 3, 4, 5 & 6 weeks of germination indicated that all seed treatments recorded significantly lower per cent damaged effective tillers/m row as compared to plots treated with soil application of insecticides before first irrigation and untreated check. There was no difference in insecticides applied alone or in combination goond katira for termite control. Among the different insecticide seed treatments, termites damage was lowest in goond Katira (5kg/ha) + neonix @ 2 ml/kg of seed whereas among the soil application, it was minimum in goond Katira (5kg/ha) + fipronil 0.6% GR applied before 1st irrigation. However, all the insecticide treated plots recorded significantly lower termite damage as compared to untreated check except.

The integrated pest modules were tested at four centres viz., Karnal, Ludhiana, Niphad, Kanpur against 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.

Evaluation of insecticides was carried out against lepidopterous pests (pink stem borer, army worm & cutworms) of wheat. Fipronil 0.6% GR @10 kg/ha (0.71%) followed by chlorantraniliprole 18.5 SC @ 150 (0.73%) was found effective and it was at par with of fipronil 0.6% GR @7.5 kg/ha and flubendiamide 480 SC @ 60 ml/ha. However, the biopesticide, *Bacillus thuringiensis* @ 1 & 1.5 lt/ha and lower dosage of flubendiamide 480 SC, chlorantraniliprole 18.5 SC were significantly inferior and were at par with untreated control (2.52%).

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 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.

For management of termites, in pre-mixed insecticide imidacloprid 18.5%+ hexaconazole 1.5% FS recorded lowest termite damage followed by Imidacloprid 600FS + Tebuconazole.

Population dynamics studies of foliar aphids on wheat and barley crops revealed comparatively higher population of aphid on barley as compared to wheat crop. The coccinellid beetle appeared after the peak period of aphid infestation on wheat and barley crop.

NEMATOLOGY

Resistance against *Heterodera avenae*

One hundred and fifty three entries of AVT were screened for resistance against *H. avenae* (CCN) under sick plot conditions or pot condition at Hisar and Durgapura centres. No entry was found resistant or moderately resistant across all the centres. However only one entry VL3028 has shown moderate level of resistance at Hisar centre.

Management of cereal cyst nematode

A new nematicide *viz* Fluensulfone 2% GR at different doses was evaluated for nematicidal properties against CCN at two locations namely Hisar and Durgapura. Minimum CCN infection and maximum yield was observed in Fluensulfone 2% GR @ 2.0 kg a.i./ha. However, it was statistically at par with all the dose of Fluensulfone 2% GR but significant over Carbofuran @2 kg a.i/ ha and untreated control.

RESOURCE MANAGEMENT

The Resource Management group of the All India Co-ordinated Wheat and Barley Improvement Project (AICW&BIP), is mainly engaged in evaluating the performance of newly developed genotypes. It is also developing new technologies and fine tuning the existing technologies. The aim is to provide to the farmers, an eco-friendly, location specific and cost effective technologies for higher productivity and profitability. The cost effective technologies are being executed through special trials on the priority basis in various wheat growing zones.

During this crop season, 85 trials were proposed, of which 83 were conducted. Out of the conducted trials, twenty two trials were rejected due to low target yield and one trial due to improper data reporting. The overall conduct of trial was 97.6% with a success and rejection rate of 74.1% and 25.9% respectively.

Zone-wise details of the coordinated varietal evaluation trials

Trial Series	Locations	Trials conducted	Trials not conducted		Rejected	
			Number	Centres	Number	Centres
Northern Hill Zone						
RIR-TS-DOS-TAS	05	05	-	-	01	Khudwani
Total	05	05	-	-	01	-
North Western Plain Zone						
IR-TS-DOS-TAS	09	09	-	-	02	Pantnagar, Karnal
RIR-TS-DOS-TAS	09	09			01	Karnal
SPL-IR-ES-HYPT	07	07	-	-	05	BISA Ladowal, Delhi, Gurdaspur, Ludhiana, Pantnagar
Total	25	25	-	-	08	-
North Eastern Plain Zone						
IR-TS-DOS-TAS	09	09	-	-	05	Ayodhya, Kalyani, Kanpur, RPCAU Pusa, Sabour
IR-LS-DOS-TAS	09	09	-	-	02	Kanpur, RPCAU Pusa,
Total	18	18	-	-	07	-
Central Zone						
IR-TS-DOS-TAD	08	08	-	-	-	-
IR-LS-DOS-TAS	08	08	-	-	-	-
RIR-TS-TAD	06	06	-	-	02	Durgapura, Udaipur
SPL-IR-ES-HYPT	05	05	-	-	01	Powarkheda
Total	27	27			03	
Peninsular Zone						
IR-TS-DOS-TAD	05	04	01	Washim	02	Dharwad, Pune
IR-LS-DOS-TAS	05	04	01	Washim	01	Dharwad
Total	10	08	02	-	03	-
Grand Total	85	83	02	-	22	-

In Northern Hills Zone (NHZ), out of 5 proposed trials, all the trials were successfully conducted, however, one trial at Khudwani in restricted irrigation was not considered for pooled analysis due to improper reporting. In NWPZ, all the 25 proposed trials, were successfully conducted. But, two trials at Karnal and Pantnagar under timely sown condition, one trial under restricted irrigation at Karnal and five trials in early sown HYPT (BISA Ladowal, Delhi, Gurdaspur, Ludhiana and Pantnagar) were not considered for pooled analysis due to lower mean than target yield. In NEPZ, all 18 proposed trials were conducted, but five trials locations (Ayodhya, Kalyani, Kanpur, RPCAU Pusa, Sabour) in timely sown and two locations (Kanpur, RPCAU Pusa) in late sown were not considered for pooled analysis due to lower mean than target yield. In CZ, all the 27 proposed trials were conducted, however, two trials (at Durgapura & Udaipur) in restricted irrigation and one trial (Powarkheda) in HYPT were not considered for pooling due to low mean target yield. In PZ, out of 10 proposed trials, eight trials out of 10 proposed, were conducted. Washim centre did not conduct the two allotted trials. Two locations (Dharwad, Pune) in timely sown and one location (Dharwad) in late sown were not considered for pooling due to low mean target yield.

The performance of 28 final year test entries under different trials is presented in the Table here. In NHZ one test entry VL 2041 was evaluated under restricted irrigation condition but was found inferior in comparison to the best check HS 562. In NWPZ, under IR-TS-DOS-TAS trial, two test genotypes namely PBW826 and HD3406 were evaluated alongwith four check varieties DBW187, DBW222, HD2967 and HD3086. In terms of yield, the test entry PBW826 recorded significant superiority over all other entries in timely sowing (60.30 q/ha) as well as on overall basis (53.94 q/ha) and also over the best check was DBW222. In RIR-TS-TAS trial, three test entries HI1653, HI1654 and HD3369 were tested and no was found superior to the best check HUW838. In NHZ, NEPZ and CZ, none of the test entries showed either numerical or significant superiority over the best check. In PZ, test entry HI8826 (d) showed numerical superiority (4.51%) over best check variety MACS3949(d).

Performance of new genotypes in various agro-climatic zones

Zone Wise Trial	Test Entries	Entry sowing superiority		Best Check	Yield gain, %	Locations
		Numerical	Significant			
North Hill Zone						
RIR-TS-TAS	VL 2041	-	-	HS 562	-	04
North Western Plain Zone						
IR-TS-DOS-TAS	PBW 826, HD3406	–	PBW 826	DBW222	3.49	07
RIR-TS-TAS	HI1653, HI1654, HD3369	–	–	HUW838	–	08
SPL-IR-ES-HYPT	DBW370, DBW371,		PBW872	DBW327	4.10	02
	DBW372, PBW872	DBW371		DBW327	0.34	02
North Eastern Plain Zone						
IR-TS-DOS-TAS	HD 3411, PBW 826, HD 3406			HD 2733	-	04
IR-LS-DOS-TAS	DBW 316, PBW 833 PBW 835	PBW 835		HI1563	-	07
Central Zone						
IR-TS-DOS-TAD	HI 1650, MACS 6768 MP 3535	-	-	HI1544	-	08
IR-LS-DOS-TAS	HD 3407	-	-	CG 1029	-	08
RIR-TS-TAD	HI 1655, CG 1036, HI 8830 (d) DDW 55 (d)	-	-	DBW 110	-	04
SPL-IR-ES-HYPT	DBW 372	-	-	GW 322	-	04
Peninsular Zone						
IR-TS-DOS-TAD	MACS4100(d), HI8826(d),	HI8826(d)	–	MACS3949(d)	4.51	02
IR-LS-DOS-TAS	DBW320	–	–	HD2932	–	03

High Yield Potential Trial (HYPT)

In NWPZ, the HYPT experiment was conducted at seven centres namely Delhi, Gurdaspur, Hisar, Karnal, Ludhiana, BISA Ladowal and Pantnagar. The data of Hisar and Karnal centres only were considered for pooled analysis while data of rest five centre (Delhi, Gurdaspur, Ludhiana, BISA Ladowal and Pantnagar) were rejected due to low mean yield (<65 q/ha) under highest fertility level. The pooled analysed data of two centres showed that grain yield enhanced significantly with increased fertilizer doses. Addition of 150% RDF and two sprays of growth retardants increased the grain yield (66.17 q/ha) significantly as compared to RDF (58.63 q/ha). This increase was to the tune of 12.9% over RDF. Genotype PBW872 ranked first on mean yield basis with yield of 67.73 q/ha, which was significantly higher than other genotypes. This genotype also yielded 70.85 q/ha under 150% RDF +

15 t FYM/ha + two sprays of growth regulators at first node and flag leaf stage which was higher than other varieties. The entry PBW872 was having bolder grains (49.45g thousand grains weight). The genotype DBW371 ranked (65.28 q/ha) second followed by the check DBW327 (65.06 q/ha), on mean yield basis.

In CZ, this trial was conducted at five centres namely BISA Jabalpur, JNKVV Jabalpur, Powarkheda, Udaipur and Vijapur. The pooled analysis showed significant effect of fertilizer application and growth regulators on yield. Addition of 15 t FYM/ha with 150% RDF significantly increased grain yield (11.09%) over RDF. Genotype GW322 remained top yielder (68.04 q/ha) followed by DBW 303 (66.68 q/ha) and both the genotypes remained at par but significantly higher than the other test genotypes.

Herbicides testing in wheat

In NWPZ, this trial was conducted at three centres namely Gurdaspur, Hisar and Jammu. The analysis of pooled data revealed that herbicide application produced significant effect on grain yield and yield attributes. The highest yield was obtained under weed free situation (51.93 q/ha) which might be attributed to higher and better use of moisture, light, nutrients and space by the crop plants. Among herbicides, pre-emergence application of pyroxasulfone + metribuzin 127.5+280 g *a.i.*/ha showed the least number of weeds (16.9) and weed dry weight (15.4 g/ sq. m.) at 90 DAS as compared to values of these traits as 112.6 and 161.5, respectively, under weedy check condition followed by pre-emergence tank mix application of pendimethalin + metribuzin at 1280 + 280 g *a.i.*/ha has resulted into less weed count (19.3) and reduced weed dry weight (21.1 g/sq. m.) at 90 DAS.

Effect of nano urea under irrigated conditions

The experiment on nano urea was conducted to explore the possibility of maximizing wheat productivity by integrated use of nano urea. The experiment was laid out in a randomized complete block design with thirteen treatments viz. control (No N) and 50, 75 and 100% of Recommended N rates along with either one or two spray of nano urea or two spray of simple urea (5%). One third nitrogen as per treatment, full phosphorus and potash as basal dose and the remaining 2/3rd nitrogen partitioned as 1/3rd at first irrigation and 1/3rd at second

irrigation were applied. Irrigation and weed control measures were followed as per recommended package of practices for the concerned zone.

In NWPZ, this experiment was conducted at eight locations (Delhi, Gurdaspur, Gwalior, Hisar, Jammu, Karnal, Ludhiana and Pantnagar). The perusal of pooled analysis data showed that application of recommended N and two spray of nano urea at tillering and jointing stage produced the maximum grain yield of 50.52 q/ha. However, the grain yield with rec. N + two spray of simple urea (5%) at tillering and jointing stage (49.45 q/ha) and with rec. N + one spray of nano urea at tillering (49.26 q/ha) were at par with rec. N + two sprays of nano urea. The addition of two spray of nano urea at tillering and jointing stage with recommended N fertilization brought about an increase of 6.38% in grain yield over rec. N treatment. The yield gain might be due to the bolder grains with thousand grains weight of 38.16 g in nano urea spray against 36.93 g for recommended dose of N fertilizer without any spray.

WHEAT QUALITY

India is the 2nd largest producer of wheat in the world. This could be made possible by developing high yielding, disease resistant wheat varieties and matching production technologies. The increase in domestic demand of baked & pasta products and economic liberalization & global trade have offered opportunities for better utilization of wheat. Wheat quality needs utmost attention to meet the trade requirements of the domestic and international markets. The report includes aspects like identification of product specific genotypes. Promising genotypes showing superiority in various quality traits including Iron and Zinc content have been identified. Zone wise variability in wheat quality and grain nutrition parameters has been recorded. During 2021-22, 120 AVT, 294 NIVT, 70 QCWBN, 40 HYPT, 40 MABB, 11 AST, and 28 IVT entries were analyzed from different zones and growing conditions.

AVT's:

All the second year AVT entries including checks were evaluated for baking for chapati, bread, biscuit, and pasta, and gluten content. All AVTs were analyzed for several physico - chemical properties such as grain appearance, test weight, protein, sedimentation value, yellow pigment, phenol test, grain hardness index, wet / dry gluten and gluten index, HMWGS and iron and zinc content. Promising product specific entries identified are linked below:

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

Category	Genotypes
Check	DBW187 (NWPZ-ITS), HD1967 & DBW222 (NEPZ-ITS), HI1636 (I)(C), GW513 (I)(C), & HI1544 (CZ-ITS), RAJ4083 (CZ-ILS); **HYPT:** GW322(C), DBW303(C), DBW187(C), HD3086(C) **MABB: NWPZ:** DBW187 (C), PBW175 (C); CZ: HD2864 (C), MP3336 (C), CG1029 (C), HI1634 (C)
AVT/HYPT/MABB	AVT: PBW833* (NEPZ-ILS), MP3535*, MACS6768* (CZ-ITS), CG1036*, & HI1655Q* (CZ-ILS) **HYPT:** NWPZ-IR-ES: PBW872*, DBW370*; **NEPZ-IR-ES:** PBW872*, DBW371*, CZ/PZ/ NEPZ-IR-ES : DBW372#* MABB: CZ: HD3407*

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

Category	Genotypes
Check	AVT: DBW296 (I)(C) (NWPZ-RITS), HI 1621(C) (NEPZ-ILS); **HYPT:** PZ: DBW187(C); **MABB:** NWPZ: HD2967 (C), DBW222 (C), PBW677 (C)
AVT/HYPT/MABB	HI 1654 (NWPZ-RITS), DBW 316 (NEPZ-ILS)

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

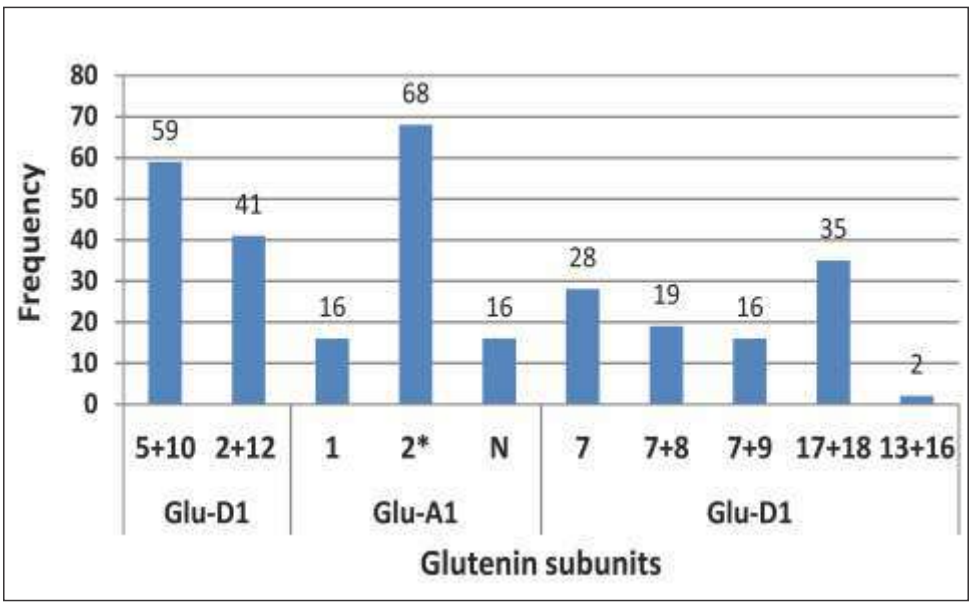
Category	Genotypes
Check	NIAW3170 (C) (NWPZ-RITS) (10.7), DBW296 (I)(C) (NWPZ-RITS) (11.1)
AVT	VL2041Q* (NHZ) (11.7), HI1654* (NWPZ-RITS) (10.6)

Promising Genotypes for Various Quality Parameters

Parameter	Value	Genotypes
		(*T. aestivum*)
Protein	**12.5%**	**NHZ :** NIL ; **NEPZ:** NIL **NWPZ:** DBW173(C), WH1124(C) **CZ :** MP1377, GW532 **PZ :** MACS6222(C), DBW407, HD3090(C), HI1633(C), MP1380 **HYPT:** PZ (DBW372#*, DBW187(C), HD3086(C), DBW377) **MABB (PZ):** HD3438, HD3439
Sedimentation value	**> 60 ml**	**NHZ :** NIL; **NWPZ :** NIL **NEPZ :** DBW 187 (C) (ITS); **CZ :** NIL **PZ:** DBW 407 (PZ-ITS) HYPT: PZ (DBW187(C) **MABB:** NWPZ: DBW187 (C)
Hardness Index	**< 35**	**NHZ :** VL2041Q* **NWPZ :** NIL; **NEPZ:** NIL; **CZ:** NIL **PZ:** NIAW3170(C)
Iron	**≥40ppm**	**NHZ :** VL2043; **NEPZ :** NIL **NWPZ :** DBW173(C), HD3369*, HI1653*, DBW644(C), DBW296(I)(C), DBW359, WH1402 **CZ :** MACS6768*, GW513(I)(C), HI1544(C), GW547, NIAW4028 **PZ :** MACS6222(C), UAS3015, MP1378, RAJ4083(C), HI163(C), HI1605(C) **HYPT:** NWPZ: PBW872*, DBW371*, DBW332(I)(C), DBW327(I)(C), PBW871, DBW373, DBW318 **MABB:** NWPZ: PBW677 (C); PZ: RAJ 4083 (C)
Zinc	**≥40ppm**	**NHZ :** NIL **NWPZ :** HD3080(C), HD2967(C), WH1124(C), DBW771(C), HD3043(C), HD3400 **NEPZ:** NIL **CZ :** MACS6768*, HI1636(I)(C), GW513(I)(C), HI1666, GW532, HI1665 **PZ :** DBW407, MP1378, RAJ4083(C), HI1633(C), MP1380 **HYPT:** NWPZ: PBW872*, DBW372#*, DBW303(C), DBW332(I)(C), PBW871, DBW373, DBW318; **HYPT:** CZ: GW322(C); **MABB:** NWPZ: HD2967 (C), PBW677 (C), PBW175 (C), PBW901 **CZ:** HI8498 (C), HI8737 (C), HI8759 (C), HI8846, HI8847
		(*T. durum*)
Protein	**>13.0%**	**CZ :** NIL; **PZ :** NIL
Sedimentation value	**≥ 40ml**	**CZ :** NIL **PZ :** MACS4100(d) (PZ-ITS), MACS3949(d)(C) (PZ-ITS), UAS446(d)(C), HI8840(d)
Yellow Pigment	**>7.0ppm**	**CZ :** DDW47(d)(C), HI8830(d)* **PZ:** MACS4100(d)*, HI8826(d)*, DDW48(d)(C)
Iron	**≥ 40ppm**	**CZ :** NIL; **PZ :** NIL
Zinc	**≥ 40ppm**	**CZ :** DDW55(d)Q*, HI8823(I)(d)(C), HI8627(d)(C) **PZ :** UAS428(d)(C) **MABB:** CZ: MP3336 (C)

High Molecular Weight Glutenin subunits (HMWGS) of *T. aestivum*

One hundred entries representing 2nd year AVT, IVT, HYPT and MABB entries including checks were evaluated for High Molecular Weight Glutenin subunits (HMWS). Subunits 5+10 and 2+12 were present in 70 % and 30 % of the total entries, whereas entries having 1, 2* and N subunits were 29 %, 53 % and 18 %, respectively. Likewise, percent entries having subunits 7, 7+8, 7+9, 17+18 and 13+16 were 30 %, 19 %, 14 %, 35 % and 2 %, respectively. Subunits 17+18 encoded by *Glu-B1* locus and subunit 5+10 encoded by *Glu-D1* locus for stronger gluten were present in majority of entries.

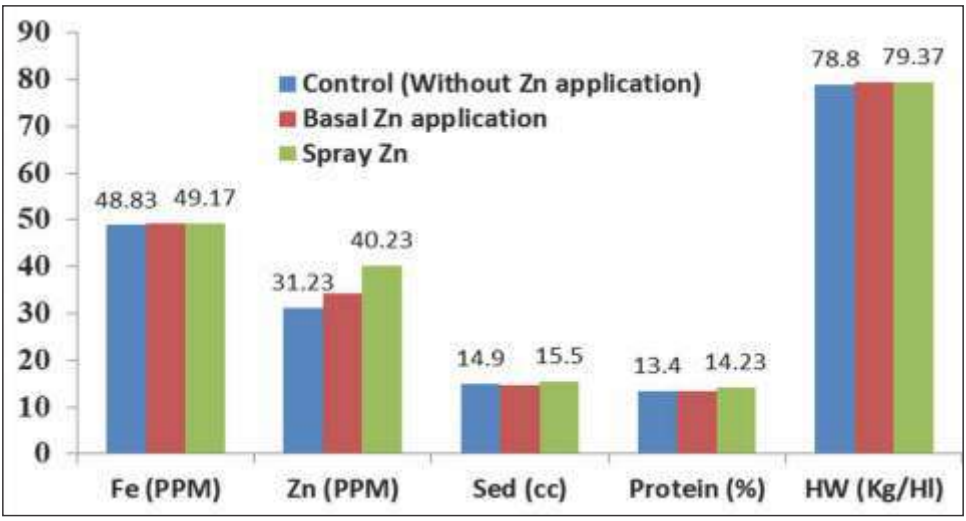


Distribution of HMW-glutenin subunits of AVT, HYPT and MABB entries

Agronomic Biofortification: Experiment conducted in 2 acres of area

Agronomic biofortification strategy is to enhance Fe and Zn content by foliar spray of Fe and Zn containing fertilizers during early grain filling stage. In this investigation, an experiment was conducted at Karnal using Zn spray on wheat variety WB 02 along with control in an area of 2 acres. The experiment contained controlled conditions, basal application of ZnSO4 in soil (25 kg/hectare) and ZnSO4 spray (0.5% in

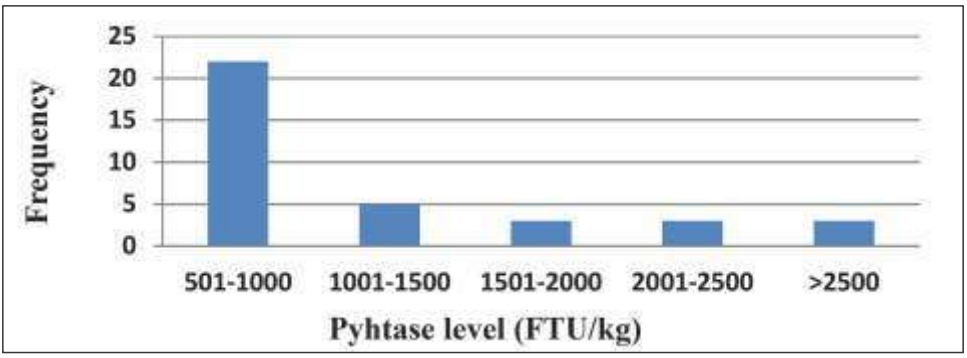
water; 4 kg per hectare). There was more than 40% increase in Zn content in treated plots. There was significant improvement in grain protein and Zn content and some improvement in hectolitre weight and sedimentation value. Our Zn spray experiments during last 4 years clearly demonstrated that agronomic biofortification is feasible in large field conditions.



Effect of Zn spray on quality traits in wheat genotype WB 02.

Development of high phytase genotypes:

Significant progress has been made in developing high phytase and low phytic acid genotypes for improving bioavailability of micronutrients to human beings. Large number of crosses have been made involving high phytase and low phytic acid genotypes. Transgressive segregants towards higher phytase and low phytic acid content have been selected from crosses with high yielding varieties. An example is given below in figure . Most of the F4 lines (HD 3086/ high phytase mutant) have phytase level <700 FTU/kg and the mutnat line has >2500 FTU/kg while some of the transgressive segregants showed >3500 FTU/kg phytase level.



Frequency distribution of Phytase level in F4 population of a cross between HD 3086 and high phytase mutant

Quality component and wheat biofortification nursery (QCWBN)

Fifty-four QCWBN entries were evaluated from 13 centres representing all the zones for Grain appearance score, Hectolitre Weight, protein, Fe and Zn content to identify genotypes possessing higher protein (14%), iron (45 ppm) and zinc content (45 ppm) together. In NWPZ zone, UASQ 332, showed higher Fe, Zn and protein content as compared to best check (WB 02). None of the entry showed desirable quality traits in CZ and NEPZ. In PZ also UASQ 332 exhibited higher Fe (45.8ppm), Zn (53.7ppm) content than the best check (WB 02) and comparable protein content (14.3%).

BARLEY NETWORK

The crop season 2021-22 started well for barley and initially looking good for barley production as the crop growth conditions were very good, however, the heat stress experienced late February onwards during the grain filling/ development process adversely affected the production in NWPZ. According to 3rd advance estimates for Rabi 2021-22, nearly 1587 thousand tons of barley has been produced in 542 thousand ha area with a productivity of 29.30 q/ha (highest so far). This is nearly 4.2% less production over the previous year. Rajasthan continues to be the largest state having >49.0 % in area and >58.0 % production followed by Uttar Pradesh, Uttarakhand and Himachal Pradesh. In case of Rajasthan there is not much change in area and production over last year. Maharashtra has an increasing trend for barley area in recent three years, but declined around five folds in the current season i.e., 16.40 in 2021-22 against 62.95 in 2020-21. The states of U.P., Himachal Pradesh and Uttarakhand have indicated stable trends and in other states only minor fluctuations are there for barley area/ 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 of the crop and farmers are not willing to take such risk except in cases where there are no better options available. Sometimes industry is taking care of limited procurement on premium price for malt barley either directly or through or market people based in important mandis. However, the crop year 2021-22, for barley has been a unique year where against the declared MSP of Rs. 1635/q, the market prices in most of mandis of Rajasthan and Haryana ranged from Rs. 2550 to 3600/q during most of the procurement period from March to May 2022, allowing the farmers to raise their income from this crop to the tune of 150 to 200% or even more in some cases. The predicted shortage of the grain for barley industry in country as well as risky international supply from Ukraine and other countries in the region might have contributed in

the sudden price rise. This may help the cause of stabilizing/ increasing the area under barley in country in addition of the heat wave experienced during the year coupled with the water availability in central India, especially in states like Madhya Pradesh. Despite this one-time development, there is a need of regular support in terms of assured procurement and higher MSP for barley from government side also to support its production.

Another extremely important factor is the need for regular breeder seed indenting by the different states, private and public sector agencies, to assure the availability of quality seed for farmers, averting an unplanned sudden demand from industry for huge seed quantity, which cannot be met because of non-prior indenting. The recent trends of decreasing breeder seed indenting is a cause of great concern to the cultivation of the crop and availability of good quality seed to willing farmers.

During the year some damage/losses in quantity and quality of the grain were observed due to heat wave observed in different areas in timely sown crop. The crop was adversely affected at grain development stage in northern plains especially north western regions, which is indicated in physical grain quality analysis for parameters like 1000 GW, proportion of bold and thin grains, which were recorded in negative side over long term observations from AICRP Barley evaluation centres. The phenomena was more visible in Northern Haryana, Punjab, and Western UP, where the location means were poorer than others in Rajasthan, Southern Haryana and adjoining regions, where the crop escaped the stage of grain filling from severe heat wave. The monitoring teams during the surveys in the major barley growing areas 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 more incidence of spot blotch in NEPZ. The smuts (mainly covered) were common in trials as well as in farmers' fields where the seed was not treated with correct fungicides.

Release of new barley varieties

The variety DWRB137, a six row-feed barley variety has been approved for area extension in NWPZ (Punjab, Haryana, Western U.P., Rajasthan) during 2021-22 by CVRC. This variety was earlier released for NEPZ and CZ, and currently leading the breeder seed production indents in country. On account of its superiority in yield and other traits, in no time, this variety became very popular among barley growers of India as indicated by its first rank in national breeder seed indent and production programme. Thus, the farmers of NWPZ will also be benefitted from this variety and will harness its potential in the region.

Another barley variety KB1425 has been released for saline-alkaline soils of Uttar Pradesh under irrigated timely sown conditions.

Barley varieties released by CVRC/SVRC during 2021-22.

SN	Variety	Parentage	Zone	Av. yield (q/ha)	Pot. Yield (q/ha)	Developed at	Production condition
1.	DWRB137	DWRB28/ DWRUB64	NWPZ NEPZ CZ	52.2 37.9 42.5	80.0 53.6 67.4	IIWBR, Karnal	Timely sown irrigated conditions
2.	KB1425	K508/ NDB1295	Uttar Pradesh	33.1	47.3	CSAUA&T Kanpur	Irrigated timely sown, in saline-sodic soils

Registration of new barley genetic stocks

Nine genetic stocks namely DWRB206, BHS478, BCLA3, BCLA11-6, DWRBG1, DWERBG3, DWRBG4, DWRBG5 and DWRBG6 have been registered with ICAR-NBPGR for their unique traits during this period. Two of them are unique for resistance to corn leaf aphid for the first time in country. These genotypes have been discovered with specific traits through their evaluation under the AICRP Wheat and Barley multilocation disease/ pest (NBDSN) or quality (BQSN) screening nurseries.

Genetic stocks registered with NBPGR New Delhi during 2021-22.

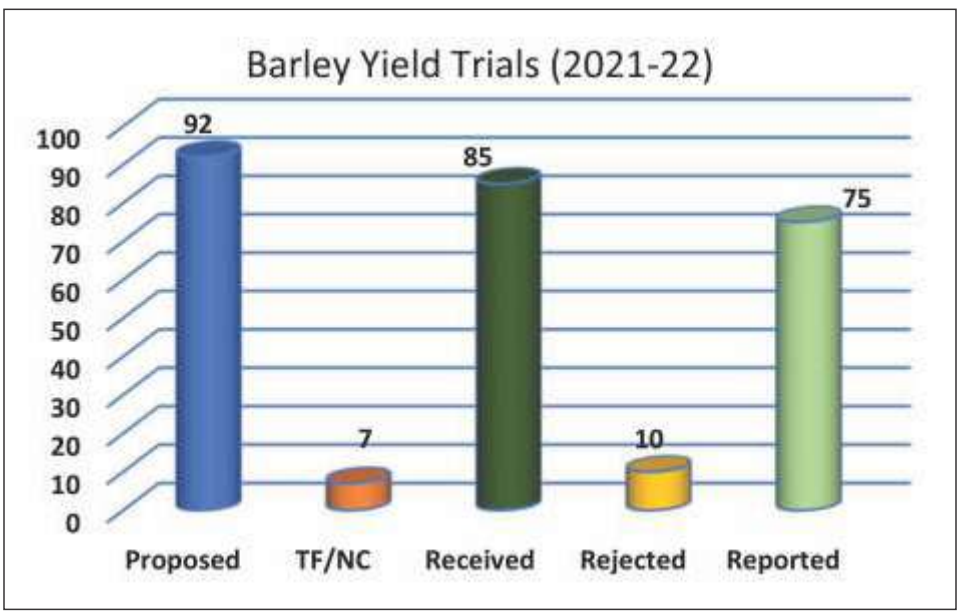
Name	INGRN	Parentage	Trait(s)	Institute
DWRB 206	21100	Zigzig/4/Tocte//Higo/ Lino/3/Petunia1	Resistant to stripe rust at APR under artificial inoculation	IIWBR, Karnal
BCLA 3	21102	EB921/ Alfa93	Corn leaf aphid resistance in two-row back ground	IIWBR, Karnal
BCLA11-6	21101	BCU390 /Alfa93	Corn leaf aphid resistance in six-row back ground	IIWBR, Karnal
BHS 478	21202	BHS385/BHS369	Seedling resistance against all races of leaf and stripe rust. Adult plant resistance to yellow rust, leaf rust and stem rust.	IARI, Shimla
DWRBG 1	21204	Legacy/4/Tocte//Gob/ Humai10/3/Atah92/Aleli /5/Arupo /K8755 /Mora	Barley genotype with a combination of low grain beta glucan (3.8%) and higher grain protein contents (13%).	IIWBR, Karnal
DWRBG 3	21205	J09049 F3 10/030552	Barley genotype with combination of low grain beta glucan content (3.88%) and desirable thousand grain weight (45g).	IIWBR, Karnal
DWRBG 4	21203	DWR30/ Shebac	Combination of high beta and high protein.	IIWBR, Karnal
DWRBG 5	21206	W260/BCU8	Huskless barley genotype with high thousand grain (43.5g) weight, in combination of bold grain percentage (63.2%) and protein content (14.7%).	IIWBR, Karnal
DWRBG 6	21207	Petunia2/M112	Huskless barley resistant for stripe rust at APR and for new pathotypes 6S0 and 7S0 at SRT and also having higher starch content.	IIWBR, Karnal

Coordinated Yield Evaluation Trials

In all 90 test entries contributed by 11 centres, were evaluated against 19 checks in the coordinated yield trials under rainfed (plains and hills), irrigated (plains) and saline soils conditions. The new barley entries include malt, feed or dual purpose types and mostly were hulled type with a few hull-less types in northern hills and plains. Barley Yield Trials (2021-22) were conducted at 11 main centres and 32 additional testing centres (including ICAR, SAUs and State Department of Agriculture) during Rabi 2021-22. Out of 92 yield evaluation trials proposed 90 trials were conducted as Gwalior centre did not conduct two trials. Five trials failed at Kumarganj due to poor management.

The data were received in time for 85 trials. Out of this data received, four trials were rejected by the monitoring teams (2 trials at Navgaon and one each at SG Nagar and Bhilwara due to faulty lay outs). After the analysis, only 75 trials (81.5% of proposed, 89.3% of received) were found good for reporting. This rejection includes the five trials failed at Kumarganj, which is funded centre because of extremely poor crop stand and improper care during the conduct of trials.

Based upon the multilocation evaluation under different trials series, 20 new entries under AVT testing were found promising, with significant superiority for the yield over the best check in the trial during 2021-22.

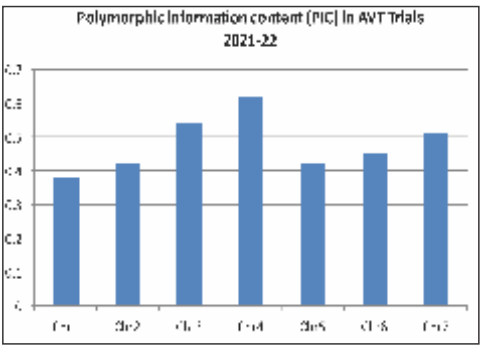


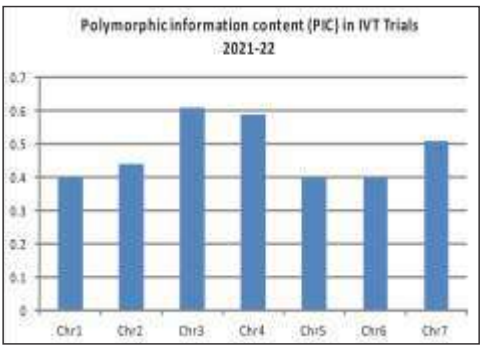
Promising entries in different trials during 2021-22

SN	Trial name	Zone	Significantly superior	Superior (numerically)
1	AVT-IR-MB	NWPZ	DWRB219	-
3	AVT-IR-FB	NEPZ	-	NDB1756, RD3034
6	AVT-SST	PLAINS	KB2031, DWRB228	RD3059, NDB1782, RD3062, RD3060
8	AVT-RF- NC	NHZ	UPB1103, VLB175	-
9	AVT-RF- DP-GY- CUT	NHZ	VLB175, HBL876	HBL875, VLB177, UPB1102, VLB176
	AVT-RF- DP-FY- CUT	NHZ	-	HBL877, VLB175
Total			**20**	**39**

Molecular Profiling of Barley Trials 2021-22

Molecular profiles were generated to distinguish entries with their respective checks in barley trials including both, IVT and AVT for 2021-22. Total 46 SSR/STS markers covering all the seven linkage groups of barley were screened with 109 lines including entries and checks. Total 97 alleles were scored for both trials. The band fragment size varied from 90 bp to 1500 bp with PIC values ranging from 0.0 to 0.69 for screened molecular markers. Molecular statistics were also evaluated for AVT and IVT trial level. For AVT trials, all entries were clearly distinguished in UPGMA clustering in range of 0.54-.1.0 similarity coefficient in UPGMA based dendrogram. Average PIC across linkage groups varies from 0.38 to 0.61 for test entries and their respective check. In IVT trials, average PIC across seven linkage groups of barley varies from 0.40 to 0.60 and chromosome 3H was found most variable. In barley trials for 2021-22, all the test entries could be distinguished using screened markers and generated unique profiles. Molecular statistics were comparable with previous crop season trials suggesting that genetic variability in barley improvement programme have been maintained.





Breeder seed production

The breeder seed production of 632.31q of 21 varieties was allocated among 8 BSP centres against the breeder seed indent of 22 varieties from DAC&FW for production during 2021-22. Seven states *viz*., Punjab, Haryana, Himachal Pradesh, Madhya Pradesh, Rajasthan, Uttar Pradesh and Uttarakhand and four public sector agencies *viz*., National Seeds Corporation, IFFDC, NAFED & KVSS as well as private

seed companies under the National Seed Association of India indented breeder seed of different varieties. The highest breeder seed indent was placed by Rajasthan (190.00q) followed by Uttar Pradesh (120.0q), NSAI (31.6q), and National Seed Corporation (31.0q). From variety point of view, amongst 21 varieties, maximum breeder seed indent was received for the variety DWRB 137 (120.70q) followed by HUB 113 (50.0q), RD 2899 (49.10q) and RD 2907 (44.0q).

A total of 632.31q breeder seed with a surplus of 212.46q over the total allocated quantity (419.85q) of 21 varieties was produced by 8 BSP centres during 2021-22. Among 8 breeder seed production centres, maximum breeder seed was reported from RARI, Durgapura (306.20q) with surplus of 165.70q against allocation followed by CCSHAU, Hisar (139.160q) and IIWBR, Karnal (110.20q). Top ten breeder seed indented varieties contribute to the tune of 93.27% in total allocation whereas these varieties contribute 95.24% share in total breeder seed production during 2021-22. A total of 36.06q nucleus seed of 19 varieties was produced against 20.10q allocation in BNS-1 with a surplus of 15.96q seed during 2021-22. National Seed Corporation, New Delhi has reported a total of 23.15q carry over test stock seed of variety DWRB 182 notified in 2021.

Germplasm Evaluation & Exchange

In order to facilitate the availability of promising new diversity in the national barley program, the All India Coordinated Wheat and Barley Improvement Program (AICWBIP) organizes the import and conduct of international trials and nurseries in country. During Rabi 2021-22, two international yield trials and one observation nurseries were supplied from ICARDA which included a total of 158 genotypes for different production conditions. One set each of these nurseries and trials was evaluated at ICAR-IIWBR, Karnal and rest of the sets were evaluated at different locations as per the requirements. In addition, EIBGN (45 entries) was supplied to 12 different locations as a set of 75 entries including six checks repeated five times in NWPZ, NEPZ and NHZ. Similarly, the NBGSN comprising of a set of 19 promising genetic stocks endowed with trait(s) of breeding value, received from different cooperating centres was supplied at 12 centres for utilization.

International trials and nurseries evaluated during crop season 2021-22

S. N.	Trials/Nurseries	Genotypes received	National Check	# Sets	Locations
1	2022 International Barley Yield Trial for Feed Forage and Malt in Favourable Environments (IBYT-FFM-22)	23	DWRB137	4	Durgapura, Hisar, Kanpur, Karnal
2	2022 International Barley Yield Trial for Arid and Semi-Arid regions (IBYT-ASA)	23	Lakhan	4	Pantnagar, Karnal Durgapura, Kanpur,
3	2022 International Barley Observation Nursery (IBON-22)	112 + 3 checks	DWRB137	5	Hisar, Kanpur, Karnal, Ludhiana, Durgapura

Survey and surveillance for diseases and pests

During farmers' field surveys conducted by different scientists 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. 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 incidence was found to be moderate to high in barley fields at all the locations. Among natural enemies, *coccinellid* beetles, *chrysoperla* and *syrphid* fly were frequently noticed predating on barley aphids.

Pathotypes distribution and seedling resistance tests

During 2021-22, there was no report of yellow, stem and leaf rusts of barley from the farmer's fields. Eight barley stripe rust samples were received from barley screening nurseries at Durgapura, Rajasthan. These samples were pathotyped on differentials and only one pathotype 57 (0S0) was identified in all samples.

All the NBDSN and EBDSN lines were screened against different pathotypes of three rust pathogens of barley under precise conditions of temperature and light. Wherever needed, the confirmatory and selected testing was also undertaken. These lines were evaluated against six pathotypes of *Puccinia striiformis* f. sp. *hordei* (M, 57, 24, G, Q and 6S0), five pathotypes of *P. graminis* f. sp. *tritici* (11, 21A-2, 40A, 117-6 and 122), 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 *Psh*, *Ph* and *Pgt*. In seedling rust resistance evaluation, out of 109 lines of NBDSN, none of the lines was resistant to all three rusts of barley. Eight lines were resistant to both leaf and stripe rust pathotypes/isolates. In addition, several lines were resistant to stripe (27 entries), leaf rust (23 entries) and stem (2) rusts.

Seedling rust resistance in NBDSN lines during 2021-22

Rust/s	No. of lines	Lines
Leaf and stripe	08	BHS352(C), BHS491, HBL875, HBL878, K603(C), KB2008, LAKHAN(C), VLB177
Stripe	27	BH1046, BHS489, DWRB137(C), DWRB182(C), DWRB226, DWRB228, HUB113(C), KB2004, KB2013, KB2015, NDB1756, NDB1783, NDB1784, NDB1785, NDB1800, PL937, PL940, RD2899, RD3034, RD3049, RD3054, RD3059, RD3061, RD3063, UPB1095, UPB1105, UPB1107
Leaf	23	BH1041, BH1043, BHS400(C), BHS490, BHS492, DWRB230, DWRB232, DWRB234, HBL113(C), HBL874, HBL876, HUB281, KARAN16(C), NDB1789, PL935, PL938, RD3050, RD3055, RD3056, RD3062, VLB118(C), VLB175, VLB176
Stem	02	UPB1102, UPB1104

Field screening and chemical control experiments on diseases and pests

Out of 396 entries in IBDSN from different breeding centres, 23 entries were found free from yellow rust (ACI = 0) and 182 entries showed resistant reaction having ACI less than 10.

- Total 109 entries evaluated in NBDSN, 19 entries found free from yellow rust, 60 entries showed resistant reaction having ACI less than 10. In case of leaf blight screening, 22 entries showed moderate level of resistance with an average score (double digit) 14-35 and HS < 57.
- Among 43 EBDSN entries, 4 found free from yellow rust, whereas 18 shown resistant reaction. The 6 entries also showed moderate level of resistance against leaf blight with an average score 14-35 and HS < 57.
- Among eight different fungicidal treatments, two spray of *viz*., Tebuconazole 50% + Trifloxystrobin 25%, Picoxystrobin 7.05% + Propiconazole 11.7% and Propiconazole 25% was found most effective in management of foliar blight.

- A total of 109 barley NBDSN entries (including checks were screened against foliar aphid at seven locations. On the basis of aphid score recorded location-wise, seven entries at Durgapura viz., two at Karnal and one at Kanpur were categorized as moderately resistant (Score = 3). Another set of 31 barley promising entries along with highly susceptible check (Alfa-93) were tested against aphids at six locations five entries viz., BCLA51, HVS 14, HLR 20, ICARDA-9, ICARDA-11 and ICARDA-27 were found to be in resistant category (Grade 2) at four locations.
- Efficacy of new insecticide molecules and their combinations were tested against foliar aphid in barley. Treatment of Thiamethoxam 25% WG@50 gm/ha, Beta-Cyfluthrin 9%+ Imidacloprid 21% (Solomon) @ 400 ml/ha and Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC (Alika) @150 ml/ha was found the best treatment followed by Sulfoxaflor 12 % SC @250 ml/ha in managing aphid population in barley.
- A total 109 entries of NBDSN and 43 of EBDSN were screened against the Cereal Cyst Nematode (CCN) at two locations viz. Durgapura, and Hisar. Most of the entries fall in the category of susceptible or highly susceptible.

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. Seven special trials were conducted in different zones to achieve the objective. A total of 54 trials were proposed and conducted at different locations and 53 were reported, one trial was rejected by monitoring team.

Recommendations from the concluded experiments

Productivity enhancement through adjusting sowing dates in barley

The optimum sowing dates recommended after three years of experimentation in different production keeping in view the productivity of barley are NWPZ: 01-15 November; NEPZ: 11-15 November, CZ: 01-15 November and NHZ: 20 October-05 November.

Yield maximization of barley through integrated nutrient supply and PGRs application

On the basis of superiority in productivity and economics, Fertilizer (RDF) +10t FYM + PGR(Plant Growth regulator : chlormequat-chlorid (CCC) @1.25 L ha-1 at GS30-31 followed by ethephon (Cerone) @0.5 L ha-1 at GS39-40) is recommended in all the zones.

Effect of Zn application on quality and productivity of barley

On the basis of superiority in productivity, quality and economics soil application with zinc sulphate @ 25 kg/ha and soil application @12.5 kg Zn Sulphate per ha followed by foliar spray (0.5% zinc sulphate) were recommended for all the zones. Both the treatments were at par and superior to other treatments.

Enhancing productivity and quality of barley using Silicon in low moisture areas.

On the basis of superiority in productivity and economics, silicon @ 150kg/ha with three irrigations are recommended for application in barley.

Malt barley trial

The major industrial use of barley is in malting and brewing industry. This year a total of 217 samples of malt barley trials from eight locations of NWPZ were analyzed in the barley quality laboratory at IIWBR Karnal. The mean values were taken for identifying promising lines based on minimum standards determined by the 'NCGMBD' for malt barley in the country revised time to time with the latest revision on 22.06.2020. Several genotypes were observed as good source for individual grain and malt quality traits, though they may not have good values for remaining traits.

Promising entries for individual malting quality traits

Trait	Promising entries	Trait	Promising entries
Hectoliter weight	DWRB 219, DWRB 221	Filtration Rate	DWRB 219, PL 934, RD 3063, DWRB 233, UPB 1108
Bold Grains	UPB1108, RD3055, PL933, RD3056, DWRB 233	Diastatic Power	RD 3058, UPB 1108
Husk Content	DWRB 221	FAN Content	DWRB 230, RD 3056, RD 3055
Grain β- glucan	DWRB221, BH1040, DWRB233 DWRB229, UPB1107	Wort β-glucan	DWRB 230, DWRB 229, BH1040
Malt Friability	RD3056, DWRB230, RD3055, BH1043	Over all MQ	DWRB 221** RD 3056**

**Better or at par to the best check **As compared to two row checks*

Barley quality screening nursery

The Barley Quality Screening Nursery was conducted for finding better sources of hulless and malt barley for different quality traits. The Nursery was conducted at six locations i.e., Karnal, Hisar, Pantnagar, Durgapura, Ludhiana and Kanpur. The nursery was sent under four categories i.e., low protein barley, naked/hulless barley, evaluation of protein/beta glucan content in entries contributed by malt barley & molecular breeding programme and for higher anti-oxidant activity. The promising genotypes from 489 samples analyzed in the nursery are given in table.

Promising entries from BQSN for different traits

Traits	Promising entries#
Protein Content	**Low** (BCU 6315, BCU 6316, BCU 6369) **High** (HLR-136, HLR-24, HLR-34, HLR-10)
Starch Content	BCU 6400*, BCU 5968*, HLR-196, HLR-64, HLR-322, HLR-90
Malt Friability	BCU 6369, BCU 6316, BCU 5968*, BCU 6444*, BCU 5969*, BCU 6315, BCU 6398*, BCU 6482*
Hot Water Extract	BCU 6400*, BCU 5968*, BCU 6444*, BCU 6316, BCU 6398*, BCU 5969*, BCU 5915**
Diastatic Power	BCU 6398*, BCU 6482*
Free Amino Nitrogen	BCU 5709, BCU 6482*
Antioxidant Activity	BCU 2336
Grain β- glucan	Low (RMB 2103) High (HLR-90, HLR-240)

*#At par or better than Indian check variety *Hulless barley **Black colored grain*

The feed grain samples (497) from various trials grown at different locations were analyzed for physical parameters and protein content. Hectoliter weight (test weight) was measured with ICAR-IIWBR Hectoliter Weight instrument. The crude protein content was estimated using FOSS NIR system and has been given on dry weight basis. The entries having higher thousand grain weight, protein content and hectoliter weight have been listed here.

Promising entries for thousand grain weight, protein content and hectoliter weight

S.N.	Trial	Zone	1000 GW	Protein content	Hectoliter weight
1	IVT (IR)	NWPZ	HUB 281	UPB 1105	HUB 281
2	IVT (IR)	NEPZ	PL 937	KB 2015	UPB 1105
3	IVT (IR)	CZ	PL 936	HUB 281, BH 1045	UPB 1105
4	AVT (RF)	NHZ	HBL 876	BHS 400 ©	VLB 179, HBL 877
5	IVT (RF)	NEPZ	RD 3050	NDB 1789	RD 3050
6	IVT-SAL/ ALK	NWPZ/NEPZ/CZ	KB 2013	KB 3060	RD 2907 ©
7	IVT-IRTS-NB	NWPZ/NEPZ/CZ	KB 2019©	KB 2019©	Karan 16©
8	AVT-IRFB	NEPZ	RD 3034	DWRB137 ©	RD 3034

TECHNOLOGY OUTREACH PROGRAMME

Barley Frontline Demonstrations (2021-2022)

To disseminate a new technology among farmers, it is necessary that the technology is demonstrated at the farmers' field. During the rabi crop season 2021-22, 250 Barley Frontline Demonstrations (BFLDs) of one acre each were allotted to 32 cooperating centres all over India in seven states/UT namely, Himachal Pradesh, Uttar Pradesh, Jammu & Kashmir, Punjab, Haryana, Rajasthan and Madhya Pradesh. Out of these, 228 BFLDs were conducted by 29 centres, covering 238 acres area of 277 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 (60), followed by Rajasthan (48), MP (39), Punjab (33), Haryana (33), J&K (8) and HP (7). The highest gain in barley yield was recorded in MP (35.54 %) followed by HP (34.85%), J&K (32.37 %), Central UP (28.09%), Eastern UP (24.15%), Rajasthan NWPZ (22.47%) and All Rajasthan (21.59 %). The lowest gain in yield was reported in Haryana (7.20 %). The centre wise yield gain was highest at Rewa (89.13%) in CZ and lowest at Bathinda in NWPZ (03.02%).

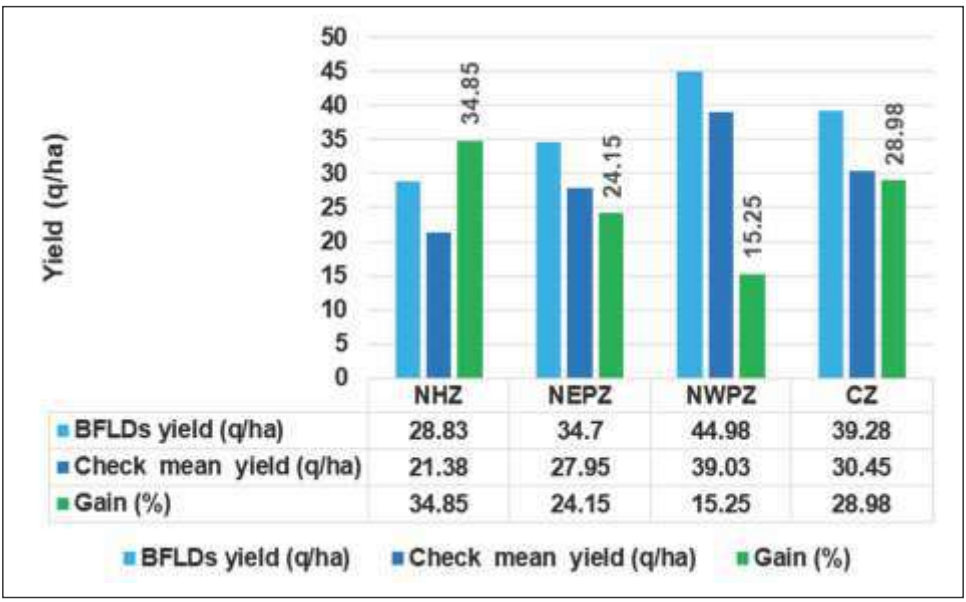
State wise performance of improved barley varieties during *rabi* 2021-22

State/UT	BFLDs yield (q/ha)	Check yield (q/ha)	Gain (%)
HP	28.83	21.38	34.85***
Eastern UP	34.70	27.95	24.15***
Central UP	38.88	30.35	28.09***
Western UP	56.18	51.10	9.93***
All UP	38.83	32.03	21.23***
J&K	27.50	20.78	32.37***
Punjab	38.80	35.03	10.78***
Haryana	43.93	40.98	7.20**
Rajasthan (NWPZ)	61.45	50.18	22.47***
Rajasthan (CZ)	42.25	35.30	19.69***
All Rajasthan	53.93	44.35	21.59***
MP	37.85	27.93	35.54***

**** Significant at 1 per cent level, ** Significant at 5 per cent level*

The highest average yielding varieties were; HBL 713 (32.33 q/ha) at Bajaura centre in NHZ, RD 2907 (44.45 q/ha) at Gorakhpur in NEPZ,

DWRB 137 (66.43 q/ha) at Durgapura Jaipur in NWPZ and DWRB 137 (49.00 q/ha) at Rajgarh in CZ. The dual purpose barley variety HBL 804 yielded 25.08 q/ha grain yield and 33.48 q/ha green fodder yield at Bajaura centre, in comparison to this, the check variety HBL 276 yielded 17.35 q/ha grain yield and 28.18 q/ha green fodder yield at Bajaura centre. It is evident that recent varieties outperformed old/check varieties at all the locations. The yield gain due to varietal intervention ranged from 3.21% at Bathinda, Punjab to 89.13% at Rewa, MP. Variety wise yield data revealed that HBL 713 (36.00 q/ha), RD 2907 (46.00 q/ha), DWRB 137 (70.00 q/ha) and DWRB 137 (51.00 q/ha) performed better than other varieties at Bajaura, Gorakhpur, Durgapura Jaipur and Rajgarh centres in the NHZ, NEPZ, NWPZ and CZ, respectively.



Zone wise productivity of improved barley varieties over check during rabi 2021-22

The yield gain due to improved varieties over check was highest in NHZ (34.85 %) followed by CZ (28.98 %), NEPZ (24.15 %) and NWPZ (15.25 %). .

The ICAR-IIWBR team accompanied by the experts from the Ministry of Agriculture & Farmers Welfare and the concerned centres, monitored the barley FLDs and SCSP wheat demonstrations at Rewari, Alwar, Bhiwani, Hisar, Kanpur, Ayodhya, Mirzapur, Rewa, Panna,

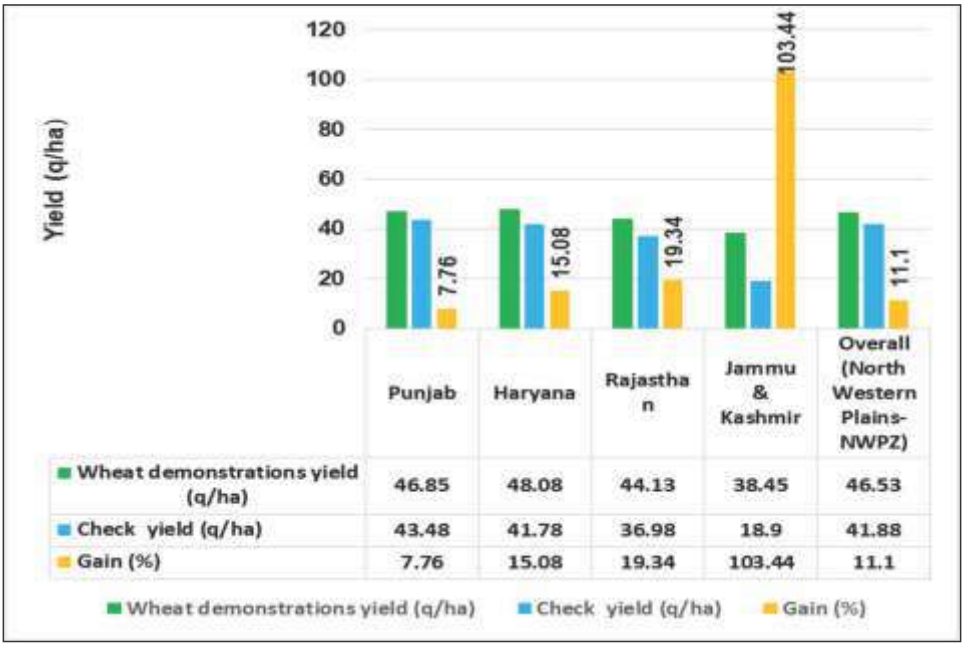
Tikamgarh, Ludhiana, Amritsar and Kathua centres during the rabi crop season 2021-22.

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

Farmers need to be educated and upskilled on recent barley production technologies, complete package of practices and soil health management. There is a need of government intervention to ensure supply of quality seeds as well as quality inputs to the farmers. Farmers need to be updated on impact of climate change on barley cultivation and adaptation strategies for mitigation. 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* 2021-2022

Under the SCSP Programme, 250 varietal demonstrations of wheat varieties DBW 187 and DBW 303 were organized during 2021-22 rabi crop season to assess their performance at farmers' field. The demonstrations were carried out through KVKs of Punjab (18), Haryana (4), Rajasthan (2) and Jammu & Kashmir (1) benefitting 250 farmers. The demonstrations were conducted in 18 aspirational districts of Punjab (Amritsar, Barnala, Bathinda, Faridkot, Fatehgarh, Firozpur, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Mansa, Moga, Muktsar Sahib, Rupnagar, Sangrur, Nawanshahar and Tarn Taran), 4 aspirational districts of Haryana (Ambala, Fatehabad, Sirsa and Yamunanagar), 2 aspirational districts of Rajasthan



Yield gain in wheat demonstrations under the SCSP programme during rabi 2021-22

(Sriganganagar and Hanumangarh) and 1 aspirational district of Jammu & Kashmir (Samba) covering a total of 250 acres area and 250 farmers of Scheduled Castes (SC) category.

In Punjab, the demonstrations were conducted in 180 acres area benefitting 180 SC farmers; in Haryana, the demonstrations were conducted in 40 acres area benefitting 40 SC farmers; in Rajasthan, the demonstrations were conducted in 20 acres area benefitting 20 SC farmers; in J&K (UT), the demonstrations were conducted in 10 acres area benefitting 27 SC farmers. In each aspirational district, 10 demonstrations were conducted. At all the locations, the yields of demonstrated varieties were more than the check varieties. Improved wheat varieties DBW 187 and DBW 303 with complete package of practices (irrigation management, nutrient management, weed control, seed treatment etc.) were demonstrated.

The yield gain due to improved variety (DBW 187) was highest in Samba (115.17%) district of J&K and lowest (03.23%) in Amritsar district in Punjab state. The highest yield gain of DBW 303 was recorded in Fatehabad (25%) district in Haryana state and the lowest yield gain was in Ferozpur (04.39%) district in Punjab state.

Under SCSP wheat demonstrations, the state wise yield gain was highest i.e. 103.44 % in Jammu & Kashmir (UT). The lowest yield gain was 7.76 % in Punjab state. The zonal (NWPZ) yield gain was 11.10 %. Due to sudden rise in temperature during second week of March 2022, the expected yields were not realized for both the varieties. Even then, they outperformed the existing varieties.

In Haryana state, the significant yield gain due to improved wheat variety DBW 303 over check mean yield was highest at Sirsa (23.96 %). In Punjab state, the highest significant yield gain due to improved wheat variety DBW 187 was at Moga (13.57 %). In Rajasthan state, the highest significant yield gain due to improved wheat variety DBW 187 was at Sriganganagar (23.72). In J&K (UT), the highest significant yield gain due to improved wheat variety DBW 187 was at Samba (115.17%).

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

Wheat

Analysis of data indicated that on an average, demonstration of improved wheat varieties (DBW 187 and DBW 303) at the farmers' field under the SCSP programme gave ₹3.90 per rupee of investment in comparison to the farmers' practice (₹3.35). A significant difference in returns per rupee of investment was noticed between the demonstrated and the check plots at the farmers' field. The difference in profit levels between demonstration and check plots was highest in the case of Jammu & Kashmir. Operational costs were found to be marginally lower in wheat demonstrations in comparison to the check plots. Overall, by adopting a new wheat variety, a farmer earns a profit of ₹88810/ha in the NWPZ. Further, ₹690 has to be spent to produce a quintal of wheat through a new variety against ₹829 (farmers' choice of variety in the 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 ₹71423 profit per hectare. A significant difference in returns per rupee of investment was noticed between the demonstration and check plots across states and zones. Rajasthan registered the highest returns per rupee of investment (₹4.12) through demonstrations, followed by Haryana (₹4.04) and Punjab (₹3.30). The difference in returns per rupee of investment between demonstration and check plots was highest in UT of Jammu & Kashmir, followed by Rajasthan and Himachal Pradesh. The difference in profit between FLD and check plots ranged from ₹31503 in UT of Jammu & Kashmir to ₹8456 in Haryana. Interestingly, operational costs in Punjab were lower in FLDs than in check plots. The probable reason might be a 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 (₹3.82), followed by CZ (₹2.46) and NHZ (₹2.44). Estimates of the cost of production indicated that the cost incurred in producing a unit quantity of barley output was the least (₹783 per quintal) in Haryana owing to relatively 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 organizing Foundation Day, World Soil Day, Mahila Kisan Diwas, Agricultural Education Day, Kisan Diwas, Kisan Mela, 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 52 lectures benefitting students, farmers and scientific community; attended the meetings and participated in seminars/symposia/ conferences/ workshops and coordinated 42 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 10 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 60th All India Wheat & Barley Research Workers' meet held in Virtual Mode August 23-24, 2021

S. N.	Recommendations	Action Taken
Crop Improvement		
1.	Newly released varieties will be taken up in seed chain for cultivation. Also, 30 new genetic stocks will be shared with co-operators.	All the wheat varieties notified for cultivation through CVRC were included in breeder seed indent allocation. The seed produced will be further used for sharing with seed agencies. Also the genetic stocks registered were shared with co-operators through national nurseries (NGSN).
2.	Crop Improvement The newly identified varietal proposals will now be put up to CVRC for release and notification as soon as possible	Nine new wheat varieties (JKW261, DBW296, DBW327, DBW332, HUW838, HI1636, GW513, MP1358, HI8823, and two (DBW222, DBW187) for area extension were proposed for release through CVRC and thus notified for cultivation. Similarly, seven varieties were notified after recommendation of the SVRC.
3.	A total of 433 new trial sets to be executed during 2021-22 as a part of work plan. Constitution & dispatch of all coordinated trials will be done by ICAR-IIWBR, Karnal. Work plan for national nurseries (NGSN, SSN) and international nurseries was also finalized for execution.	A total of 517 yield trials constituted (Added MABB trials) and dispatched from ICAR-IIWBR, Karnal and were conducted during 2021-22 successfully. The data from these trials and nurseries were analysed and are being presented in this wheat workers meet. Also, the germplasm sharing in form of national / international trials / nurseries was executed as per the plan.
4.	High fertility early sown trial now will be a national trial: NIVT 6A (NWPZ & NEPZ) and 6B (CZ / PZ).	The trial on early sowing under high fertility conditions was conducted across all four zones during 2021-22 as NIVT 6A & NIVT 6B.
5.	NHZ trial (RI-LS) has been extended for one year in view of the promotion and will be reviewed accordingly	The trial under restricted irrigation late sown conditions has been merged with the main trial of NHZ and will be conducted accordingly.
6.	Based on ecological and geographical locations the following centres will be shifted to different zones; Dhaulakuan – NWPZ; Gwalior – NWPZ; Durgapura – CZ.	The work plan for crop season 2021-22 was proposed as per the workshop recommendation and revised allocation of trials / nurseries were made accordingly to Dhaulakuan – NWPZ; Gwalior – NWPZ; Durgapura – CZ.
7.	SPL-Dic trials/ nurseries, MLHT, DHTSN and SDN be discontinued from this crop season	As per recommendation, SPL-Dic and MLHT were not constituted during 2021-22 crop season.
8.	For promotion of durable rust resistant materials, limit of ACI has been revised to 20.0 under both natural and artificial conditions.	The ACI limit (20) was revised for both natural and artificial conditions and has become a promotion criterion for all the three rusts in AICRP wheat yield trials.
9.	Under HRD, One Orientation Course on AICRP activities for new incumbents is proposed to be started from 2021-22 season. Key areas for capacity building of young scientists will be identified.	A training cum orientation course on *"Methods and Techniques for Crop Improvement under AICRP Wheat & Barley"* was organized during March 9-11, 2022 at ICAR-IIWBR, Karnal. A total of 30 participants (mostly new entrants) from different organizations (SAUs, State & Central Universities, ICAR Institutes, ICARDA, BISA etc.) across the country participated in the programme.

S. N.	Recommendations	Action Taken
10.	As an initiative to strengthen research for wheat improvement, trait/problem specific programs will be proposed at major centres from coming crop season	A meeting with SAUs and other centres under AICRP was convened to discuss and finalize centre wise trait(s) with an aim to strategize the wheat improvement program as per the pressing needs of each zone / centre. The same has been included in Crop Improvement Annual Progress report 2021-22.
11.	Digitalization in AICRP will be further strengthened. All the proposals, yield trial data should be submitted as a soft copy.	Data from all the trials and nurseries under AICRP Wheat Breeding are received in soft copies. Proposals for IPPSN, NIVT/IVT/SPL trials are accepted online as soft copy.
12.	The suggestions made by DG- ICAR, DDG (Crop Science) will be translated into action points by respective programmes.	All the suggestions made by DG- ICAR, DDG (Crop Science) during wheat workshop are implemented in holistic manner by concerned disciplines) for the betterment of the program.
Resource Management		
1.	Sowing from 25th ^{O}ct to 5th Nov. is recommended for maximizing wheat grain yield in NHZ and NWPZ.	The recommendation has been implemented in the institutional programme and also conveyed to the concerned implementing authorities.
2.	Sowing from 5th to 15th Nov. is recommended for maximizing wheat grain yield in NEPZ, CZ and PZ.	The recommendation has been conveyed to the concerned implementing authorities in these zones.
3.	Application of 150% recommended dose of NPK+ 15 t/ha FYM+ growth regulator (CCC) @0.2% + tebuconazole @0.1% of commercial product dose at first node and flag leaf stages) produces the maximum wheat grain yield across the zones.	The recommendation has been implemented in the institutional programme and also conveyed to the concerned implementing authorities.
4.	Surface seeding of 150 kg seed/ha primed with 1% KNO3 is recommended for maximizing wheat grain yield, especially in wetland of NEPZ.	The recommendation has been conveyed to the concerned implementing authorities.
5.	New experiments on nano fertilizer as well as bio NPK on wheat to enhance nutrient use efficiency should be planned as per the suggestion of Secretary, DARE and DG, ICAR.	New experiments on nano fertilizer as well as bio NPK on wheat as suggested were planned and conducted across wheat growing zones during 2021-22
Crop Protection		
1.	Cultivate newly released yellow rust resistant varieties in view of current pathotype prevalence in Haryana, Punjab, Himachal Pradesh and Jammu.	Awareness among farmers of yellow rust prone areas like Punjab, Haryana, Himachal Pradesh and Jammu were promoted to cultivate newly released resistant varieties such as DBW303, DBW187, WH1270, DBW 222, PBW 771, HD 3226, PBW 752, HD 3237, HD 3096 etc through field visits, digital social means such as SMS services, Kisan gosthies and TV talks.
2.	Newly released blast resistant varieties should be deployed in NEPZ specifically in West Bengal.	Blast resistant varieties (HD 3293, DBW 187, HD 3249, HD 2967, DBW 252 and HD 3171) are being promoted through small trainings and variety awareness campaign by the cooperating centres in NEPZ. Seed of these varieties were provided for multiplication to UBKV in West Bengal for rapid spread of the varieties. Published literature on resistant varieties in Bengoli language distributed among farmers and state agriculture department.

S. N.	Recommendations	Action Taken
3.	Strict monitoring for wheat blast in NEPZ specially areas bordering to Bangladesh. Use of preventive measures i.e. quarantine, adoption of alternate crop plan, seed treatment etc. in disease prone areas.	Survey were conducted in West Bengal near Indo-Bangladesh boarder by team of scientist from UBKV, Cooch Behar, and BCKV, Kalyani told the farmers about the seed treatment and to avoid the self-grown wheat seed.
4.	Use Tebuconazole 50 % + Trifloxystrobin 25 % WG @ 0.06% for the effective management of yellow rust on appearance of disease and repeat after 15 days, if needed.	Farmers and state agriculture officials were made aware of this recommendation for the effective management of yellow rust through trainings, workshops and Kisan Mela etc.
5.	Seed treatment with pre-mixed insecticide Imidacloprid 18.5%+ Hexaconazole 1.5% FS @ 2 ml/Kg seed is recommended for management of termites in wheat.	Farmers and state agriculture officials were made aware of these recommendations through trainings, workshops and Kisan Mela etc.
6.	Training to scientist recently associated with crop protection programme for diseases and insect pest scoring, recording and reporting to further improving effectiveness of the programme.	Training was organized on "Field trial conduction, data recording and reporting under wheat and barley crop protection programme" from 1st – 3rd February, 2022 through virtual mode at ICAR-IIWBR, Karnal for scientists working in crop protection under the coordinated system.
Quality Improvement		
1.	Wheat quality group and crop improvement should work in a complementary mode for improving industrial and nutritional uses along with yield. This has become necessary as per the requirements of domestic and international market.	A meeting of AICRP centres was held on 22nd February 2022 under the chairmanship of Dr. G.P. Singh, Director, ICAR-IIWBR to finalize traits for breeding. Main breeding centres would be working on both hard and soft wheat as well as nutritional quality traits while some of the centres will focus on specific traits. Now both soft and hard wheat entries represent advanced trials. Many of the entries have higher Fe, Zn and protein content in advanced trials.
2.	Large variations are there in protein, Fe and Zn content among centres. That may be because of variation in soil quality and other environmental conditions. It was therefore recommended that centres conducting trials should generate data on nitrogen, Fe, Zn content in soils before sowing the trial and after the harvest. Standard common agronomic practices should be followed by each centre.	Some of the centres provided soil data on Fe, Zn and nitrogen status in the trials soils. Large variations were found in all the parameters across locations and zones. Details will be presented during the wheat and barley workers meet.
3.	Because of Covid-19 crisis, samples from Mandi/Farmers' filed could not be collected during this year, therefore, samples from mandi/farmers' filed samples will be evaluated next year 2021-22 for quality analysis to compare with trial results in different zones.	Many of the centres provided wheat samples collected from farmer's field and mandis. All the samples were analyzed for hectolitre weight and grain protein content. Details will be presented during the wheat and barley workers meet.
4.	*Dicoccum* should be evaluated for nutritional quality traits as recommended during last workshop which could not be accomplished due to Covid-19 crisis.	*Dicoccum* trial has been discontinued and hence could not be analyzed.

S. N.	Recommendations	Action Taken
Barley Improvement		
1.	Targeted research for product specific quality, biofortification and export quality of barley needs to be emphasized. Barley varieties with improved malting quality to curtail import of barley be identified. Bench mark needs to be set for quality traits.	The work on development of barley cultivars with industrial and nutritional utilization has been emphasized at IIWBR as well as AICRP Centres. The bench mark for malting quality evaluation in barley are already in place and a system of weighted score based on values for several traits is being followed, which has been developed in consultation with industry.
2.	The co-operators must ensure that germination percentage of the entry supplied for testing is not less than 85%.	The recommendation has been implemented from *Rabi* 2021-22 season and the reports on germination were collected.
3.	A letter of consent to conduct trials should be taken for willingness to conduct trials from non-funded centres.	The email and telephonic consent was taken from voluntary centres. Even then at one centre (Gwalior) mid-season change of staff has resulted in non-conductance of barley trials.
4.	Promotions and retention of entries should only be based on statistical significance or the numerically superior than the best check test entry with advantage of some speciality trait viz. important grain quality parameters.	Implemented *w.e.f. Rabi* 2021-22 as per recommendations under work plan formulation.
5.	All the centres should adhere to the technical programme sent to them and should follow the plot size mentioned for each trial.	The recommended technical program has been followed, except one or two centres where frequent shifting/ transfer of scientific staff or negligence has resulted in wrong layout/ plot conductance of barley trials. This will be further taken care during ensuing crop season.
6.	The centres should ensure that AUC of their centre is sent to ICAR-IIWBR well in time for timely disbursement of funds.	This is being regularly followed by PI Barley and PI Coordination, however still some centres make delays in it and they have been reminded.
7.	The vacant positions at funded centres should be filled immediately.	IIWBR is continuously requesting for the action from competent authorities at these centres
8.	The SAUs must consult ICAR-IIWBR authorities before transferring their staff engaged in AICRP activities of wheat and barley crops.	IIWBR is continuously requesting competent authorities at centres however, still there are some issues which we are trying hard to sort out.

Annexure II

Financial highlights for the Year 2021-22

A. Budget utilization

Name of Scheme	Total BE 2021-22	Total R.E. 2021-22	Total Remittance Received 2021-22	TOTAL EXP.	% of EXP. Against RE
IIWBR, KARNAL	2931.78	3375.12	3375.12	3374.99	100 %
AICRP on Wheat & Barley	1790.82	1910.64	1910.64	1910.64	100 %

Expenditure statement for the year 2021-22 in respect of ICAR-IIWBR, Karnal

(₹ in Lakhs)

Name of Scheme	HEAD	BE 2021-22	RE 2021-22	EXPENDITURE Other than NEH & TSP	TSP	NEH	SCSP	TOTAL EXP.	% of EXP. Against Net RE
	Grants in Aid - Capital	0	158.12	145.91	0	12.18	0	**158.09**	100 %
IIWBR, KARNAL	Grants in Aid -Salaries	2070.03	2160.00	2160.00	0	0	0	**2160.00**	100 %
	Grants in Aid-General								
	(1) Pension	180.00	260.00	260.00	0	0	0	**260.00**	100 %
	(2) Others	681.75	797.00	758.00	25.91	7.99	5.00	**796.90**	100 %
	TOTAL	**2931.78**	**3375.12**	**3323.91**	**25.91**	**20.17**	**5.00**	**3374.99**	100 %

(₹ in Lakhs)

Name of Scheme	HEAD	BE 2021-22	RE 2021-22	EXPENDITURE Other than NEH & TSP	TSP	NEH	SCSP	TOTAL EXP.	% of EXP. Against Net RE
	Grants in Aid - Capital	0	18.32	15.26	0	3.06	0	**18.32**	100 %
AICRP (Wheat & Barley)	Grants in Aid - Salaries	1518.18	1644.82	1594.82	0	50.00	0	**1644.82**	100 %
	Grants in Aid - General								
	(1) Pension	0	0	0	0	0	0	0	0
	(2) Others	272.00	247.50	219.00	17.00	8.00	3.50	**247.50**	100 %
	TOTAL	**1790.82**	**1910.64**	**1829.08**	**17.00**	**61.06**	**3.50**	**1910.64**	100 %

B. Revenue Generation for the year 2021-22

(₹ in Lakhs)

S. N.	Year	Target	Revenue Generated as per Schedule 8, 10 & 12 of Balance Sheet 2021-22
1.	**2021-22**	257.00	260.34

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 on31.7.2022
1	2017-20	07	Replies of audit paras have been submitted vide letter No. 8-3/Fin/IIWBR/20-21/2824 Dated 27/28.07.2022.
2	2020-21		External Audit for the year 2020-21 is awaited.

D. Status of ICAR inspection report as on 31.07.2022

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, 2020-21 and 2021-22 is awaited.

STATEMENT SHOWING NET GRANT RELEASED TO AICRP ON WHEAT & BARLEY CENTRES DURING THE YEAR 2021-22

(Amount in ₹)

S.N.	Name of Centre	GIA-Salary (Rs.)	GIA General(Rs.)	Capital(Rs.)	Grand Total(Rs.)
1	Bajaura	1687500	389753		2077253
2	Bilaspur	4315340	425385		4740725
3	Coochbehar	1875000	386057		2261057
4	Dharwad	8887500	918209	381500	10187209
5	Durgapura	16111243	928522		17039765
6	Faizabad	6616259	748398		7364657
7	Gwalior	4338897	403446		4742343
8	Hisar	8565000	1012500		9577500
9	Jabalpur	2460755	237664		2698419
10	Jammu	5475000	265684		5740684
11	Junagadh	2738536	90125		2828661
12	Kalyani	2814203	618754		3432957
13	Kanpur	9010045	974568	381500	10366113
14	Ludhiana	10340766	1094958	381500	11817224
15	Mahableswar	2624114	427500		3051614
16	Niphad	5540817	764932		6305749
17	Palampur	5882384	645745		6528129
18	Pantnagar	10875000	746142		11621142
19	Powerkhera	5876097	348330		6224427
20	Ranchi	539	193649		194188
21	Sabour	5707341	379907		6087248
22	Sagar	384	311638		312022
23	Srinagar	1583228	195000		1778228
24	Udaipur	5538998	326693		5865691
25	Vijapur	3369492	713899		4083391
26	Pune (100%)	7336661	769640	381500	8487801
27	Varanasi (100%)	1869645	713204		2582849
	Voluntary Centers	0	3827511		3827511
	TSP Grant	0	1413825		1413825
	Total	**141440744**	**20271638**	**1526000**	**163238382**
NEH					
1	Shillongani	6524651	275366		6800017
2	Imphal (100%) NEH	0	233822	306000	539822
	Total	**6524651**	**509188**	**306000**	**7339839**
	G. Total	**147965395**	**20780826**	**1832000**	**170578221**

STATUS OF AUC/UC FOR THE YEAR 2021-22 IN R/O CENTRES UNDER WHEAT AND BARLEY

S. N.	Name of Center	Name of University	Position of AUC/UC
1	BAJAURA	HPKVV PALAMPUR	Only AUC Received
2	BILASPUR	IGKVV RAIPUR	Only UC Received
3	COOCH BEHAR	UBKV COOCH BEHAR	Only UC Received
4	DHARWAD	UAS DHARWAD	Only UC Received
5	DURGAPURA	RAU BIKANER	Not Received
6	FAIZABAD	NDUA&T FAIZABAD	Only UC Received
7	GWALIOR	RVSKVV GWALIOR	Only UC Received
8	HISAR	HAU HISAR	Only UC Received
9	JABALPUR	JNKVV JABALPUR	Not Received
10	JAMMU	SKUAS & T JAMMU	Only UC Received
11	JUNAGADH	JAU JUNAGADH	Only UC Received
12	KALYANI	BCKVV NADIA	Only AUC Received
13	KANPUR	CSAUA&T KANPUR	Only UC Received
14	LUDHIANA	PAU LUDHIANA	Only UC Received
15	MAHABALESWAR	MPKVV RAHURI.	Only AUC Received
16	NIPHAD	MPKVV RAHURI	Only AUC Received
17	PALAMPUR	HPKVV PALAMPUR	Only UC Received
18	PANTNAGAR	GBPUA & T PANTNAGAR	Not Received
19	POWARKHEDA	JNKVV, JABALPUR	Only UC Received
20	RANCHI	BAU RANCHI	Only UC Received
21	SABOUR	RAU SAMASTIPUR	Only UC Received
22	SAGAR	JNKVV JABALPUR	Only UC Received
23	SRINAGAR	SKUAS & T SRINAGAR	Only AUC Received
24	UDAIPUR	MPUAT, UDAIPUR	Only UC Received
25	VIJAPUR	SDAU, SARDAR KRUSHI NAGAR	Only AUC Received
26	PUNE	ARI PUNE	Only AUC Received
27	VARANASI	BHU VARANASI	Only AUC Received
28	SHILLONGANI	AAU JORHAT	Only UC Received
29	IMPHAL NEH	CAU, IMPHAL	Only UC Received

61st All India Wheat and Barley Research Workers' Meet

(August 29-31, 2022)

Rajmata Vijayaraje Scindia Krishi Vishwavidyalaya, Gwalior (MP)

61वीं अखिल भारतीय गेहूँ एवं जौ अनुसंधान कार्यकर्ता गोष्ठी

(29-31 अगस्त, 2022)

राजमाता विजयाराजे सिंधिया कृषि विश्वविद्यालय, ग्वालियर (मध्य प्रदेश)