प्रगति प्रतिवेदन
PROGRESS REPORT
2022-23
निदेशक की रिपोर्ट
DIRECTOR'S REPORT

अखिल भारतीय समन्वित गेहूँ एवं जौ अनुसंधान परियोजना

AICRP on Wheat and Barley

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

ICAR-Indian Institute of Wheat and Barley Research, Karnal

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

DIRECTOR'S REPORT 2022-23

GYANENDRA SINGH
DIRECTOR

भा.कृ.अनु.प.–भारतीय गेहूँ एवं जौ अनुसंधान संस्थान, करनाल
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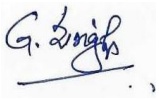
I greatly appreciate all the voluntary centres for their support in wider evaluation of the nurseries and trials. The notable contributions and sincere efforts made by all the Principal Investigators, team of scientists and technical staff of various disciplines along with other staff members of administration and finance at ICAR-IIWBR 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 and Dr. HM Mamrutha in compiling this report is duly acknowledged.



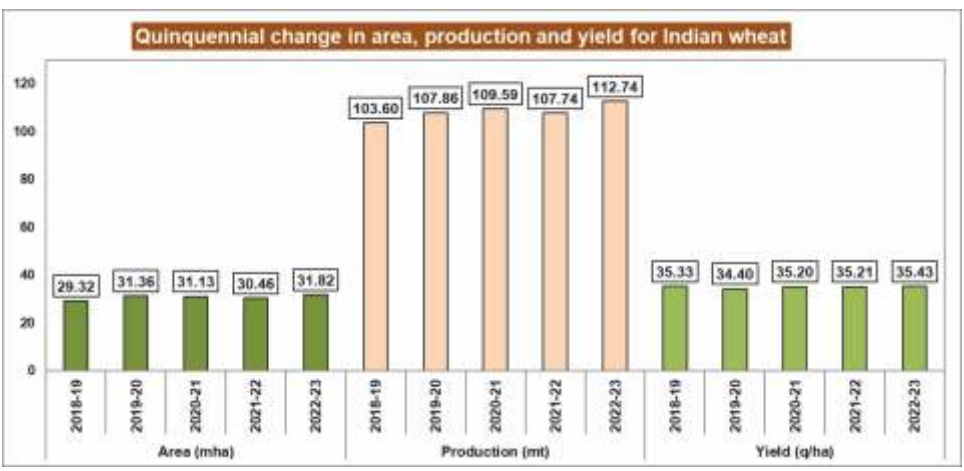
Place : Karnal
Date : August 18, 2023

(GYANENDRA SINGH)
Director

DIRECTOR'S REPORT (2022-23)

Globally, wheat and barley crops have been under cultivation in 270.95 million hectares (Wheat: 224.05 million hectares and Barley: 46.90 million hectares) with the annual production reaching an all-time highest output estimated at 936.01 million tonnes (Wheat: 793.37 million tonnes and Barley: 142.64 million tonnes) (Source: USDA). The nutri-rich cereals respectively hold the first and fourth position in terms of global cereals acreage for the period 2022-2023. In India, these *Rabi* cereals are grown in 32.44 million hectares (24.81% of total crop acreage) contributing 35.96% of the total foodgrains produced during 2022-2023. Wheat has been under cultivation in 31.82 million hectares and barley covered 0.62 million hectares during the 2022-2023 *Rabi* season (Source: III Advance Estimate, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India). In the current production season (2022-2023), the wheat output is pegged at 112.74 million tonnes with national average productivity of 35.43 q/ha. Similarly, the output from barley registered 1.69 million tonnes during 2022-2023 from 0.62 million hectare area with average national productivity of 27.33 q/ha.

Scenario for Wheat in India



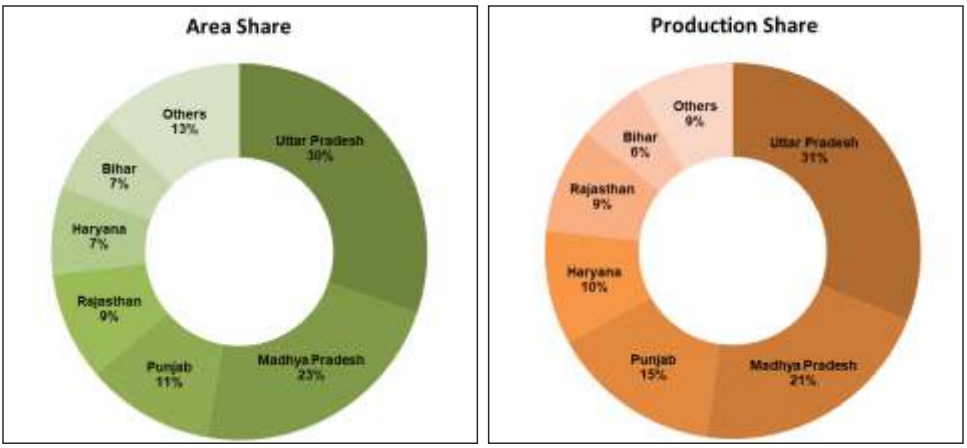
In India, the production of wheat has been increasing consistently in the recent past, despite the adverse effects of climate change. During 2022-23, the wheat output has witnessed a record harvest estimated at 112.74 million tonnes as per the III Advance Estimate, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India. The increase over last year is 5 million tonnes (4.64%). The increase in production is attributed to deployment of superior climate resilient wheat varieties developed by the ICAR-IIWBR and All India Coordinated Wheat and Barley Improvement Program, strengthening of seed value chain and bridging of yield, and information gaps. Madhya Pradesh has shown a significant increase in the crop area as well as production.

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

State	2021-22 (Final Estimate)			2022-23 (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	11	1248	20	26	1299	10.88	14.60	51
Bihar	2239	6224	2780	2204	6360	2886	-35	136	106
Chhattisgarh	156	192	1229	127	191	1501	-29	-1	271.98
Gujarat	1040	3333	3205	1149	3646	3172	109	313	-33
Haryana	2305	10447	4533	2376	11128	4684	71	681	151
Himachal Pradesh	320	549	1714	320	565	1764	-0.11	15.81	49.99
Jharkhand	228	519	2282	180	380	2109	-47	-140	-173
Karnataka	165	212	1287	162	231	1423	-3	18	136
Madhya Pradesh	6500	22978	3535	7150	23995	3356	650	1018	-179
Maharashtra	1132	2144	1894	1219	2374	1948	87	230	54
Odisha	0.18	0.31	1705	0.15	0.25	1667	-0.03	-0.06	-38
Punjab	3525	14861	4216	3508	16474	4696	-17	1613	480
Rajasthan	2580	10096	3913	2950	10250	3475	370	155	-438.00
Telangana	7	14.06	2009	3.00	5.85	1950	-4.00	-8.21	-59
Uttar Pradesh	9420	33950	3604	9633	34911	3624	213	961	20.00
Uttarakhand	298	863	2896	285	848	2974	-13	-15	78
West Bengal	221	656	2974	180	544	3020	-40.51	-112.19	46
Others	314	692	2204	358	814	2273	44	122	68
INDIA	**30459**	**107742**	**3537**	**31825**	**112743**	**3543**	**1366**	**5001**	**5**

Source: DES, MoA&FW, India.

Among the wheat-producing states, Uttar Pradesh accounted for the highest share of crop output estimated at 34.91 million tonnes (31%), followed by Madhya Pradesh (23.99 million tonnes: 21%), Punjab (16.47 million tonnes: 15%), Haryana (11.13 million tonnes: 10%),



Rajasthan (10.25 million tonnes: 9%) and Bihar (6.36 million tonnes: 6%). The aforementioned six states hold a share of about 91% of total wheat production in India. Barring Chhattisgarh, Jharkhand, Odisha, Telangana, Uttarakhand, and West Bengal, the rest of the states registered an increase in production during the *Rabi* 2022-23 in comparison to 2021-22. Overall production from all these states has increased by 5 million tonnes owing to increase in yield levels and/or acreage. The highest increase was recorded in Punjab (1.61 million tonnes: 9.8%) followed by MP (1.08 million tonnes: 4.4%) and UP (0.96 million tonnes: 2.83%) whereas in West Bengal a decline of 0.12 million tonnes (20.59%) was the maximum among wheat growing states.

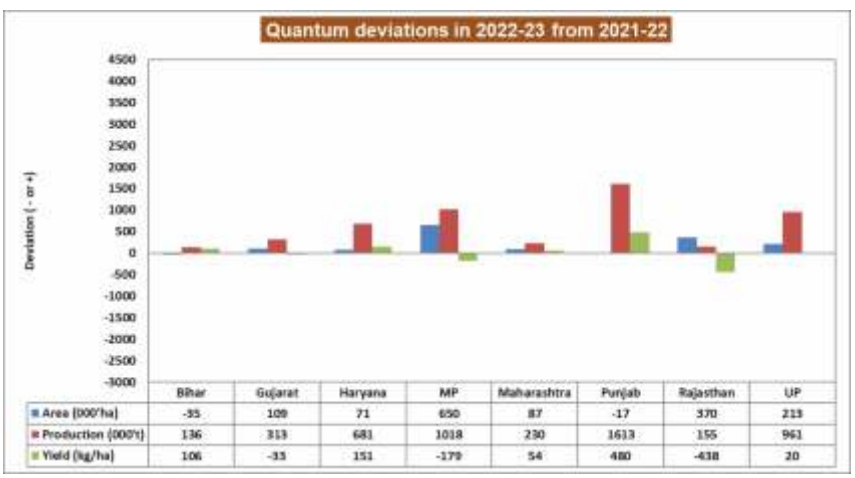
State-wise area under wheat exhibited regional differences and it has increased by 1.37 million hectares (4.48%) during the current season in comparison to the recent past. The highest increase in acreage was observed in Madhya Pradesh (+6.5 lakh hectares: 10%) followed by Rajasthan (+3.7 lakh hectares : 14.34%) whereas the maximum decline in acreage was noticed in West Bengal (- 4.05 lakh hectares: - 18.33%). As usual, Uttar Pradesh holds the top slot in wheat acreage (9.63 million hectares: 30.27%), followed by Madhya Pradesh (7.15 million hectares: 22.47%), Punjab (3.51 million hectares: 11.02%), Rajasthan (2.95 million hectares: 9.27%), Haryana (2.38 million hectares: 7.47%) and Bihar (2.20 million hectares: 6.93%). The aforementioned states altogether comprise 87.42 per cent of the total area and produce 91 per cent of the total wheat. Out of 17 major wheat producing states, 8

states were having declining trend in terms of area under wheat. On production front there was an increasing trend in 11 states. It was noted that in MP, Rajasthan and Jharkhand there was a negative trend on yield of wheat. Overall productivity has shown a marginal improvement from 3437kg/ha during 2021-22 to 3543kg/ha during 2022-23.

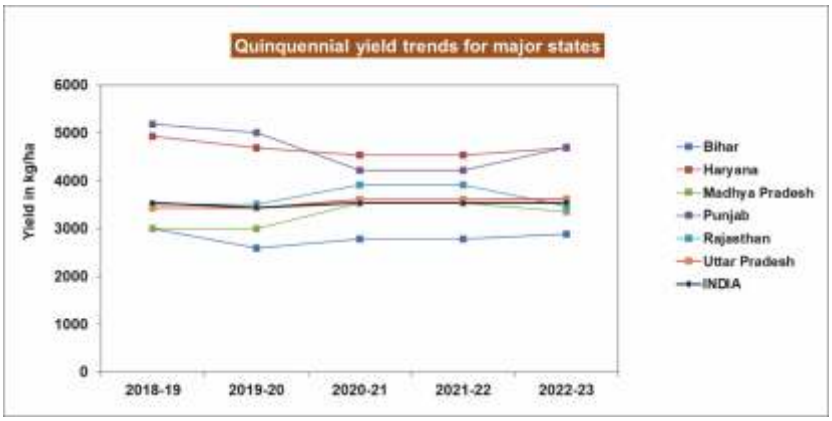
Contribution of yield and/or area to wheat production (2022-23)

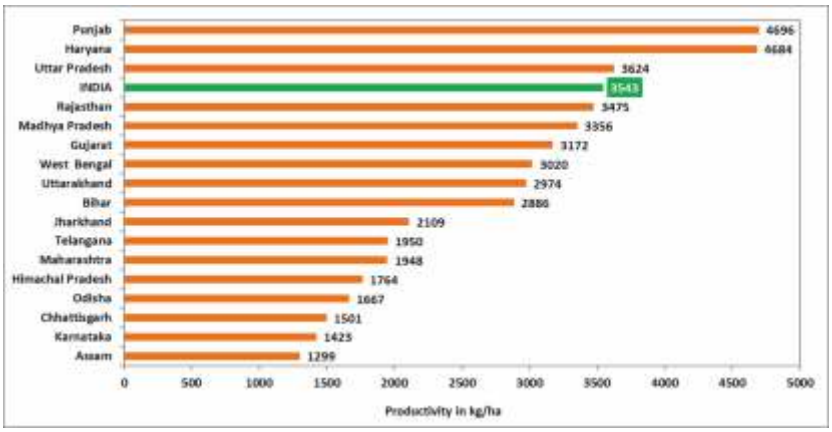
State/Country	Change in production in 2022-23 over 2021-22		% contribution by	
	Quantity (in '000 tonnes)	Deviation (in %)	Area	Yield
Assam	14.60	128.34	119.37	4.09
Bihar	136	2.19	-1.56	3.81
Chhattisgarh	-1	-0.36	-18.42	22.13
Gujarat	313	9.38	10.52	-1.03
Haryana	681	6.52	3.09	3.33
Himachal Pradesh	15.81	2.88	-0.03	2.92
Jharkhand	-140	-26.87	-20.87	-7.58
Karnataka	18	8.56	-1.82	10.57
Madhya Pradesh	1018	4.43	10.00	-5.06
Maharashtra	230	10.71	7.64	2.85
Odisha	-0.06	-18.54	-16.67	-2.25
Punjab	1613	10.85	-0.48	11.39
Rajasthan	155	1.53	14.33	-11.19
Telangana	-8.21	-58.40	-57.14	-2.94
Uttar Pradesh	961	2.83	2.26	0.55
Uttarakhand	-15	-1.79	-4.36	2.69
West Bengal	-112	-17.11	-18.37	1.55
Others	122	17.62	14.08	3.10
INDIA	5001	4.64	4.49	0.15

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



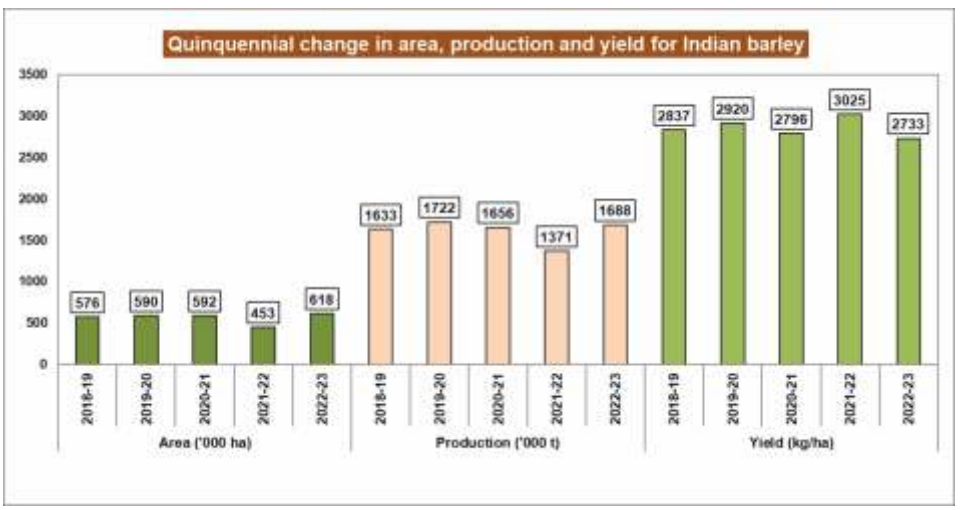
Analysis on contribution of yield and/or area to the current year's overall wheat production indicated that the average national productivity has increased marginally by 0.17% (+6 kg/ha) in 2022-23. State wise estimates indicated that Chhatisgarh, Jharkhand, Odisha, Telangana, Uttarakhand and West Bengal witnessed a negative change in the crop output for the *Rabi* season 2022-23. Similarly, with the exception of Jharkhand, Gujarat, Himachal Pradesh, Madhya Pradesh, Odisha and Rajasthan, the rest of the states have witnessed a rise in their productivity levels during the current season (2022-23). The crop yield varied across states and it ranged from as high as 4696 kg/ha in Punjab to the lowest 1248 kg/ha in Assam. Haryana, Punjab, and Uttar Pradesh have registered yield levels much higher than the national average (3484 kg/ha). The increase in productivity during 2022-23 over the previous year was highest in the case of Punjab (+480 kg/ha: +11.21%) and the highest reduction was noticed in the case of Rajasthan (-438 kg/ha: -11.19%).

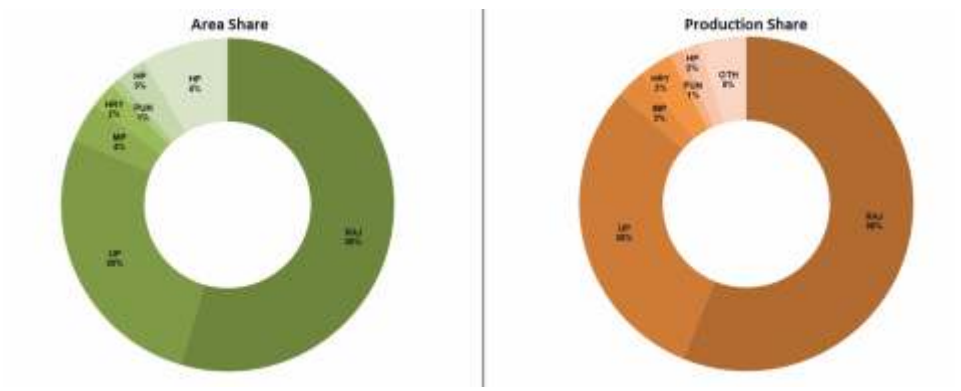




Scenario for Barley in India

Barley, a competing crop to wheat, has shown a similar pattern in area and production scenario with regional differences across states. For the *Rabi* 2022-23 crop season, barley production witnessed an increase by 3.17 lakh tonnes and the output was estimated at 1.69 million tonnes (Source: III Advance Estimate from the Directorate of Economics and Statistics, Ministry of Agriculture and Farmers' Welfare, India). The rise in production is attributed to the area increase by 36.42% (+1.65 lakh hectares) despite there was reduction in the yield level by 9.65% (+292 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.





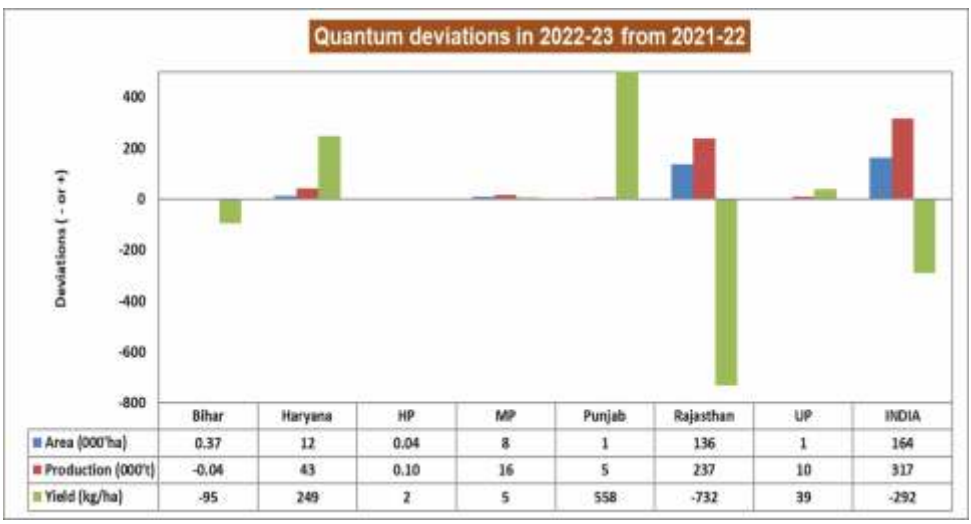
Quantum change in area, production and yield of barley

State/Country	2021-22 (Final Estimate)			2022-23 (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	7.0	12.4	1779	7.3	12.3	1684	0.37	-0.04	-95
Chhattisgarh	1.2	1.0	818	0.9	0.6	733	-0.31	-0.33	-85
Haryana	3.3	10.6	3237	15.3	53.3	3486	12.01	42.69	249
Himachal Pradesh	18.1	31.4	1733	18.2	31.5	1735	0.04	0.10	2
Madhya Pradesh	16.0	32.5	2030	24.0	48.8	2035	8.00	16.36	5
Punjab	5.0	15.5	3096	5.7	20.8	3654	0.70	5.35	558
Rajasthan	200.5	711.0	3547	336.7	947.8	2815	136.22	236.70	-732
Uttar Pradesh	165.0	500.6	3034	166.0	510.1	3073	1.00	9.51	39
Uttarakhand	20.0	29.3	1464	20.0	29.2	1461	0.00	-0.06	-3
West Bengal	0.2	0.3	1659	0.2	0.3	1700	0.03	0.05	41
Others	17.2	26.8	1562	23.4	33.0	1411	6.22	6.18	-151

Source: DES, MoA&FW, India.

Contribution of yield and/or area to barley production (2022-23)

State/Country	Change in production in 2022-23 over 2021-22		% contribution by	
	Quantity (in '000 tonnes)	Deviation (in %)	Area	Yield
Bihar	-0.04	-0.33	5.26	-5.32
Chhattisgarh	-0.33	-34.17	-26.50	-10.45
Haryana	42.69	400.86	365.05	7.70
Himachal Pradesh	0.10	0.32	0.21	0.11
Madhya Pradesh	16.36	50.37	50.00	0.25
Punjab	5.35	34.56	14.00	18.04
Rajasthan	236.70	33.29	67.95	-20.64
Uttar Pradesh	9.51	1.90	0.61	1.29
Uttarakhand	-0.06	-0.20	0.00	-0.20
West Bengal	0.05	18.46	15.61	2.47
Others	6.18	23.07	36.24	-9.67
INDIA	317	23.08	36.24	-9.66



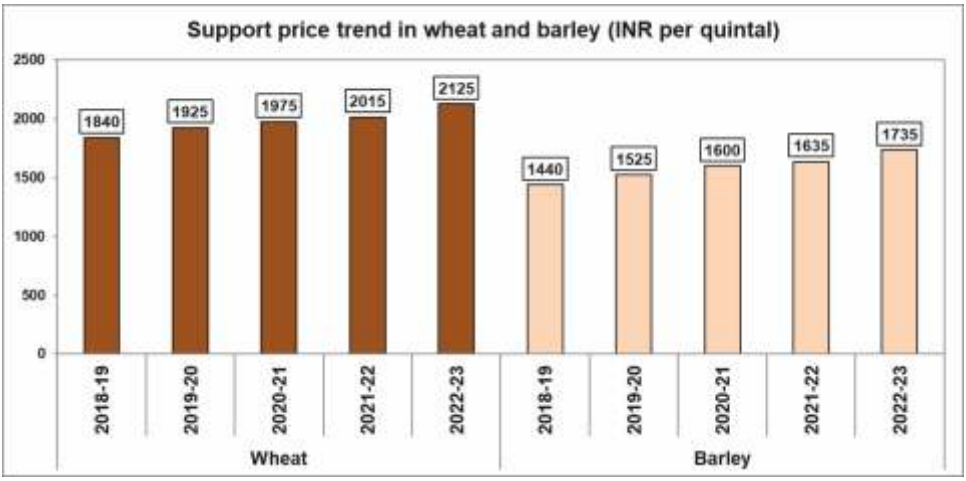
Among barley growing states, Rajasthan holds the top slot in production (0.94 million tonnes: 56%), followed by Uttar Pradesh (0.51 million tonnes: 30%), Haryana (0.05 million tonnes: 3%) and Madhya Pradesh (0.05 million tonnes: 3%). The aforementioned four states altogether accounted for about 92% of the total barley produced in the country. Rajasthan consecutively ranks first in terms of barley acreage (0.34 million hectares: 55%) during 2022-23, a plausible reason for its high share in production as well (56%). During 2022-23 *Rabi* season, the average productivity in barley was highest in the case of Punjab (3654kg/ha), followed by Haryana (3486kg/ha), Uttar Pradesh (3073 kg/ha) and Rajasthan (2815 kg/ha). The aforementioned states registered the productivity levels more than the national average (2733 kg/ha).

Among barley growing states, a wide range of variation has been noticed in crop acreage, production and productivity levels. Productivity has declined in states like Bihar, Chhatisgarh, Rajasthan, Uttarakhand and West Bengal ranging from 3 to 732 kg/ha. The crop acreage has witnessed an increasing trend in majority of the states barring Chhattisgarh. Surprisingly, Haryana, Himachal Pradesh, Madhya Pradesh, Punjab, Uttar Pradesh and West Bengal have exhibited a positive change in all the three variables *viz*., area, production and productivity of barley. The increase in barley output was highest in the case of Rajasthan (+0.24 lakh tonnes (27.82%) followed by Haryana (0.43 lakh tonnes: 402.74%) The overall productivity of the country fell down by 292kg/ha. The highest decline was recorded in Rajasthan (732kg/ha). The maximum gain in yield was observed in Punjab (558kg/ha: 18.02%)

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 5.46% and barley by 6.12% in comparison to the past year's support price helped farmers to take prior sowing decision. The extent of change in the support prices didn't have a positive impact on both the crops acreage. The area under wheat has increased

by 1.36 million hectares, and, barley acreage increased by 1.65 lakh hectares. It is also clear from the quinquennial data that the support price difference between wheat and barley hover around ₹390 to ₹380 per quintal and the divergence increased in 2022-23 in comparison to 2021-22.

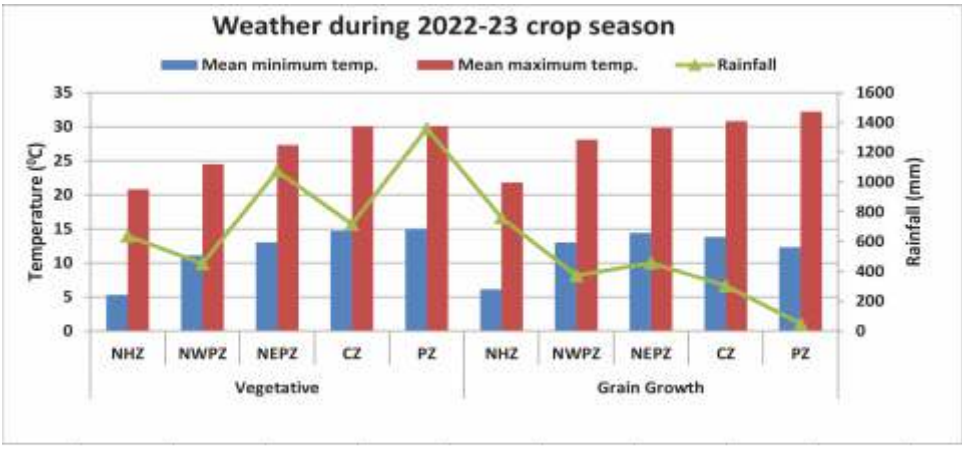


Weather Scenario 2022-23

Meteorological data was received from 46 centres across NHZ (7), NWPZ (8), NEPZ (9), CZ (14) and PZ (8). The mean minimum temperature (min.T) and mean maximum temperature (max.T) were 6.1^{0}C and 21.8^{0}C in NHZ, 13^{0}C and 28.1^{0}C in NWPZ, 14.4^{0}C and 29.8^{0}C in NEPZ, 13.8^{0}C and 30.8^{0}C in CZ and 12.3^{0}C and 32.2^{0}C in PZ during grain filling period. Compared to previous crop season, the mean min.T was higher in NWPZ, NEPZ and CZ and was lower in NHZ and PZ. Whereas, the mean max.T was lower in all the zones; by 1.3^{0}C, 0.8^{0}C, 0.4^{0}C, 0.5^{0}C and 0.4^{0}C in NHZ, NWPZ, NEPZ, CZ and PZ respectively, during grain filling period. In NHZ, the max.T remained <26°C during the grain filling period, in NWPZ the max.T was <30°C from March till the crop maturity. In NEPZ the max.T remained <33°C during grain filling period and in CZ and PZ, the max.T was <34°C from grain filling period till crop maturity.

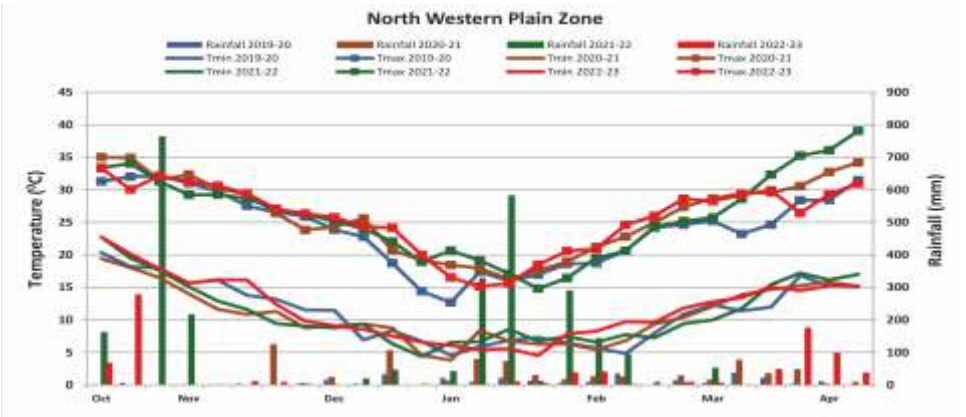
All zones received rainfall during the crop season. Maximum rainfall of 1529.2mm was recorded in NEPZ followed by 1408.5 mm in PZ, 1398 mm in NHZ, 1020 mm in CZ and 825 mm in NWPZ. Compared to

previous year, less rainfall was received in all the zones and was distributed in both vegetative and reproductive stages. The rainfall received in the month of March across zones has helped in maintaining cooler temperature during grain filling period compared to previous year.

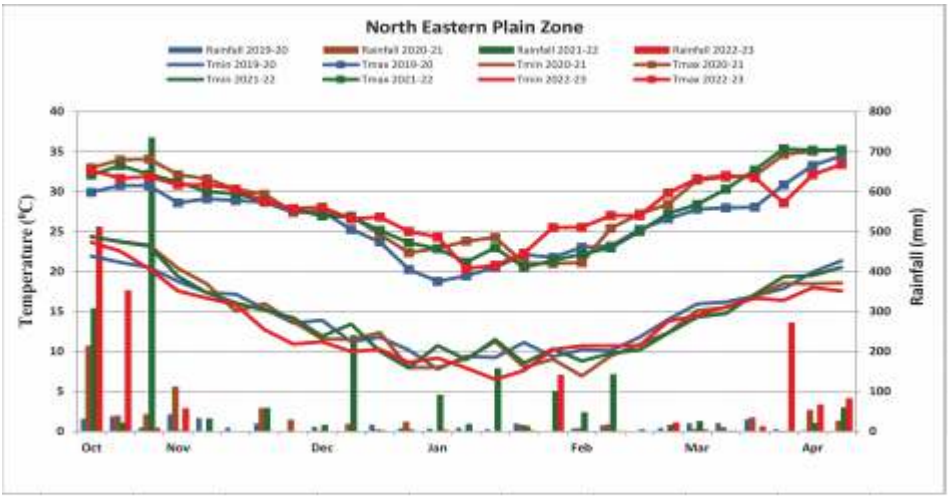


The weekly average weather data of cropping duration for all four major wheat growing zones (NWPZ, NEPZ, CZ and PZ) were compared with previous 3 years (2019-20,2020-21, 2021-22) and the trend of min.T, max.T and rainfall are discussed below:

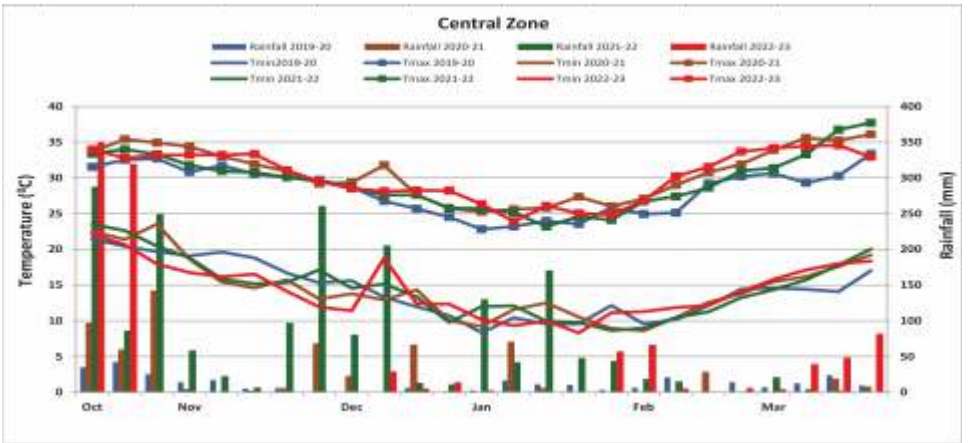
In NWPZ, the weekly average min.T was 0.5^0, 0.9^{0}C and 0.6^{0}C higher than 2019-20, 2020-21 and 2021-22 crop seasons respectively. The weekly average max.T was 1.8^{0}C higher than 2019-20 crop season and 0.4^{0}C lower than 2020-21 and 2021-22 crop seasons. The rainfall received was higher than 2019-20 and 2020-21 crop seasons and lower than 2021-22 crop season.



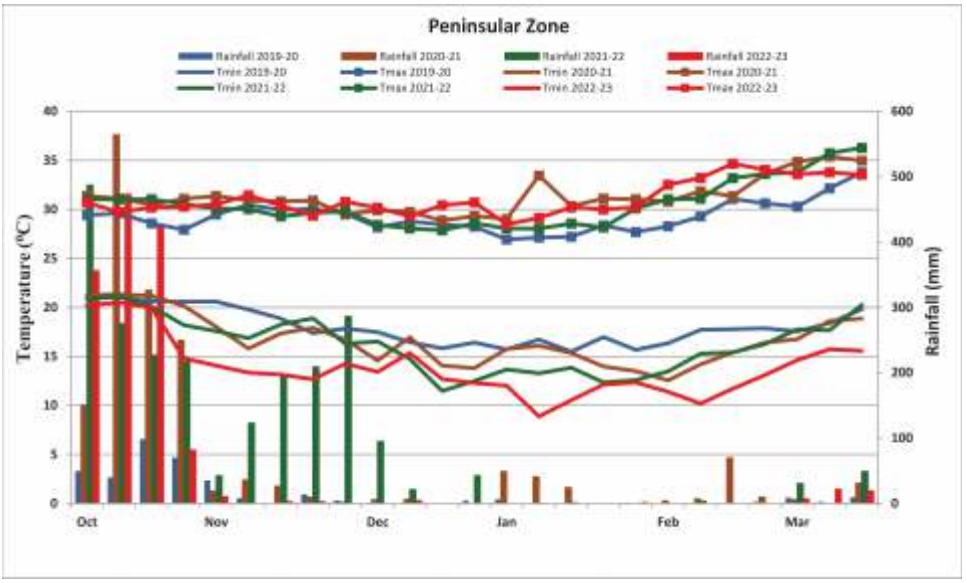
In NEPZ, the weekly average min.T was 1^{0}C, 0.7^{0}C and 1^{0}C lower than 2019-20, 2020-21 and 2021-22 crop seasons respectively, and the max.T was 1.8^{0}C and 0.5^{0}C higher than 2019-20 and 2021-22 crop seasons respectively, and was 0.2^{0}C lower than 2020-21 crop season. The rainfall received was higher than 2019-20 and 2020-21 crop seasons and lower than 2021-22 crop season.



In CZ, the weekly average trend of min.T was 0.1^{0}C, 0.15^{0}C, and 0.29^{0}C lower than 2019-20, 2020-21 and 2021-22 crop seasons respectively. The mean max.T was 2^{0}C and 0.8^{0}C lower than 2019-20 and 2021-22 crop seasons respectively, and was 0.4^{0}C higher than 2020-21 crop season. The rainfall received was higher than 2019-20 and 2020-21 crop seasons and lower than 2021-22 crop season.



In PZ, the weekly average trend of mean min.T was 4.2^{0}C, 2.8^{0}C and 2.4^{0}C lower than 2019-20, 2020-21 and 2021-22 crop seasons respectively. The mean max.T was 1.8^{0} C and 0.6^{0}C higher than 2019-20 and 2021-22 crop seasons respectively and was 0.2^{0}C lower than 2020-21 crop season. The rainfall received was higher than 2019-20 crop season and was lower than 2020-21 and 2021-22 crop seasons.



Overall, weather data analysis indicates that the mean maximum temperature remained lower in most of the zones compared to previous years and maximum temperature remained <30^{0}C in most of the days of grain filling period and rainfall occurred both at vegetative and reproductive growth period in majority of the wheat growing zones. Thus, all these favourable environmental factors contributed significantly for record wheat production during the year 2022-23.

MAJOR RESEARCH ACHIEVEMENTS

CROP IMPROVEMENT

Development and Release of New Wheat Varieties

Central Released Varieties

This year 2022 was very fruitful as the Central Sub-Committee on Crops Standards, Notification and Release of Varieties for Agricultural Crops in its 89th meeting recommended the release and notification of 18 bread wheat varieties [(PBW872, DBW371 (Karan Vrinda), DBW372 (Karan Varuna), DBW370 (Karan Vaidehi), MACS Sakas (MACS 6768), HD3406 (Unnat HD2967), HD3411 (NICRA Pusa Wheat 341I), HD3407 (Unnat HD2932), PBW826, VL Cookies (VL2041), Pusa Wheat 3369 (HD3369), Pusa Jagrati (HI1653), Pusa Aditi (HI1654), Karan Prema (DBW316), PBW833, Pusa Ojaswi (HI1650), Vidhya (CG1036), HI1655 (Pusa Harsha)] and four durum wheat varieties [(Pusa Kirti (HI8830), DDW55 (Karan Manjari), HI8826 (Pusa Poshtik), MACS4100 (MACS Jejuri)] for different production conditions in various zones. Of these, PBW872, DBW371 (Karan Vrinda), DBW 372 (Karan Varuna), MACS 6768 (MACS Sakas) qualify the criterion of bio-fortified varieties. HD 3406, HD 3411 and HD 3407 were developed through marker assisted back cross breeding.

Wheat varieties released by CVRC during 2022-23

Variety	Developed by	Zone	Prod. Cond.	Grain yield (q/ha)		Special features
				Av.	Pot.	
Bio-fortified bread wheat varieties						
PBW872	PAU, Ludhiana	NWPZ	IR, ES, HF	75.2	93.4	High Fe (42.3 ppm) and Zn (40.7 ppm)
DBW371 (Karan Vrinda)	ICAR-IIWBR, Karnal	NWPZ	IR, ES, HF	75.9	87.1	Protein content (12.2%) & Fe (44.9 ppm)
DBW372 (Karan Varuna)			IR, ES, HF	75.3	84.9	Protein content (12.2%) Zn (40.8 ppm)
(MACS6768) MACS SAKAS	ARI, Pune	CZ	TS, IR	56.6	92.4	Protein (12.0%), Fe (41.2ppm), Zn (45.1 ppm)
Varieties developed through Marker Assisted Backcross Breeding						
HD3406 (Unnat HD2967)	ICAR-IARI, N. Delhi	NWPZ	TS, IR	54.73	70.4	3.26% superior in yield to recurrent parent HD2967,
HD3411 (NICRA Pusa Wheat 341I)		NEPZ	TS, IR	46.75	65.8	1.5% superior in yield to recurrent parent HD2733
HD3407 (Unnat HD2932)		CZ	LS, IR	46.75	69.6	Better resistance to leaf and stem rust to recurrent parent HD2932
PBW826	PAU, Ludhiana	NWPZ & NEPZ	TS, IR	63.6 (NWPZ) 49.7 (NEPZ)	84.0 (NWPZ) 70.5 (NEPZ)	Resistant to wheat blast

Variety	Developed by	Zone	Prod. Cond.	Grain yield (q/ha)		Special features
				Av.	Pot.	
VL 2041 (VL Cookies)	ICAR-VPKAS, Almora	NHZ	TS, RF	29.6	44.4	Soft grain (GHI22.6), Biscuit spread factor (11.7)
DBW370 (Karan Vaidehi)	ICAR-IIWBR, Karnal	NWPZ	IR, ES, HF	74.9	86.9	High protein content (12.0%)
HD 3369 (Pusa Wheat 3369)	ICAR-IARI, N. Delhi	NWPZ	TS, RI	50.6	71.4	Fe content (40.6 ppm)
HI 1653 (Pusa Jagrati)	ICAR-IARI RS, Indore	NWPZ	TS, RI	51.1	69.3	Resistant to wheat blast and leaf rust
HI 1654 (Pusa Aditi)	ICAR-IARI RS, Indore	NWPZ	TS, RI	51.8	78.2	Tolerant to wheat blast and leaf rust
DBW 316 (Karan Prema)	ICAR-IIWBR, Karnal	NEPZ	LS, IR	41	68	Resistant to wheat blast and all the three rusts, protein content (13.2%), tolerant to drought (DSI-0.88) and heat stress(HSI- 0.19)
PBW833	PAU, Ludhiana	NEPZ	LS, IR	42.75	58.8	Good chapatti quality (score 8.2) and protein content (12.9%)
HI 1650 (Pusa Ojaswi)	ICAR-IARI RS, Indore	CZ	TS, IR	57.2	73.8	Highly resistant to leaf and stem rust, high zinc content (42.7 ppm)
CG 1036 (Vidhya)	IGKV RS, Bilaspur	CZ	TS, RI	39.3	60.4	Hard grain, good chapati score (8.5), Resistance to leaf and stem rust
HI1655 (Pusa Harsha)	ICAR-IARI RS, Indore	CZ	TS, RI	38.8	59.8	Hard grain, good chapati score (8.4), resistance to leaf and stem rust
DBW 303 (Area extension)	ICAR-IIWBR, Karnal	CZ	IR, ES/TS,	58.3	80.3	High yield, resistance and wider adaptability
Durum wheat						
HI 8830 (Pusa Kirti)	ICAR-IARI RS, Indore	CZ	TS, RI	40.4	65.3	Resistance to leaf and stem rust, good amount of yellow pigment (7.4)
DDW55 (Karan Manjari)	ICAR-IIWBR, Karnal	CZ	TS, RI	35.6	56.5	Zn (43.3 ppm), hard grains, good hectoliter weight
HI8826 (Pusa Poshtik)	ICAR-IARI RS, Indore	PZ	TS, IR	48.8	73.7	Resistance to leaf and stem rust, hard grains
MACS4100 (MACS JEJURI)	ARI, Pune	PZ	TS, IR	46.0	61.8	Resistance to leaf rust, hard grains and good amount of yellow pigment (7.1); good pasta acceptability(6.6)

State Release Varieties

Seven wheat varieties namely K 1616, VL Gehun 2028, VL Gehun 3010, HPW 373, JAUW 672, SKW 396 and NIAW3624 were recommended for notification 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 2022-23

S.N.	variety	Developed by	State	Production condition	Average yield (q/ha)	Potential Yield (q/ha)
1.	K 1616	CSAUAST, Kanpur	Uttar Pradesh	TS, RF	23.96	49.5
2.	VL Gehun 2028	ICAR-VPKAS, Almora	Uttarakhand	TS, RF (organic cultivation in hills)	22.7	30.7
3.	VL Gehun 3010			LS, IR	58.19	85.2
4.	Him Palam Gehun 3 (HPW 373)	CSK HPKVV, Palampur	HP (lower and mid hills)	LS, RF	27.6	36.2
5.	JAUW 672	SKUAST, Jammu	Jammu region	ES/TS, RI	44.13	54.5
6.	SKW396 (Shalimar wheat3)	SKUAST, Srinagar	Mid and lower hills of Kashmir valley	TS, RF	32.3	38.6
7	NIAW 3624	MPKV ARS, Niphad	Maharashtra	TS, RI	30.56	42.1

Registration of New Genetic Stocks

During the year 2022-23 , a total of 19 genetic stocks of wheat were registered for traits like resistance to rusts, higher protein content, water use efficiency, heat tolerance, salt tolerance and high grain iron and zinc content. The genetic resources unit of the IIWBR, Karnal multiplies the seeds of these registered genetic stocks and supplies to breeder across the country for use in wheat improvement.

Registration of Varieties with the PPV&FRA

Four wheat varieties namely MP(JW) 3382, DBW296, DBW327 and DBW332 were registered under extant category by the PPV&FRA, New Delhi vide registration number REG/2016/1387, REG/2021/0219, REG/2021/0220 and REG/2021/0221, respectively.

Conduction of Coordinated Trials

The wheat coordinated varietal evaluation programme entails a huge multilocation testing programme which is undertaken at 67 centers with the cooperation of 28 funded and 39 voluntary centres spread across five wheat growing zones in the country. During the crop season 2022-23, a total of 15 trial series [(AVTs (4), NIVTs (9), IVTs(1) and SPLs (1)] were laid out in the different zones under five major production conditions *viz.* early-sown irrigated, timely-sown irrigated, late-sown

Genetic stocks registered during 2022-23

Name	Developed by	Traits
HS545	ICAR-IARI Regional Station, Shimla	Resistant to all pathotypes of brown rust presence of Lr24/Sr24.
DBW325	ICAR-IIWBR, Karnal	Highly resistant to wheat blast, resistant to leaf rust and karnal bunt.
IC0640204 (RLBW02)		Resistant to stripe rust, resistant to leaf rust, tolerant to tem rust.
DBW342		Resistant to wheat blast resistant to stem and leaf rust.
CPIIWBR-121		Immune or complete field (adult plant) resistance against yellow rust disease at 9 different hot spot locations
DBW400		Resistant to leaf rust.
BFKW-2		High grain protein (16.7%), Iron (45.7 ppm) and Zinc (47.8 ppm) content.
BFKW-7		High grain protein (17.1%), Iron (53.3 ppm) and Zinc (54.2 ppm) content.
IC128335	ICAR-NBPGR, N. Delhi	Drought tolerance with higher antioxidant (1.8 fold) activity.
IC416188		Terminal heat tolerance.
IC533742		High level of salt tolerance.
EC178071-428		High level of salt tolerance.
IC112049		Terminal heat tolerance, high productive tiller numbers, thousand grain weight and harvest index.
PAU16076	PAU, Ludhiana	Resistant to yellow rust with gene Yr5.
PAU16077		Possesses genes for resistant to Leaf rust-stripe rust (Lr57-Yr40). Stripe rust (Yr15).
PAU16078		Resistance to leaf rust (Lrtri) and stripe rust.
PAU16075		Glu-B3/GliB1 locus transfer on 1RS chromosomal arm. Resistant to stripe rust with transfer of gene Yr5.
UASQ 332	UAS, Dharwad, Karnataka	High Zinc content (47.3 ppm).
GW A 2019-957	Wheat Research Station, SDAU, Vijapur	High Zinc content (47.0 ppm).

irrigated, timely-sown restricted irrigation and timely-sown rainfed. This year altogether 360 test entries (251 NIVT, 86 AVT and 23 IVT) were evaluated with 58 check varieties in different trials. In all, 323 trial sets were supplied to 67 centres and 319 trials were conducted (98.8%).

During the crop season, out of total 319 total trials conducted, data of 250 trials (78.4%) has been reported based on set norms for disease resistance and yield performance. Rejection by Monitoring Team was the primary reason (37) for Comparatively less reporting of trials.

Breakup of yield trials during 2022-23

Zone	Proposed	Conducted	Reported
NHZ	19	18	12
NWPZ	90	89	74
NEPZ	57	55	45
CZ	95	95	73
PZ	63	62	46
Total	323	319	250

Varieties in the Final Year Evaluation in AVTs

During this crop season, total 13 entries were in the final year of yield evaluation in various AVTs and SPL trials of the different zones. One entry namely DBW359 was tested in two zones viz., Central and Peninsular Zone. The proposals received for identification would be considered by Varietal Identification Committee.

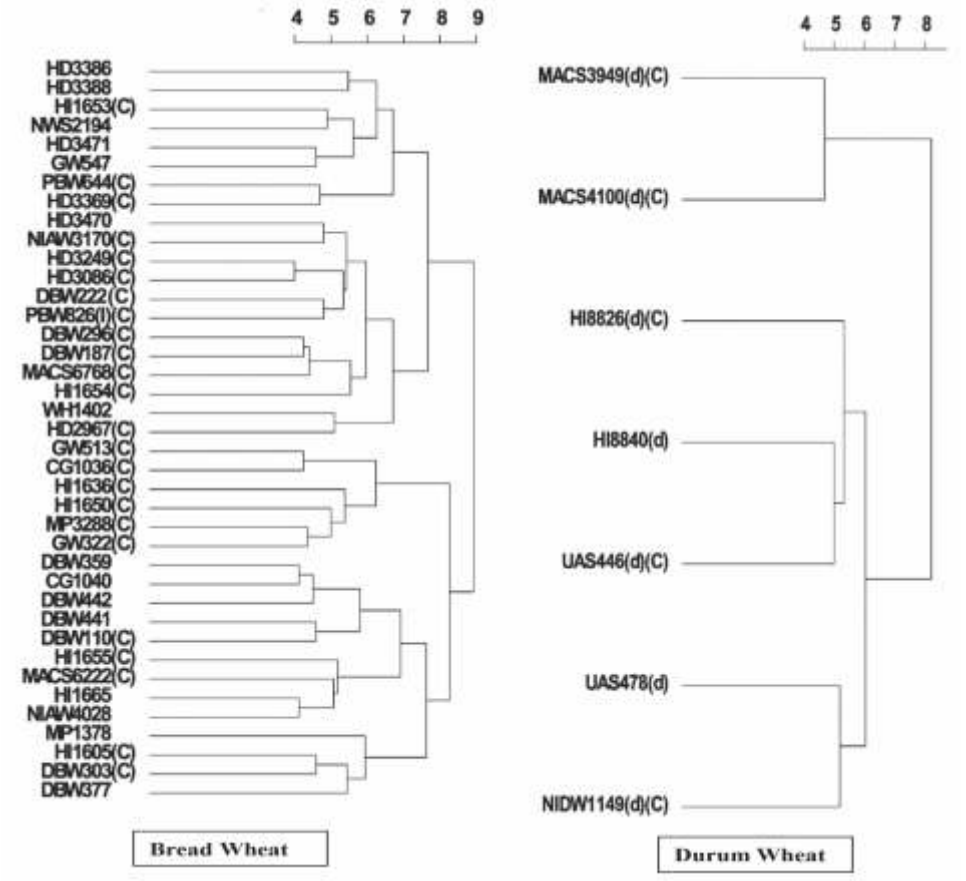
Varieties in final year of evaluation in AVTs and SPLs during 2022-23

Zone/ Trial	Final year entries
North Western Plains Zone	
AVT-IR-TS-TAS	HD3386
AVT-RI-TS-TAS	WH1402
North Eastern Plains Zone	
AVT-IR-TS-TAS	HD3388
Central Zone	
AVT-IR-TS-TAD	NWS2194, GW547
AVT-RI-TS-TAS	DBW359, CG1040
Peninsular Zone	
AVT-IR-TS-TAD	MP1378
AVT-RI-TS-TAS	HI1665, DBW359, NIAW4028, UAS478(d), HI8840(d)
SPL-HYPT	
SPL-HYPT-IR-ES-CZ	DBW377

Marker Assisted Gene Prospecting in AVT Entries of Wheat

AVT final year (2022-23) entries and checks were screened using various STS/ AS-PCR markers linked to specific genes including waxiness (*WxB1*), abiotic (drought tolerance) stress (*DREB*), vivipary (*Vp1B3*), leaf rust resistance (*Lr*), photoperiod response (*Ppd1*) and vernalization (*Vrn*). The dendrogram, utilising 9 STS and 39 SSR

markers, demonstrated the genetic relationships between different genotypes. This analysis resulted in the formation of two distinct clusters, one for durum wheat entries and the other for bread wheat entries.



Dendrogram showing diversity among AVT final year entries and checks

Promising Varieties in Advanced Varietal Trials

Out of total 72 genotypes evaluated in AVT first year of different zones during this crop season, only 02 genotypes were identified to be superior on the basis of their yield performance and response to the incidence of rusts. DBW386 has been found promising in irrigated timely sown conditions of North Western Plains Zone and North eastern Plains Zone and HI1674 was found promising under late sown irrigated conditions of Peninsular Zone.

Promising Varieties in Initial Trials

Among the total 274 new entries evaluated for their performance in different NIVTs/IVTs, 43 entries were found promising on the basis of high yielding ability and disease resistance. Out of total 43 promising entries, 12 entries were observed to be promising for timely sown irrigated condition, 13 for late sown irrigated condition and 18 for restricted irrigation condition.

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 2022-23 through CIMMYT. Among these 350 total lines, 258 were new AICRP test entries while remaining 92 were contributed from ICAR-IIWBR breeding programs. Based on the desired level of disease score (score <10) across two dates of sowings, 99 resistant genotypes were shortlisted.

Wheat blast resistant genotypes identified in 2022-23

Wheat blast reaction	AICRP /IIWBR	Genotypes	Total
0, 0 (Free)	AICRP	NIDW1520(d), MP3577, PBW905, PBW906, DBW439, WH1321, RAJ4583, DBW441, DBW442	9
	IIWBR	RWP2024, RWP2030, RWP1332, WAP2214, WAP2222, WAP2223, WAP2224, DBW88M-11, DBW88M-16, DBW88M-17, DBW88M-18, DBW88M-19, DBW88M-22, DBW88M-23	14
Upto 10 (Resistant)	AICRP	DBW408, RAJ4576, RAJ4577, RAJ4578, HUW854, BRW3944, KRL2106, NWS2442, BCW28, PBW910, WH1316, UP3122, HD3449, HD3467, DBW416, DBW417, PBW914, MACS6837, GW554, PWU16, UP3126, WH1324, DBW425, MP3568, HI1687, UAS482(d), PDW364(d), MPO1396(d), MACS4135(d), GW1366(d), DBW429, K2210, DBW428, DBW432, UAS484(d), DDW64(d), MACS4131(d), HI1691, DBW433, DBW435, JWS1333, MP3572, DBW438, BRW3922, UP3130, GW557, RAUW107, DBW443	48
	IIWBR	DBW88M-24, RWP1939, RWP1944, RWP1365, RWP1449, WAP2217, WAP2219, DBW88M-21, NE-WB22-4, DBW88M-20, RWP1350, NE-WB22-12, QLT22-1, QLT22-2, NE-WB22-14, WAP2218, DBW88M-3, NE-WB22-11, WAP2220, WAP2216, NE-WB22-1, WAP2213, RWP2020, NE-WB22-3, DBW88M-1, RWP2036	26
Total			**97**

It is important to note here that this season 23 entries were found highly resistant (0, 0 score), and 74 entries were found resistant (maximum score up to 10 only). A total of 40 entries from IIWBR breeding projects were resistant (score up to 10), thereby indicating that anticipatory breeding work at ICAR-IIWBR is effective and will be useful at national level.

Evaluation of National and International Nurseries/Trials

International germplasm: During 2022-23, 136 sets of eight trials and seven nurseries comprising a total of 1470 lines (1289 bread wheat and 181 lines of durum wheat) were obtained from CIMMYT, Mexico; 11 sets of four trials comprising of 472 lines (351 bread wheat and 121 lines of durum wheat) were received from ICARDA, Morocco and 120 lines of facultative winter wheat were obtained from IWWYP, Turkey and evaluated at various centres.

National Nurseries: During 2022-23, national genetic stock nursery and segregating stock nursery (SSN) were constituted by the institute and supplied to different co-operators across locations. The Salinity/ Alkalinity Tolerance Screening Nursery (SATSN) was constituted by the CSSRI and evaluated at 5 locations.

National Genetic Stock Nursery (NGSN): The NGSN comprising 107 genotypes including *T. aestivum* (93) and *T. durum* (14) was provided to 33 centres as "suggested crossing block". Pooled analysis of data was done for identification of promising lines. The utilization report indicated that 30 centres out of 33 utilized the NGSN entries. It was also found that 16.95% genotypes in the NGSN were utilized for hybridization as parents.

Segregating Stock Nursery (SSN): 26th Segregating Stock Nursery (SSN) comprising of 209 segregating populations (F2/F3) was shared with 23 wheat breeding centres to select superior plants/ material as per the breeding objectives and prevailing conditions. The utilization report indicated that the nursery could achieve 36.9 per cent utilization across the centres. Most of the crosses were utilized by one or the other centre for various traits (yield components, disease resistance, physiological traits) and a total of 10172 plants were selected across

the centres.

Salinity/Alkalinity Tolerance Screening Nursery: The Salinity/Alkalinity Tolerance Screening Nursery was evaluated at 5 centres consisted of 15 test entries and three checks (KRL 210, Kharchia 65 and DBW 187). Superior lines were identified on the basis of the analysis of grain yield and comparison with the pooled value. Out of 15 test entries, 9 entries (KRL 2101, KRL 2105, KRL 2114, KRL 2201, KRL 2202, KRL 2203, KRL 2204, KRL 2205 and WBL 2308) were found to be promising on the basis of mean yield along with resistance to all the three rusts (stem leaf and yellow rust) as evident from IPPSN 2022-23.

Physiological Investigations on Heat and Drought Stress Tolerance in Wheat

Heat and Drought Tolerance Screening Trial (HDTST) was conducted to identify the temperature and drought stress tolerant lines among AVT final year genotypes. A total of 25 entries including checks were sown at 12 locations under timely sown (TS), late sown (LS) and drought stress (DR) conditions.

Magnitude of Heat and Drought Stress:

- In NWPZ and NEPZ, the mean minimum and maximum temperature across centres was higher by 1.3^{0}C and 1.1^{0}C respectively, under reproductive stage in LS compared to TS conditions. The RH ranged from 42-73% and the rainfall received was more under LS reproductive stage compared to TS.
- In CZ and PZ, the mean minimum and maximum temperature across centres was higher by 1.9^{0}C and 1.8^{0}C respectively, under reproductive stage in LS compared to TS conditions. The RH ranged from 38-70% and the rainfall received was higher in reproductive phase in both the zones.

Under heat stress, the genotype HD3386 showed lowest HSI (0.76) with a minimum yield reduction of 18.6%, but was higher than the best check WH730 (0.63). Under drought condition, CG1040 showed

lower DSI (0.87) but slightly higher than the best check MACS6768 (0.86) with a minimum yield reduction of 32.6%. The genotypes showing HSI /DSI <1 are listed here.

List of wheat genotypes identified as heat/ drought tolerant

Trial	Genotypes	
	HSI<1	DSI<1
HDTST	HD3386 (0.76), NIAW4028 (0.85), GW547 (0.88), HD3388 (0.89), UAS478(d) (0.89), CG1040 (0.89), HI8840(d) (0.94), NWS2194 (0.97), HI1665 (0.98).	CG1040 (0.87), GW547 (0.90), NIAW4028 (0.90), HI1665 (0.91), HD3386 (0.91).

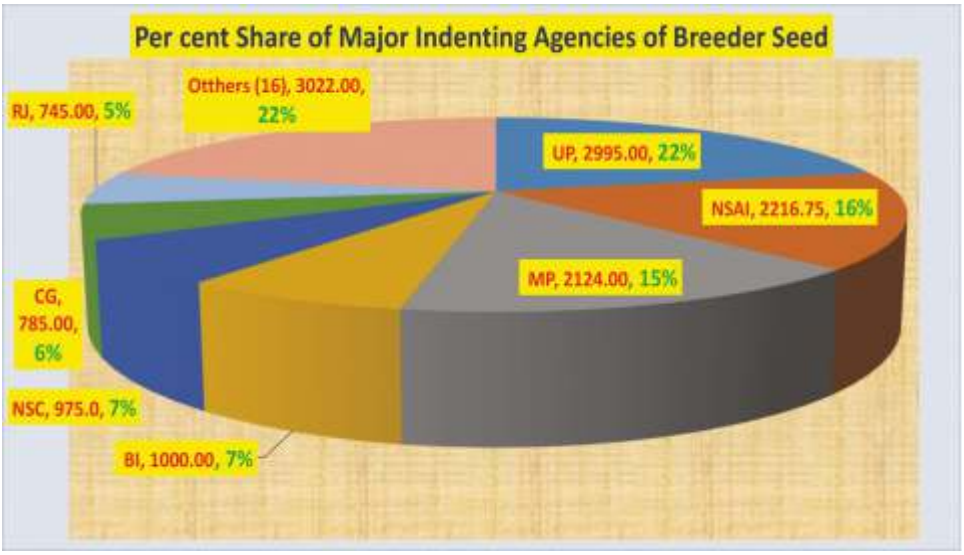
Values in the paranthesis indicates HSI /DSI

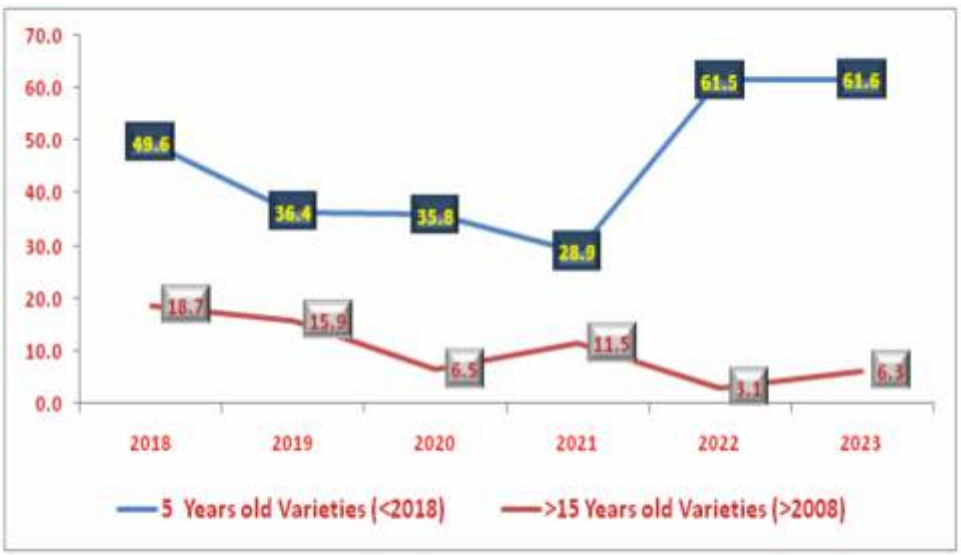
Breeder & Nucleus Seed Production

During 2022-23, a total indent of 13862.75q breeder seed of 147 wheat varieties was received from DA&FW, New Delhi for total 23 indenting agencies. Out of total indenting agencies, 08 were public sector agencies (NSC, IFFDC, IFCCO, KCO, NFL, Hindustan Insecticide Ltd., KVSS and NAFED) while indent of National Seed Association of India (NSAI) represented private seed sector. Among the indenting agencies, UP has maximum indent of 2995.00q followed by NSAI (2216.75q) for private seed companies, Madhya Pradesh (2124.00q) and Bihar (1000.00q). A total of 5409.60q (39.02 per cent) breeder seed indent was for 26 latest varieties notified during 2021 and 2022 *viz*., DBW 327, HD 3293, DBW 332, DBW303, CG 1023, HD 3298, etc. The maximum indent was received for DBW 303 (1414.40q) followed by DBW 187 (1352.20q) and HD 3226 (769.80q). All the top ten indented varieties had share of 52.90 % in the total indent.

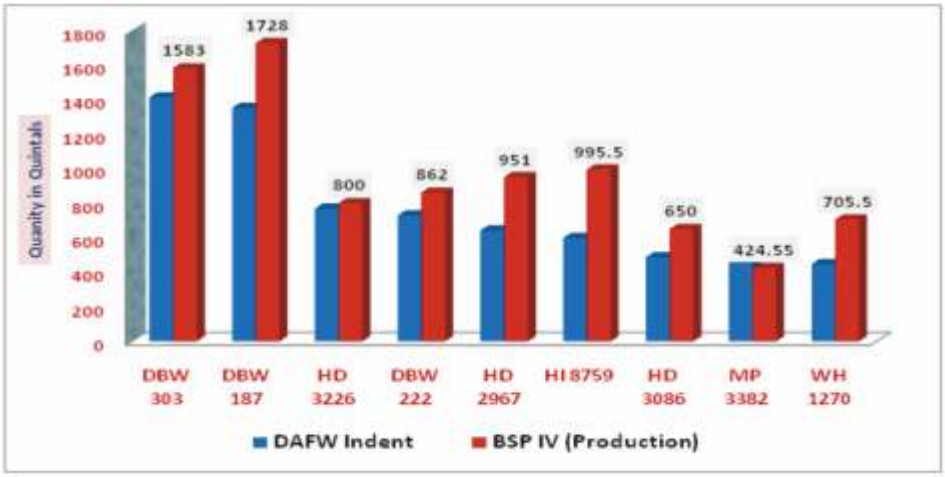
Breeder Seed Allocation & Production

As per the BSP 1, a total of 13655.55q of breeder seed of 118 varieties was allocated to 31 BSP centres for the production during 2022-23 against 13862.75q total indent. The indent of 197.20q breeder seed of 29 varieties viz., HD 2985, HD 2189, RAJ 1482, HD 2329, Malviya 234, HUW 234 etc. was not allocated to the BSP centres due to very old varieties and insufficient nucleus seed availability.





The total breeder seed production was 19812.85q during 2022-23 with surplus production of 6147.30q. Among all 31 BSP centres, ICAR-IIWBR, Karnal, produced maximum quantity *i.e.*, 2771.00q of breeder seed against 2632.20q indent followed by IARI-RS, Indore (2679.00q) and PAU, Ludhiana (2107.0q) against 1055.75q. The highest quantity of breeder seed was produced for DBW 187 (1728.00q) followed by DBW 303 (1583.0q) and HI 8759 (995.50q) against DA&FW indent. Three varieties *viz.*, MP3465 (-236.50q) followed by MP 1255 (-87.60q) and HD 4728 (-85.00q) had deficit breeder seed production against



Breeder seed indent and production of top five indented wheat varieties

S.No.	BSP Centre	Breeder Seed Allocation (q)	Breeder Seed Production (q)	Surplus /Deficit (q)
1	IIWBR, Karnal	2632.20	2771.00	138.80
2	IARI-RS, Indore	1437.30	2679.00	1241.70
3	PAU Ludhiana	1055.75	2228.60	1172.85
4	IARI, New Delhi	1253.60	1795.00	541.40
5	SKNAU, Durgapura	720.80	1719.91	999.11
	Total	**7099.65**	**11193.51**	**4093.86**

the allocation of indented quantity. Only two BSP centres *viz*., SVPUA&T, Meerut (-80.65q) and SKAUST, Jammu (-0.50q) produced deficit breeder seed against the allocation.

Nucleus Seed Allocation & Production

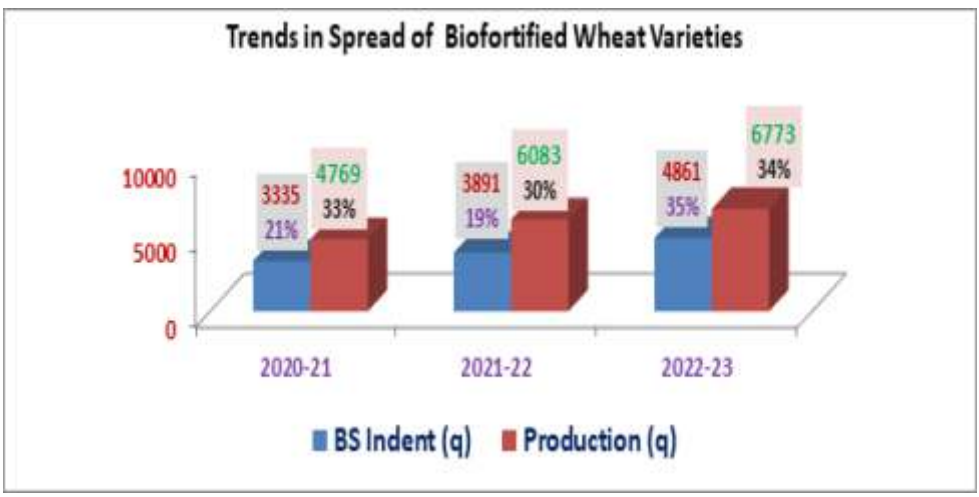
Allocation of 418.0q nucleus seed of 118 wheat varieties was made to the 31 BSP Centres. A total of 875.30q of nucleus seed was produced with a surplus of 458.80q. The highest quantity (113.50) of nucleus seed was produced by IARI-RS, Indore followed by PAU, Ludhiana (107.50q) and JNKVV Jabalpur (100.0 q).

Test Stock Multiplication

National Seed Corporation was given target for test stock multiplication of 22 varieties identified for release during last workshop (2022) and reported a total of 1076.79q seed of all 22 newly identified wheat varieties namely, DBW 316 (99.45 q), DBW371 (86.5 q), DBW 370 (81.60 q), DBW 372 (76.5 q) and DDW 55 (76.5 q), HD 3407 (54.0q) and HD 3411 (52.24q), PBW 872 (36.0q) and VL2041 (71.4 q) during 2022-23 on NSC farms.

Trends for Biofortified Varieties in Seed Chain

During the last three years, more than 28 biofortified wheat varieties have been released and the seed is being distributed among the stake holders. These varieties have been popularized in view of mitigating the malnutrition problem among vegetarian population. As a result, indent of breeder seed and the production is continuously increasing.



Commercialization of Technologies at IIWBR:

Commercialization of wheat varieties was carried out through granting of Licenses under MoA with different private seed companies and registered seed growers during 2022 for the varieties, DBW303, DBW187, DBW222, DBW327, and DBW332. A total of 141 MoAs were signed with different stakeholders for the production and distribution of seeds of these varieties to the farmers. Variety-wise MoA are listed below:

SN	Varieties	Number
1.	DBW 303	11 Agreements
2.	DBW 187	5 Agreements
3.	DBW 222	1 Agreement
4.	DBW 327	100 Agreements
5.	DBW 332	24 Agreements

This commercialization activity has generated total revenue of Rs 11,926,700 (One Crore, Nineteen Lakhs, Twenty-Six Thousand and Seven hundred only).

Signing of MoA for licensing of wheat varieties DBW 371 and DBW 372 with Seed Companies

CROP PROTECTION

The main objective of the crop protection programme is to reduce yield losses caused by biotic stresses such as diseases, insect pests and nematodes by keeping rigorous vigil on crop health at various crop stages and by strategic deployment of resistant genotypes and effective management tactics. In addition, the crop protection programme collaborates closely with breeding initiatives to develop disease and insect pest resistant variants.

PATHOLOGY

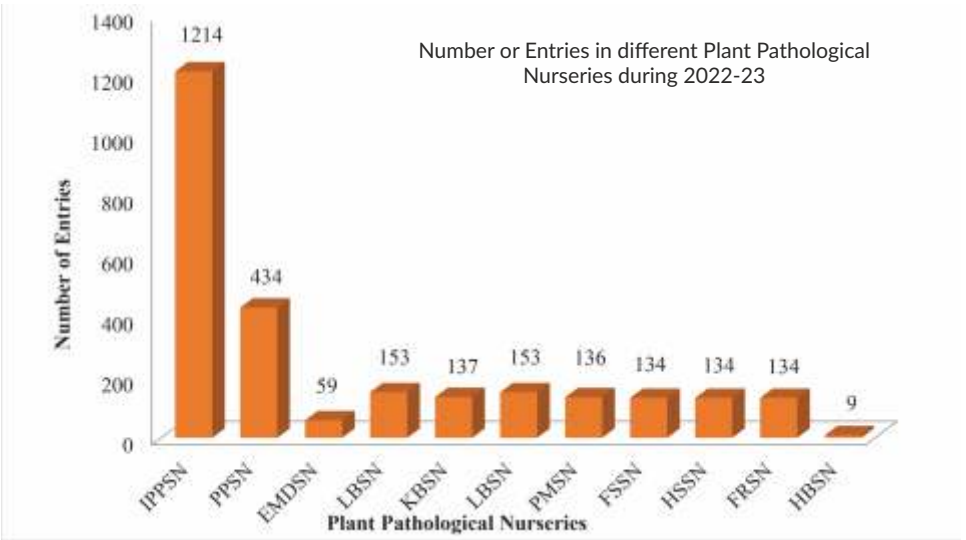
Survey and Surveillance for Diseases

Regular surveys were carried out during 2022–23 Crop Season to check on the health of the wheat and barley crops, with a major focus on the incidence of yellow rust in the NWPZ and potential threat of wheat blast disease. The surveys were carried out by wheat crop protection scientists from various cooperating centres, including ICAR-IIWBR, Karnal. Information gathered from various centres was shared through the "*Wheat Crop Health Newsletter*", Vol. 28 (Issues 1 to 4), which was published during the crop season and also uploaded on ICAR-IIWBR's website (www.iiwbr.icar.gov.in). The first report of yellow rust occurrence of wheat was reported from village Donal of Rup Nagar on 20.12.2022 on wheat cultivar HD3086. Stripe rust then extended to additional areas of Punjab, Haryana, Himachal Pradesh, Uttarakhand, Jammu, and Rajasthan. Likewise, the first occurrence of leaf rust was noticed in Nalwipar village of Karnal district on wheat cultivar DBW303. The occurrences of leaf rust were also noticed from central India in MotiMonpari village of Gujarat, Nadia districts of West Bengal and in Ozarkhed (Dindori tehsil) and Pimpalgaon Mor (Igatpuri tehasil in Nashik district) in Maharashtra on variety Ajeet 102 and on some off-type plants. Stem (black) rust occurred naturally in Wellington areas of Tamil Nadu. Other than rusts, the minor incidence of foliar blight was recorded in eastern, central and peninsular India. Similarly, minor sporadic incidence of loose smut, flag smut and foot rot was also reported. as in past no exotic diseases and pathotypes like *Ug99* race of stem rust and wheat blast were reported from any part of

the country. The overall crop health status was excellent in all the wheat growing areas of the country.

Host Resistance

Wheat germplasm and advance breeding materials were evaluated against diseases, insect pests and nematodes to identify resistance sources at various hot spot locations under artificially inoculated conditions during 2022-23. The major plant pathological nurseries evaluated included Initial Plant Pathological Screening Nursery (IPPSN), Plant Pathological Nursery (PPSN), Elite Multiple Disease Screening Nursery (EMDSN), 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 (HSSN), Foot Rot Screening Nursery (FRSN) and Hill Bunt Screening Nursery (HBSN). The number of entries tested under different plant pathological nurseries is shown in figure here.



Entries Identified Resistant Against Rusts in Advance Breeding Lines:

Rust resistance entries in AVT (2022-23) with ACI upto 10.0 are given below:

- ***Stem, Leaf and Stripe rusts:*** UP3102, PBW893, DBW173(C), PBW771(C), WH1402, DBW296(C), HI1654 (C), HD3388, DBW444 and NIDW1149 (d)(C)
- ***Stem and leaf rusts:*** HS691, VL907(C), VL892(C), VL2041(C), DBW386, HD3428, K2108, HD3059(C), PBW826(C), DBW252(C), HI1669, HI1670, GW547, HI1636(C), HI1650(C), HI1674, HI1634(C), CG1029(C), CG1036(C), HI1655(C), NIAW4183, NIAW4153, AKAW5314, AKAW5100, MP1378, DBW443, PWU15, PBW891, HI8841(d), HI8826(C), MACS6222(C), HI1672, HI1673, HI1675, DBW394, DBW395, MACS6814, NIAW4114, NIAW4120, UAS3022, MP3557, PBW897, GW538, LOK79, RAJ4083(C), HD3090(C), HI1633(C), HI1665, DBW397, NIAW4028, PBW872(C), DBW377, GW543, DBW187(C) and DBW303(C)
- ***Stem and Stripe rusts:*** DBW359, MP3556
- ***Leaf and Stripe rusts:*** PBW889, HD3369(C), UAS478(d), HI8840(d), DDW61(d), UAS446(d)(C)
-

Identification of multiple disease resistant entries

- ***Resistant to all three rusts + KB + FS + PM:*** HI8846(d), HI 8830 (d), WHD 965 (d), HI 8827 (d), HI 8839(d), WH1403, HI8847(d)
- ***Resistant to all three rusts + KB + PM:*** PBW870
- ***Resistant to all three rusts + FS + PM:*** PBW902, VL3029, HD3407, HPW 489, HPW 495
- ***Resistant to all rusts+ LB+ FS+PM:*** HPW493
- ***Resistant to yellow rust+ leaf rust + KB+ PM+FS:*** HPW484, VL3028
- ***Resistant to yellow rust+ stem rust + FS +PM:*** HPW487
- ***Resistant to yellow rust+ leaf rust + FS:*** HD3440
- ***Resistant to yellow rust + leaf rust:*** VL3028, HPW 484, B2011\CIMCOG\18, 41st ESWYT 141
- ***Resistant to yellow rust+ KB+ PM+FS:*** HS694
- ***Resistant to yellow rust+ PM + FS*** VL2043, HD3402
- ***Resistant to leaf rust + stem rust + KB+ PM + FS:*** CG 1036, WH1402, HPW 496
- ***Resistant to leaf rust + stem rust + PM + FS:*** HI1654, HD3438, HD3437

- ***Resistant to leaf rust + stem rust + PM:*** GW547, NIAW4028, GW532, HI1655Q, MACS6795, HI 1651
- ***Resistant to leaf rust + stem rust:*** HI1665, WH1403, HD3407, HI8847, 41st ESWYT 113, EC 0529881, IC 624342
- ***Resistant to stem rust+ PM+FS :*** HD3392
- ***Resistant to KB+FS+PM:*** VL2044
- ***Resistant to FS + PM:*** HPW 497

Pathotype Distribution of Puccinia Species on Wheat and Barley

During 2022-23, a total of 772 samples of three rusts of wheat were pathotyped from India and Nepal.

Stripe Rust of Wheat and Barley (Puccinia striiformis)

During this crop year, 230 samples of stripe rust of wheat [*Puccinia striiformis* f. sp. *tritici*, *Pst*) were analyzed from five Indian states (Himachal Pradesh, Punjab, Haryana, Uttarakhand, and Rajasthan) and Nepal. A total of eight pathotypes {238S119, 110S119, 46S119, T (47S103), P (46S103), 79S68, 6S0, and 7S0] of wheat stripe rust pathogen were identified. The field population was avirulent to *Yr5*, *Yr10*, *Yr15*, and *Yr* sp. Most of the stripe rust samples of wheat were analyzed from Punjab (132) followed by Himachal Pradesh (51) and Uttarakhand (31). During the cropping season, frequency of pathotype 238S119 was maximum (54.78%) followed by 110S119 (27.39 %). The frequency of 46S119 (virulent on *Yr2*, *Yr3*, *Yr4*, *Yr6*, *Yr7*, *Yr8*, *Yr9*, *Yr17*, *Yr18*, *Yr19*, *Yr21*, *Yr22*, *Yr23*, *Yr25*, and *Yr*A) was reduced to 12.17%. Pathotypes 46S103 and 79S68 were identified in 2 and 1 samples, respectively. Only one pathotype 57 (0S0) of *Puccinia striiformis* f. sp. *Hordei* (*Psh*) was identified in 2 barley yellow rust samples collected from Tehri and Ranichauri (UK).

Stem Rust of Wheat (P. graminis f. sp. tritici)

A total of 49 samples of wheat stem (black) rust were received from four Indian states (Gujarat, Maharashtra, Tamil Nadu, and Uttarakhand)

during the crop season. Five pathotypes of *P. graminis* f. sp. *tritici* were identified from the analysis of 49 samples. Population analyzed during the year had avirulence to *Sr26*, *Sr27*, *Sr31*, *Sr32*, *Sr35*, *Sr39*, *Sr40*, *Sr43*, *SrTt3* and *SrTmp*. Pathotype 11 (79G31=RRTSF), virulent on *Sr2*, *Sr5*, *Sr6*, *Sr7b Sr9a*, *Sr9b*,*Sr9c*, *Sr9d*, *Sr9f*, *Sr9g*, *Sr10*, *Sr13*, *Sr14*, *Sr15*, *Sr16*, *Sr17*, *Sr18*, *Sr19*, *Sr20*, *Sr21*, *Sr28*, *Sr29*, *Sr30*, *Sr34*, *Sr36*, *Sr38*,*Sr*McN was recorded in more than 32% of the samples analyzed during the season, which was followed by 40A (26.53%) and 40-3 (22.4%). Pathotypes 40-3 and 21 were identified in eleven and three samples, respectively. Diversity of black rust pathogen was maximum in Tamil Nadu.

Leaf rust of Wheat (P. triticina)

A total of 493 samples of wheat leaf rust pathogen were analyzed from 12 states of India and neighboring country Nepal. Nineteen pathotypes were identified in these samples. Pathotype 77-9 (121R60-1) was the most widely distributed and occurred in 36.11% of the samples followed by 52-4 (121R60-1,7) in 27.79% samples. Pathotype 77-5 (121R63-1), which remained most predominant for more than 20 years was observed in 15.82% samples only. The remaining 14 pathotypes were identified in 20.28% of samples only. The *P. triticina* population from Uttarakhand was highly diverse as the highest number of pathotypes (14) was detected in the samples collected from Uttarakhand. In Nepal 4 pathotypes were detected in 26 samples. Unlike Indian scenario pathotype 52-4, detected in 16 samples, was the most predominant in Nepal. The three most virulent and prevalent pathotypes of *Puccinia* spp. on wheat is shown in the Table.

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

Wheat Rusts	Predominant pathotypes
Stem	79G31(11), 62G29(40A) and 127G29 (40-3)
Leaf	121R60-1(77-9), 121R63-1,7 (52-4) and 121R63-1(77-5)
Stripe	238S119, 110S119 and 46S119

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, more than 8500 wheat and barley lines were evaluated at seedling stage under controlled conditions during 2022-23. Of these, 270 lines including 134 of AVT and 136 of NBDSN/EBDSN were subjected to multiple pathotypes screening under controlled light and temperature conditions. Advanced wheat lines (134) were evaluated at seedling stage against 60 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 Lines in AVT Entries

Three AVT entries (DBW222*, DBW386, and HI1665*) were found resistant to all the pathotypes of *P. graminis tritici*, *P. triticina* and *P. striiformis*. Resistance to black and brown rusts was observed in nine entries while resistance to brown & yellow, and black & yellow was recorded in three entries. Eighteen lines were found resistant to leaf rust whereas 19 entries were found resistant to stem rust pathotypes. Fifteen entries conferred resistance only to yellow rust pathotypes, however, nine and ten entries were found resistant to all the pathotypes of brown and black rusts, respectively.

Rust resistant wheat lines in AVT

Rusts	No. of lines	Detail of lines
Brown, Black and Yellow	03	DBW222*, DBW386, HI1665*
Brown and Black	09	DBW394, DBW444, HI1673, HI1675, HI8826*, MACS6222, NIAW4120, PBW897, PWU15
Brown and Yellow	03	DDW61, HI1636, PBW889
Black and Yellow	03	HD3386*, PBW771*, UAS481
Brown only	09	DBW443, HD2967*, HD3059*, HI1634, HI1668, HI1672, LOK79, MP3288, NWS2194*
Black only	10	CG1040, DBW303, DBW377, DBW380, MACS6814, MP1378*, NIAW4183, PBW887, PBW899, UAS3022
Yellow only	15	CG1036, DBW110*, DBW252*, DBW397, GW538, HD3388*, HD3469, HI1653*, HI1669, HI1670, HI8841, HPW484*, NIAW4028, PBW826*, WH1310

* Different seed lot to that of previous cropping season

Characterization of Rust Resistance Genes

Yr-genes

Among the 134 lines of AVT, *Yr* genes were characterized in 78 lines. *Yr* genes were postulated in lines where differential interactions were observed and in other cases tight linkage of *Yr* genes to other *Lr* and *Sr* genes also facilitated the inference for the presence of a resistance gene. Three *Yr* genes viz. *Yr2*, *Yr9*, and *YrA* contributed to yellow rust resistance in Indian wheat material. Among the postulated *Yr* genes, *Yr2* was the most common and characterized in 62 lines. *Yr9* and *YrA* were postulated in 10 and 08 entries, respectively, whereas their combined presence was postulated in only two AVT entries (HI1668 and K2108).

Sr-genes

Thirteen stem rust resistance genes (*Sr*2, *Sr5*, *Sr7b*, *Sr8a*, *Sr8b*, *Sr9b*, *Sr9e*, *Sr11*, *Sr13*, *Sr24*, *Sr28*, *Sr30* and *Sr31*) were characterized in 93 AVT lines. The frequency of *Sr7b* was maximum as it was postulated in 43 AVT entries followed by *Sr11*and *Sr2*, which were characterized in 25 and 24 entries, respectively. *Sr31* linked with *Lr26* and *Yr9* and conferring resistance to all the known *Pgt* pathotypes in Indian subcontinent was postulated in seven AVT entries, while *Sr24* linked to *Lr24* was characterized in three entries. Other *Sr* genes i.e. *Sr9b* & *Sr13*, *Sr30*, *Sr5*, *Sr8a*, *Sr9e* & *Sr8b*, and *Sr28*, were postulated in 20, 18, 16, 06, 03, and 01 entry, respectively. The *Sr* genes were characterized singly or in combination of up to four gens. DBW252 (C) had combination of four *Sr* genes (*Sr8a+5+11+2+*).

Lr-genes

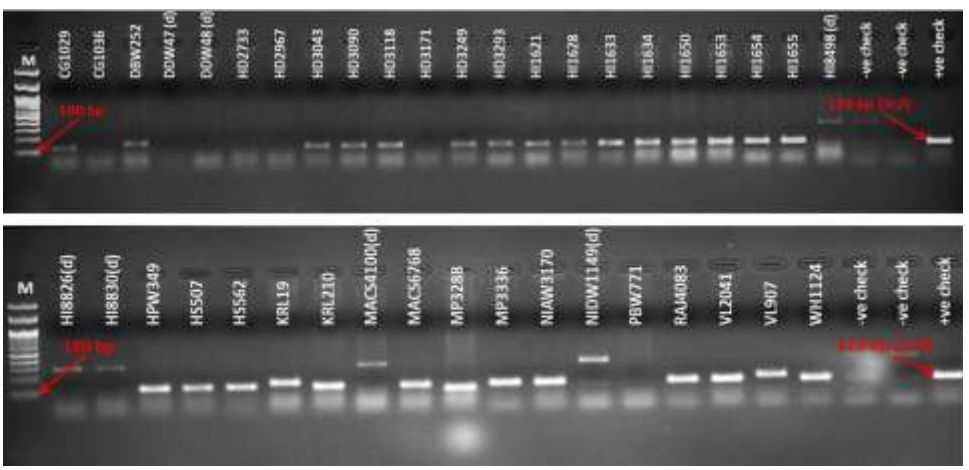
Eight *Lr* genes viz. *Lr1*, *Lr3*, *Lr10*, *Lr13*, *Lr23*, *Lr24*, *Lr26*, and *Lr28* were characterized in 100 AVT lines. *Lr13* was the most commonly occurring leaf rust resistance and was characterized in highest number of lines (68) followed by *Lr10* (45 lines), *Lr1* (22 lines), and *Lr23* (20 lines). *Lr24* was postulated in 03 entries. *Lr26* and *Lr3* were characterized in seven and four entries, respectively. *Lr28* was postulated in three entries (HD3469, HI1669, and K1317). Majority of the genes occurred in combination and many of the lines have leaf rust resistance derived from 3 or more *Lr* genes. Diversity of rust resistance genes in advanced wheat material (AVT) is given here.

Diversity for rust resistance genes in AVT lines

Rust	No. of lines	Number of genes inferred: Details of resistance genes
Stripe	78	Three: *Yr2, 9, A*
Leaf	100	Eight: *Lr1, Lr3, Lr10, Lr13, Lr23, Lr24, Lr26, and Lr28*
Stem	193	Thirteen: *Sr2, Sr5, Sr7b, Sr8a, Sr8b, Sr9b, Sr9e, Sr11, Sr13, Sr24, Sr28, Sr30 and Sr31*

Screening of Wheat Varieties for Stem Resistance Genes Presence Using Molecular Markers

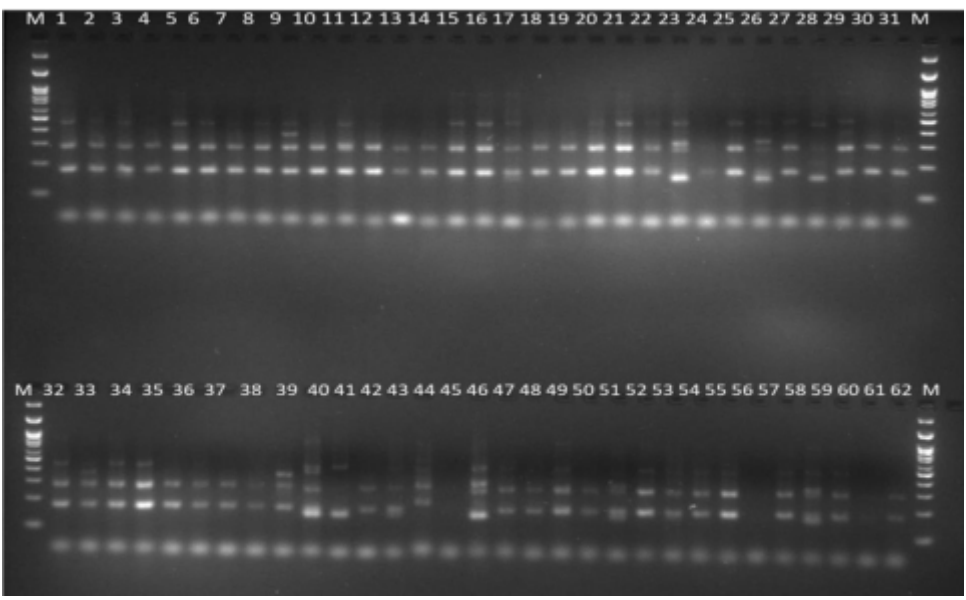
Recently released forty wheat varieties were screened to identify the presence of four slow rusting/APR genes (*Sr2/Yr30*, *Sr57/Lr34/Yr18*, *Sr58/Lr46/Yr29*, *Sr55/Lr67/Yr46*) and three all stage (ASR) *Sr* genes (*Sr24/Lr24*, *Sr31/Lr26/Yr9*, and *Sr38/Lr37/Yr17*) using closely linked molecular markers to these genes. This study indicated the presence of six *Sr* genes (*Sr2*, *Sr57*, *Sr58*, *Sr24*, *Sr31*, and *Sr38*) in 35 varieties. The APR gene *Sr55* was not identified in any of the varieties with CFD71 marker. *Sr2* gene linked marker (*Xgwm*533) indicated the presence of this gene in 24 varieties. Other APR genes i.e. *Sr58* and *Sr57* were confirmed in three and nine varieties, respectively. While the ASR genes *Sr24*, *Sr31*, and *Sr38* were identified in three, six, and eight varieties, respectively.



Amplification profiles of forty wheat varieties against *Sr2* linked SSR marker *Xgwm*533 on agarose gel. M: 100 bp ladder (HiMedia Laboratory Pvt. Ltd., India); 1-40: wheat varieties; -ve: negative checks for *Sr2* (RAJ4238, K1001); -+ve: positive check for *Sr2*(UAS428). The 120 bp fragments indicate presence of *Sr2*.

Population Diversity, Dynamics and Differentiation of Puccinia spp.

Sixty-two leaf rust samples collected from eight Indian states and Nepal were pathotyped on differential set and investigated for the population diversity, dynamics, and differentiation with the help of twenty-five *P. triticina* specific simple sequence repeat markers. Total eight primer pairs showed polymorphism with these field isolates among 25 SSR primers tested. The number of alleles per primer pair varied from 1 to 6. Amplification product sizes of these primers varied between 0.1 and 0.08 kb. Primer pair SSR-P TATTG-60 generated the highest number (6) of alleles. Reproducible and clear bands were scored for analysis. Particular band size was scored for each of the amplified bands using Jaccard's similarity coefficient (Jaccard, 1908). Cluster analysis was carried out based on a neighbor-joining algorithm using the UPGMA (unweighted pair group method with arithmetic averages) in DARwin6.0.21 software and dendrogram was generated by using a similarity matrix. An unrooted dendrogram generated by unweighted NJ cluster analysis grouped *P. triticina* isolates into three major clusters.



Electrophoresis on 3% agarose gel showing the pattern of SSR-P CAC-45 on sixty-two pathogenic isolates of *P. triticina*. 1 to 62: isolates of *P. triticina* and M: 100 bp DNA ladder.

Genetics of Rust Resistance

CebadaCapa (*Rph7*), Trumph (*Rph12*) and Magnif104 (*Rph5*) were crossed with RD3028, BH1035, VL173, KB1926, RD3089, RD3013, RD3016, and PL908 in different combinations for the purpose of developing brown rust resistant genetic stocks of barley. Seventeen different cross populations were advanced to F_3 generation for the development brown, yellow and black rusts resistant genetic stocks. For the study of genetic analysis of brown and black rusts, populations of four crosses HI1563×Agra Local, HD3043×Agra Local, HI8627×A-9-30-1 and A-9-30-1×HI8807 were advanced to F_4 generation.

Wheat Disease Monitoring/ SAARC Nursery

The 55th Wheat disease monitoring nursery (WDMN) was planted at 40 strategic locations covering all the major wheat growing areas in the country, especially those situated near the bordering areas to the neighboring countries. Data have been received from 30 locations. Yellow rust was noticed at all the locations of NHZ and NWPZ except at IIWBR, RS, Shimla. All the entries of WDMN in other zones were free from yellow rust. Yellow rust was very severe at many locations in NWPZ and NHZ, where severity of more than 60S was reported on many entries. Brown rust was reported from Almora and Shimla in NHZ; and Rajouri, Kathua, Jammu, Hisar, Durgapura, Abohar, Gurdaspur, Ludhiana, and Pantnagar in NWPZ. Brown rust appeared only at Sabour and Faizabad in NEPZ. It was observed at Raipur, Vijapur, and Powarkheda in CZ. Brown rust also appeared at Pune and Dharwad in PZ, and Wellington in SHZ. Of the 30 locations of WDMN black rust was observed only at Wellington and all the entries were black rust free in all other zones. SAARC wheat disease monitoring nursery was planted at 31 locations in India, Bangladesh, Bhutan, Nepal, Afghanistan and Pakistan. Information on wheat diseases in SAARC Wheat Disease Monitoring Nursery has been received from 15 locations in India and four locations in Bangladesh.

National Repository of Pathotypes of Puccinia species on Cereals

A total of 150 pathotypes (races) 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 the same were also conserved in liquid nitrogen (-196°C). 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 49 scientists/researchers.

Utilization of Resistant Sources

The NGSN comprising 15 entries with confirmed sources of high level of disease resistance were shared with 30 breeding centres across different agro climatic zones of the country for their utilization in breeding for resistance to biotic stresses. The utilization was upto 60% by different centres. The entries utilized at most of the centres were HI 1544, HS 681, DBW 342 and RAJ 4541. Durgapur centre utilized maximum nine entries in their breeding programme followed by Cooch behar and Sagar.

Management of Diseases Through Chemicals

Field trials for the evaluation of efficacy of six chemical fungicide combinations *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%), Azoxystrobin 11% + Tebuconazole 18.3% w/w SC (0.1%), along with standard recommended fungicides [Propiconazole (0.1%) and Tebuconazole (0.1%) were performed in randomized block design with three replications for the management of head scab, leaf rust, stem rust and leaf blight during the cropping season 2022-23 at different locations. Azoxystrobin 18.2% w/w + Cyproconazole 7.3% w/w SC @ 0.1% was found most effective against head scab of wheat, when tested at two different locations. Similarity, Tebuconazole 50% + Trifloxystrobin 25%

WG @0.06% showed maximum disease reduction against both leaf rust and stem rust diseases across the locations. In case of leaf blight, Azoxystrobin 12.5% + Tebuconazole 12.5% @0.1% was the best performing fungicide across the seven locations. No phytotoxicity was recorded with any of the tested concentrations of fungicides on wheat plants.

Advisory for Stripe Rust Management

During the current season 2022-23, the weather remained congenial in the month of January for yellow rust in NWPZ. However disease severity remained low due to development of resistant varieties. Timely advisories for stripe rust and Karnal bunt disease management 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 2022-23 in North and South West Bengal near Indo-Bangladesh borders by teams of scientists from ICAR-IIWBR, Karnal, UBKV, Cooch Behar and BCKV, Kalyani, Nadia and no wheat blast was observed. Awareness was also created among farmers to take all preventative measures available against wheat blast and to grow the recommended resistant varieties. For identification of wheat blast resistant sources, advance breeding lines and potential germplasm were screened at Jessore, Bangladesh through, CIMMYT. A total of 350 entries were screened against wheat blast at Jessore at two different dates of sowing during 2022-23.

Post-harvest Surveys for Karnal Bunt

A total of 7997 grain samples collected from various mandies in different zones were analyzed at cooperating centres. The overall 15.41% samples were found infected. The samples from Rajasthan showed maximum infection (34.99%). In general the Karnal bunt infection was less in comparison to previous year.

Karnal bunt situation in the country during 2022-23 crop season

State	Total Samples	Infected Samples	Infected samples (%)	Range of infection (%)
Punjab	2521	188	7.46	0.00-0.292
Haryana	2281	488	21.39	0.00-0.85
Rajasthan	403	141	34.99	0.10-4.8
Uttrakhand	1534	416	27.11	0.01-0.75
Gujarat	574	0	--	--
Madhya Pradesh	406	0	--	--
Maharashtra	228	0	--	--
Karnataka	50	0	--	--
Total	**7997**	**1233**	**15.41**	**0.00-4.8**

Training for Human Resource Development

To bring more uniformity in disease creation and data recording, training was organized on "Precise and uniform data recording and reporting in wheat and barley crop protection trials" from February 22-24, 2023 at ICAR-IIWBR, Karnal. The scientists and technical workers of research institutes and private companies involved in disease and insect pest recording participated in the training progarmme.

ENTOMOLOGY

Survey and Surveillance for Insect Pests

- In order to monitor the insect pest of wheat and barley, a survey of Punjab state were undertaken during 2022-23 crop season. The aphid incidence was below economic threshold level in most parts of Punjab during the months of February-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 2022-23 crop year except for few minor infestations.
- In Maharashtra state, survey was carried out in the villages of Nashik viz., Talegaon, Avankhede, Ozarkhed, Ambaner, Sajola and Khirad at different wheat crop stages on farmer's field during the February 2023. Fifty-eight samples with medium incidence of aphid were

recorded during the survey. The Coccinellids larvae, beetles & *Chrysoper lacarnea* predator adults were also observed. The incidence of stem borer and jassids were recorded to be of low intensity.

- In Gujarat state, surveys were conducted to insect pest situation in wheat crop during Rabi 2022-23. The termite damage in wheat fields was recorded below 1 % across the area surveyed. The incidence of aphid was observed to be 0.5 to 1% 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 Kanpur, survey was conducted in various villages viz., Araul, Daleep Nagar, Magharwara, Kundi, Devpura, Jahanabad during 2022-23. Incidence of shootfly was recorded between 1 to 1.66 at these locations. The incidence of termite was observed 13 per cent on wheat varieties viz., PBW343 and HUW234 at Daleep Nagar. However, it was 10% in locations Magharwara, Kundi, Devpura, Jahanabad on variety HD2967. High infestation (30-35 aphid/tiller) of foliar aphid was recorded on barley variety namely, 'Barley Local' at surveyed locations. The higher incidence of pink stem borer (13.3%) was observed in irrigated crop of variety HD2967 at Daleep Nagar.
- Moderate to severe incidence of foliar wheat aphid was observed in Karnal district of Haryana. The minor damage of termite and root aphids was also observed in early period of crop growth in Karnal and its nearby locations Kunjpura, Kathial, Raisina and Hajwna. In some fields, incidences of pink stem borer were observed in early (December month) and later in the season (March month). The grubs and adults of coccinellid beetles were seen frequently in fields infested with aphids. This year incidence of aphids, termites, pink stem borer and army worm was reported to be low (1-2%). Termites and root aphid was reported to be around 1-2% during November and December. Aphid infestation started appearing in the month of January and the population in the beginning was around 2-5 aphids/tiller but in February, higher infestation of aphids (20-25 aphids/tiller on an average) was observed 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 of 5.42% of shoot fly was reported in entry NIAW4120. However, the highest shoot fly infestation index of 19.02% was recorded in entry UP3102. At Ludhiana centre, lowest infestation index of 4.26% was reported on PBW891 and highest infestation index of 8.51% on Sonalika. At Dharwad location, the lowest shootfly index (1.56%) was recorded on entry HI1612(C) while highest infestation (37.88%) was observed on UP3102. At Kanpur location, lowest infestation 3.33 % was observed on MACS3949(d)(C) and highest infestation of 21.87% was recorded on entry MP1378.

Brown Wheat Mite: At Ludhiana, entry MP1386 recorded the minimum mite population of 8.33/10 cm^2 area while maximum mite population of 17.33 /10 cm^2 was recorded in entry Sonalika. This seasonal incidence of mite was very low at Durgapura and Kanpur locations; therefore data of mite incidence was not included.

Foliar Aphid: Based on the average score of aphids at four locations; Ludhiana, Karnal, Niphad and Pusa, seven entries viz., HI1612(C), HD3059(C), DBW252(C), MP3288(C), HI1655(C), MACS6811 and DBW395 scored an average score of below 3.5 and were in moderately resistance category (grade 3). Location-wise, at Ludhiana centre three entries, HI1650(C), MP3288(C) & HI1655(C) and eleven entries at Karnal centre viz., HD3249(C), PBW826(C), DBW398, GW513(C), HI1650(C), MP3288(C), DBW110(C), HI1655(C), NIDW1149(d)(C), DBW380 and CG1044 were found to be in moderately resistance category (grade 3). At Niphad, five entries, HD3171(C), HI1669, MP4010(C), HI1634(C) and NIAW4153 were found to be of resistance category (grade 2) where as at Pusa, twelve entries showed resistance response (grade 2). 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, Kharibari, Pantnagar, and Khudwani was recorded to be very low and therefore data was rejected.

Root aphid: Out of total 134 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 was lowest (7.69%) in entry HD3392 and the maximum score of 18.50% was recorded for HI8839(d). The lowest population of 9.00 brown wheat mites/10 cm^2 was recorded in entry HD3438 while Sonalika had highest population of 15.67 mites/10 cm^2 at Ludhiana. Based on average score of four locations (Ludhiana, Karnal, Pusa and Niphad), 8 entries NIAW4028, HI1655Q, WHD 965 (d), PBW902, GW547, GW532, VL2043 and HPW 489 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 wheat crop (first fortnight of Nov 2022) 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. 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 week (SMW) of 2023 in all sowing dates. The root aphid appeared in the early growing season and its attack was observed on 3-5 week old crop.

- 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. The data revealed that pink stem borer incidence was significantly higher in all residue management conditions as compared to conventional tillage conditions. Its 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.
- Studies on the population dynamics of foliar aphids on wheat and barley crops showed that the population of aphids on the barley crop was significantly larger than that on the wheat crop. Following the height of the aphid infestation on the wheat and barley crop, the coccinellid beetle began to emerge.
- Effect of silicon application in the form sodium meta-silicate@ 10, 30 and 50 g/litre was tested along with one and two sprays of Actara (Thiamethoxam 25WG) @ 50 g/ha to determine the effect on aphid abundance and their coccinellid predators in wheat. It was found one or two foliar applications of sodium meta-silicate have little effect on aphid population. Although some reduction in aphid 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.
- Seed treatments with different insecticides are recommended for the control of termites in wheat. Farmers are also applying hydrogel near root zone of the crop at the time of sowing or at tillering stage in order to slowly release the soil moisture to plant. As the time of

application of insecticide for termites control coincides with hydrogel application, keeping in view, an experiment was conducted to study their compatibility with each other. 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. Among the different insecticide seed treatments, termites damage was lowest in goondKatira (5kg/ha) + neonix @ 2 ml/kg of seed after 3-6 weeks of sowing. Whereas among the soil application, it was minimum in goond Katira (5kg/ha) + fipronil 0.6% GR when applied before 1st irrigation and it recorded lower termite damage (0.38-0.86%) after 4-6 weeks of sowing.

- Efficacy of Pymetrozine 50% WG at three doses viz., 80 g /ha, 100 g/ha and 120 g/ha was evaluated against foliar aphid and compared with already recommended insecticides i.e. Thiamethoxam 25% WG @12.5 g/ha, Imidacloprid 17.8 SL @100 ml/ha and Acetamiprid 20SP @100 g/ha. The results revealed that the treatment of pymetrozine 50 % EC @ 100 and 80 g a.i./ha and the treatment with thiamethoxam 25 % WG @ 12.5 g a.i./ha were found equally effective against foliar aphids and were found at par with each other.
- Evaluation of insecticides was carried out against lepidopterous pests (pink stem borer, army worm & cutworms) of wheat. The results indicated that the lowest damage was recorded in soil application of fipronil 0.6% GR @ 8 kg/ha followed by foliar application of chlorantraniliprole 18.5 SC @ 150 ml/ha. However, all insecticidal treatments were significantly better than untreated control.
- Seed treatment of two chemicals i.e. Neonix (Imidacloprid 18.5% + Hexaconazole 1.5% FS) @ 1.5 ml/kg seed and 2 ml/kg seed & Cruiser 70 WS (thiamethoxam) @ 1 ml and 2ml and soil application of fipronil 0.3 GR @15 kg/ha, 17.5 kg/ha and 20 kg/ha and

chlorpyriphos 20EC @ 2 L/ha, 2.5 L/ha and 3.0L/ha were evaluated for management of termites. Per cent damaged effective tillers/m row recorded after 3, 4 & 5 weeks of germination indicated that all treatments recorded significantly lower per cent damaged effective tillers/m row except lower dosage of fipronil 0.6 GR and chlorpyriphos 20 EC and untreated check. However, the lowest termite damage was recorded in Cruiser 70 WS@1.5 ml/kg of seed. At ear head stage, the per cent damaged effective tillers per meter row were also minimum in the Cruiser 70 WS@1.5 ml/kg of seed (0.97 %) treatment and it was on par with all the other treatments except lower dosage fipronil 0.6 GR and chlorpyriphos 20 EC and untreated check.

- Seed protectants viz., Neem oil (*Azadiractaindica*), Blue gum oil (*Eucalyptus globulus*), Karanj oil (*Pongamiapinnata*), Castor oil (*Ricinuscumunis*), Sweet flag (Vekhand) powder (*Acoruscalamus*), Turmeric Powder (*Curcuma longa*) and Diatomaceous earth were evaluated against storage insect pest i.e. *Sitophilusoryzae* of wheat. The results indicated that the treatment with Karanj oil (*Pongamiapinnata*) @ 15 ml/kg seed was found best effective treatment against *S. oryzae*. However, neem oil, blue gum oil @ 15 ml/kg seed treatments and the treatment with Sweet flag powder@ 5 g/kg seed were found equally effective and were at par with Karanj oil treatment.
- The integrated pest modules were evaluated in four locations, including Karnal, Ludhiana, Niphad, and Kanpur, against the key wheat pests such as foliar aphids, shootflies, termites, and pink stem borer. The results showed that the IPM module treatment significantly reduced pest populations as compared to farmer practise (FP). The population of natural enemies was, however, somewhat greater in the FP treatment than in the IPM treatment.

NEMATOLOGY

Resistance against Heterodera avenae

One hundred thirty four entries of AVT were screened for resistance against *H. avenae* (CCN) under sick plot conditions or pot condition at

Hisar and Durgapura centres. Two entries at Durgapura viz., VL2041(C) and PBW887 and four entries i.e. HS692, UP3111, NIAW4114 and LOK79 at Hisar showed moderate level of resistance to *H. avenae* (CCN)

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.

Survey for Nematode Incidence

Crop health monitoring survey of wheat and barley was done during March, 2023 in Rewari and Hisar districts of Haryana. Out of 42 samples, cereal cyst nematode (CCN) was reported from 18 samples. Number of cysts ranged from 2-22 per 200 cc soil. Plant parasitic nematodes present in 200 cc soil samples were *Pratylenchus* sp., *Tylenchorhynchus* sp., *Hoplolaimus* sp., *Helicotylenchus* sp., Criconematids etc. Wheat seed gall nematode (*Anguinatritici*) and rice root-knot nematode (*Meloidogyne graminicola*) were not recorded from these samples.

RESOURCE MANAGEMENT

The Resource Management group of the "All India Coordinated Wheat and Barley Improvement Project" (AICW&BIP), in addition to evaluating the performance of newly developed genotypes, is also actively engaged in developing and refining the eco- friendly, location-specific and cost-effective wheat production technologies for higher productivity and profitability to the farmers. The work on input responsive technologies is being executed through special trials depending on the priorities of various wheat growing zones.

In four wheat growing zones, eight varietal evaluation trial series were conducted at 52 locations under different growing conditions. The newly developed genotypes were evaluated against the existing varieties used as checks. In addition, five special coordinated trials were also conducted at 68 locations to address the zonal / across the zone problems and priorities.
In total, 52 trials were proposed and all were conducted. Out of the conducted trials, nine trials were not included into pooled analysis due to low yield and improper data reporting.

Zone-wise details of the coordinated varietal evaluation trials

Trial Series	Locations	Trials	Trials not conducted		Rejected	
		conducted	Number	Centres	Number	Centres
North Western Plain Zone						
IR-DOS-LS	10	10	-	-	02	Durgapura, Jammu
RIR-TS-TAS	10	10	-	-	02	Durgapura, Sriganganagar
Total	**20**	**20**			**04**	
North Eastern Plain Zone						
IR-DOS-TS	09	09			03	RPCAU Pusa, Sabour, Shillongani
Total	**09**	**09**			**03**	
Central Zone						
IR-DOS-TAD	07	07			01	Bilaspur
RIR-TS-TAD	05	05				
SPL-IR-ES-HYPT	04	04				
Total	**16**	**16**			**01**	
Peninsular Zone						
IR-TS-DOS-TAD	04	04			01	Akola
RIR-TS-TAD	03	03				
Total	**07**	**07**			**01**	
Grand Total	**52**	**52**			**09**	

The performance of different entries in various zones is highlighted against the best check varieties. None of entries performed significantly better than the best check in any zones/trials. In NWPZ, entry HD 3386 was numerically better than the best check variety PBW 826 in date of sowing trial and in CZ under high yield potential trial, test entry DBW 377 was numerically better than the best check variety DBW 187.

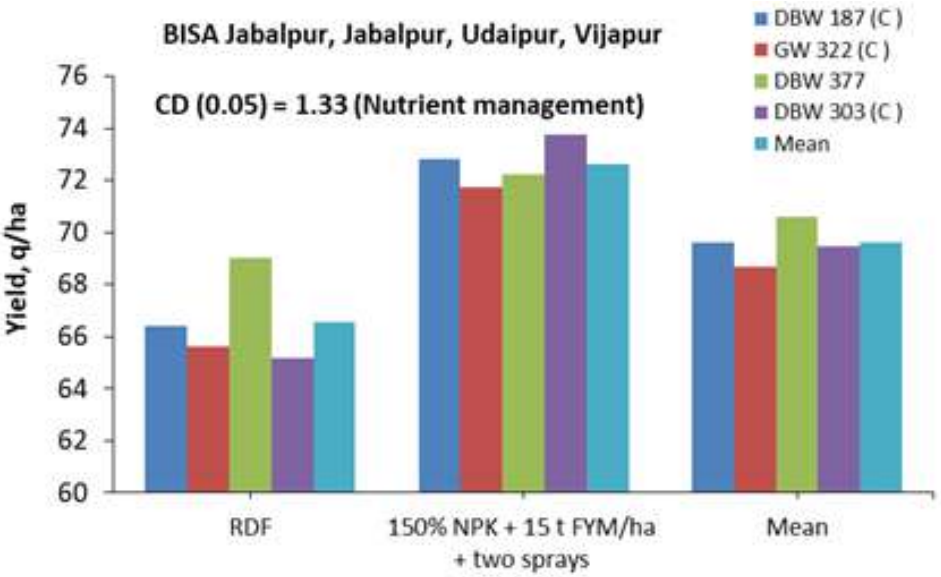
Performance of new genotypes in various agro-climatic zones

Zone wise trial	Test entries	Entry showing superiority		check	Best gain(%)	Yield	Locations
		Numerical	Significant				
North Western Plain Zone							
IR-TS-DOS-TAS	HD 3386	HD3386	-	PBW 826	-	08	
RIR-TS-TAS	WH1402	-	-	HI 1653	-	08	
North Eastern Plain Zone							
IR-TS-DOS-TAS	HD 3388	-	-	PBW 826	-	06	
Central Zone							
IR-TS-DOS-TAD	GW 547, NWS 2194	-	-	MACS 6768		-	06
RIR-TS-TAD	DBW 359, CG 1040	-	-	CG 1036	-	05	
SPL-IR-ES-HYPT	DBW 377	DBW 377	-	DBW 187	-	04	
Peninsular Zone							
IR-TS-DOS-TAD	MP 1378	HI8826(d)	-	HI 8826	-	03	
IR-LS-DOS-TAS	NIAW 4028, DBW 359, HI 1665, HI 8840 (d)	-	-	NIAW 3170		-	03

High Yield Potential Trial in CZ

This experiment was conducted to maximise the wheat yield using higher level of inorganic and organic fertilizers and spraying of growth retardant for control of lodging. The trial was conducted at four centres namely BISA Jabalpur, Jabalpur, Udaipur and Vijapur. The pooled analysis showed significant effect of fertilizer application and growth regulators on grain yield and yield attributes. The grain yield enhanced significantly with increasing fertilizer doses. Addition of 15t FYM/ha with 150% RDF significantly increased the grain yield (72.62 q/ha) as compared to RDF (66.56 q/ha). This increase was to the tune of 9.1% as compared with RDF. The application of growth retardant

significantly decreased plant height (86.3 cm) over no use of growth retardant (93.4 cm). This showed that growth retardant in combination with fungicide tebuconazole was effective for control of lodging and enhancing the grain yield owing to more tillering. On mean basis DBW 377 recorded highest grain yield (70.62 q/ha).



Maximizing the wheat productivity through fertilizer management in CZ

Efficacy of Herbicides against Diverse Weed Flora of Wheat

Weeds are major problem in wheat production. Chemical weed control is preferred over other weed control methods in wheat. Moreover, wheat is infested with diverse weed flora and for control of complex weed flora herbicide combinations are required. Therefore, keeping these in view an experiment involving twelve weed control treatments was conducted across zones at 16 locations.

In NHZ, this trial was conducted at two locations (Bajaura and Malan). The pooled analysed yield and yield attributes data of two centres revealed the maximum grain yield (42.93 q/ha) with pre-emergence tank mix combination of pendimethalin + metribuzin at 1250 + 280 g/ha followed by with pre-emergence tank mix combination of pendimethalin + pyroxasulfone at 1250 + 127.5 g/ha. The lowest weed density and dry weight were recorded with pre-emergence tank mix

combination of pendimethalin + metribuzin at 1250 + 280 g/ha.

In NWPZ, this trial was conducted at five centres namely Durgapura, Gurdaspur, Hisar, Jammu and Ludhiana. The herbicide application produced significant effect on grain yield. The highest yield was obtained under weed free situation (55.50 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 pendimethalin + pyroxasulfone 1250+ 127.5 g/ha showed the least number of weed count of 12.5 and weed dry weight of 18.1 g/ sq. m. at 90 DAS. Pyroxasulfone applied at early post emergence was also found effective in reducing the population and dry weight of weeds.

In NEPZ, this experiment was conducted at four locations (Ayodhya, Ranchi, RPCAU Pusa and Shillongani). The maximum grain yield (52.87 q/ha) was obtained in weed free condition followed by treatments having pre-emergence tank mix application of pyroxasulfone + metribuzin @127.5 + 280 g a.i./ha, pre-emergnece tank mix application of pendimethalin + pyroxasulfone @ 1250 + 127.5 g a.i./ha and early post emergence tank mix application of pyroxasulfone+ metsulfuron @ 127.5 + 4 g a.i./ha. The weed count and weed dry weight at all growth stages reduced significantly by pre-emergence tank mix application of pyroxasulfone + metribuzin @127.5 + 280 g a.i./ha and early post emergence tank mix application of pyroxasulfone+ metsulfuron @ 127.5 + 4 g a.i./ha.

In CZ, this trial was conducted at three centres namely Indore, Powarkheda and Udaipur. The highest yield was obtained under weed free situation (55.30 q/ha). Among herbicides, EPOST Pyroxa + metsul @ 127.5 + 4 g/ha showed the least number of weed count of 15.8 and weed dry weight of 24.6 g/ sq. m. at 90 DAS.

In PZ, this trial was conducted at Dharwad and Pune centres. Pyroxa + metsulfuron 127.5+4 g/ha treatment produced the maximum grain yield (49.91 q/ha) followed by 49.29 q/ha under PE Pendi + Pyroxa @ 1250 + 127.5 g/ha treatment. Pre-emergence application of Pyroxa +

metsulfuron 127.5+4 g/ha resulted into minimum weed count (23.83) and weed dry weight (8.7 g/sq.m.).

Wheat Productivity with Nano Urea Under Irrigated Condition

This experiment was conducted to explore the possibility of maximizing wheat productivity by integrated use of nano urea. The experiment was laid out in randomized complete block design with thirteen treatments viz. control (No N) and 50, 75 and 100% of Recommended N rates along with either one spray of nano urea or two spray of nano urea or two spray of urea. One third nitrogen as per treatment, full phosphorus and potash as basal dose and the remaining 2/3rd nitrogen 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, Durgapura, Gurdaspur, Hisar, Jammu, Karnal, Ludhiana and Pantnagar). The application of recommended N and two spray of nano urea at tillering and jointing stage produced the maximum grain yield of 53.91 q/ha. However, the grain yield with recommended N + two spray of simple urea (5%) at tillering and jointing stage (53.44 q/ha), recommended N + one spray of nano urea at tillering (52.81 q/ha), 75% recommended N with two nano spray and 75% recommended N with two 5% urea spray were at par with recommended N + two sprays of nano urea. The addition of two spray of nano urea at tillering and jointing stage with recommended N fertilization brought an increase of 6.2% in grain yield over recommended N treatment.

In NEPZ, this experiment was conducted at five locations (Burdwan, Coochbehar, Ranchi, Sabour and Varanasi). The maximum grain yield (48.62 q/ha) was obtained under recommended N dose + two spray of nano urea at tillering and jointing stage treatment; however, it was statistically at par to recommended N dose + two spray of urea (5%) at tillering and jointing stage. The grain yield under recommended N dose + two spray of nano urea at tillering and jointing stage was

significantly higher than all other treatments except recommended N dose + two spray of urea (5%) at tillering and jointing stage.

In CZ, this experiment was conducted at four locations (Gwalior, Indore, Junagarh and Vijapur). The application of recommended N and two 5% urea spray at tillering and jointing stage produced the maximum grain yield of 55.8 q/ha which was at par with recommended N + two nano urea spray at tillering and jointing stage (55.4 q/ha), recommended N + two water spray (54.6 q/ha) and recommended N + one nano urea spray at tillering stage (54.3 q/ha).

In PZ, this experiment was conducted at three locations (Dharwad, Niphad and Pune). Recommended N and two spray of nano urea at tillering and jointing stage produced the maximum grain yield of 48.73q/ha. However, the grain yield with recommended N and two spray of urea (5%) at tillering and joining stage was (48.07 q/ha) which was at par to two spray of nano urea. The addition of two spray of nano urea at tillering and joinitng stage with recommended N fertilization brought an increase of 11.07% in grain yield over base treatment.

Wheat Productivity with Nano Urea Under Restricted Irrigation

This experiment was conducted to explore the possibility of maximizing wheat productivity through sole and integrated use of nano urea with recommended N under restricted irrigation. The experiment was conducted in randomized complete block design with nine treatments viz. control (no N), control + nano urea spray (one and two), recommended N, recommended N + one (at tillering) and two spray (tillering and jointing) of nano urea and urea (5%) and recommended N + one spray of nano urea at tillering + one spray of urea (5%) at jointing stage. One third nitrogen as per treatment was applied as basal dose and the remaining 2/3rd nitrogen at CRI stage of wheat. Weed control measures were followed as per recommended package of practices for the concerned zone.

In NHZ, this trial was conducted at two locations namely Bajaura and Malan. The highest grain yield (41.06 q/ha) was obtained by applying recommended dose of N along with spray of urea (5%) + nano urea at tillering stage. Also, compared to recommended N, one or two spray of either nano urea or urea did not significantly improve the grain yield.

In NWPZ, this experiment was conducted at three locations (Hisar, Karnal and Pantnagar). The application of recommended N {Rec N (1/3rd basal, 2/3rd CRI)} and two spray of 5% urea at tillering and jointing stage produced the maximum grain yield of 51.47 q/ha and it was statistically at par with recommended N and one spray of 5% urea + one spray of nano urea at tillering stage(49.57 q/ha) but was significantly superior to rest of the treatments.

In NEPZ, this experiment was conducted at four locations (Burdwan, Kanpur, RPCAU Pusa and Shillongani). The maximum grain yield (45.24 q/ha) was obtained under recommended N + two spray of urea (5%) at tillering and jointing stage treatment and it was significantly higher than all treatments except recommended N + one spray of urea (5%) at tillering + one spray of nano urea at jointing stage.

In CZ, this experiment was conducted at four locations (Gwalior, Indore, Udaipur and Vijapur). The application of recommended N (1/3rd basal, 2/3rd CRI) and two spray of nano urea at tillering and jointing stage produced the maximum grain yield of 42.4q/ha. It was statistically at par with recommended N + one urea (5%) + nano urea spray at tillering, recommended N + two urea (5%) spray at tillering and jointing and recommended N + one urea (5%) spray at tillering but was significantly superior to rest of the treatments.

Agronomic Interventions for Quality Enhancement in Wheat

This trial was conducted with an objective to enhance quality of wheat varieties by foliar spray of sulphur (S), nitrogen (N), zinc (Zn), potash (K) and their combinations. The experiment was conducted with four genotypes (HD 3226, HI 1544, DBW 187, and PBW 1 Zn) and six

combinations of foliar fertilization.

In NWPZ, this trial was conducted at four centres (Gurdaspur, Hisar, Ludhiana and Pantnagar). The maximum mean grain yield (60.03 q/ha) was produced under the treatment of 2% urea spray, which remained statistically significant over all other treatments. Among varieties, DBW187 produced the maximum and significantly higher grain yield (60.28 q/ha) than all the other varieties. Maximum iron (Fe) content (40.99 ppm) and Zn (36.62 ppm) were recorded in PBW 1 Zn genotype. However, there was no significant difference due to varieties. Among foliar sprays, maximum zinc content (38.40 ppm) was observed in treatment of foliar fertilization Zn followed by the treatment of S(38.83ppm). Maximum protein content (11.99%) was recorded in genotype HD 3226. Among foliar fertilization, maximum protein was recorded in 2% urea application, which was at par with all the treatments except 1% KCl spray.

WHEAT QUALITY

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 uppermost 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 2022-23, 146 entries of AVTs, 280 of NIVTs, 13 of HYPT and 26 of IVT were analyzed from different zones and growing conditions.

AVT/HYPT

All the second year AVT entries including checks were subjected to baking evaluation for chapati, bread, biscuit, 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 given below.

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

Category	Genotypes
Check	DBW222 (C) (NEPZ-ITS), HI1650(I) (C) (CZ-ITS), MACS6768(I) (C) (CZ-ITS), HI1636 (C) (CZ-ITS), CG1036(I) (C) (CZ-RITS)
AVT	HD3388* (NEPZ-ITS), GW547* (CZ-ITS), CG1040*(CZ-RITS)

Promising *T. aestivum* genotypes for bread (Loaf volume ~590 ml)

Category	Genotype
Check	DBW296 (C) (NWPZ-RITS), HI1654(I) (C) (NWPZ-RITS), HD2967 (C) (NEPZ-ITS)
AVT	WH1402* (NWPZ-RITS)

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

Category	Genotypes
Check	DBW296 (C) (NWPZ-RITS), HI1654(I) (C) (NWPZ-RITS), NIAW3170 (C) (NWPZ-RITS), NIAW3170 (C) (PZ-RITS)
AVT	NIL

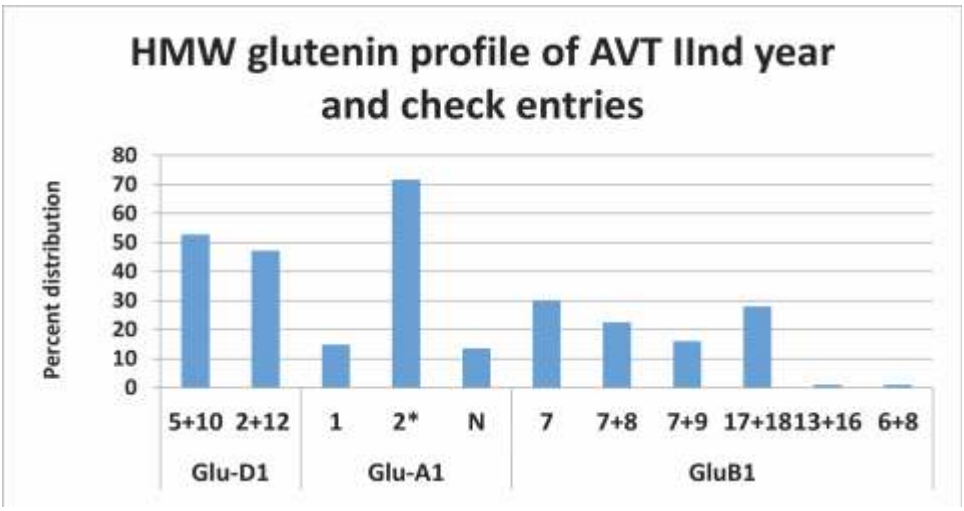
Promising Genotypes for Various Quality Parameters

Parameter	Value	Genotypes
		(T. aestivum)
Protein	**>12.5%**	**NHZ :** NIL **NWPZ:** DBW173 (C), HD3059 (C), PBW771 (C), K2108, PBW893, HD3428, **NEPZ:** NIL **CZ :** GW547*, MP3557, **PZ :** MP1378*, DBW187 (C), MACS6222 (C), PBW891, NIAW4153, HD3469, AKAW5100, DBW444, WH1306, MACS6809, AKAW5314, NIAW4183, PWU15, UAS3021, MP1386, NWS2222, DBW443, HD3090 (C), HD2932 (C), RAJ4083 (C), HI1633 (C), MP1388, GW538, DBW395, MACS6805, HI1672, HI1674, LOK79, HI1675, UAS3022, MP3557, NIAW4120, GW542, MP3556, PBW897, WH1310, HI1673, MACS6814, NIAW4114, DBW394, NIAW4028*, DBW359*, HI1665*, NIAW3170 (C), HI1605 (C), DBW397 **HYPT (NWPZ):** DBW187 (C), DBW372(I) (C), DBW380 **HYPT (CZ):** NIL
Sedimentation value	>60 ml	**NHZ :** NIL **NWPZ :** HD2967 (C), DBW187 (C), HD3086 (C), DBW222 (C), HD3470, UP3102, PBW887, HI1668, PBW889, HD3471, DBW173 (C), HD3059 (C), K2108, WH1402*, HI1654(I) (C), HD3369(I) (C), HI1653(I) (C), WH1311, DBW397, DBW398, **NEPZ :** HD3388*, PBW826(I) (C), DBW187 (C), HD3086 (C), DBW222 (C), HD2967 (C), HD3249 (C), HD3471, HD3470, DBW386, HI1612 (C), HD3171 (C), DBW252 (C) **CZ :** NWS2194*, MP3557, **PZ:** PBW891, HD3469, UAS3020, WH1306, MP3557, MP3556, PBW897, DBW394, NIAW4028*, DBW359*, HI1605 (C), **HYPT (NWPZ):** DBW187 (C), DBW303 (C), DBW380 **HYPT (CZ):** NIL
Hardness Index	**< 35**	**NHZ :** VL2041(I) (C) NWPZ : DBW296 (C), HI1654(I) (C), NIAW3170 (C), **NEPZ:** NIL **CZ:** NIL **PZ:** NIL **HYPT:** NIL
Iron	**≥40ppm**	**NHZ :** VL892 (C), VL3028, HPW484, HS691 HS692, **NWPZ :** HD3386*, PBW889, PBW893, HD3428, DBW296 (C), HD3369(I) (C), DBW397, **NEPZ :** HD3086 (C), HD3249 (C), HI1612 (C), HD3171 (C), K1317 (C), HD3293 (C), DBW252 (C), DBW398, **CZ :** HI1675, DBW359*, DBW441, **PZ :** MP1378*, PBW891, HD3469, DBW444, UAS3020, WH1306, MACS6809, MP1386, RAJ4083 (C), HI1633 (C), GW538, MACS6805, HI1672, HI1674, AKAW5104, LOK79, HI1675, UAS3022, NIAW4120, MP3556, HI1673, MACS6814, NIAW4114, HI1665*, DBW397, **HYPT (NWPZ):** DBW371(I) (C), DBW380 **HYPT (CZ):** NIL
Zinc	**≥40ppm**	**NHZ :** HS692 **NWPZ :** HD3386*, HD2967 (C), HD3086 (C), PBW826(I) (C), HD3470, UP3102, PBW887, DBW386, PBW889, DBW173 (C), HD3059 (C), JKW261 (C), PBW771 (C), K2108, PBW893, HD3428, PBW644 (C), NIAW3170 (C), DBW397, DBW398 **NEPZ:** NIL **CZ :** GW547*, MACS6768(I) (C), GW322 (C), HI1669, UAS3020, HI1670, CG1029 (C), MP4010 (C), HI1634 (C), HI1674, HI1673, HI1675, MP3557, AKAW5104, **PZ :** MP1378*, MACS6222 (C), HD3469, AKAW5100, DBW444, MACS6809, PWU15, MP1386, DBW443, HD2932 (C), RAJ4083 (C), HI1633 (C), MP1388, GW538, DBW395, MACS6805, HI1672, HI1674, UAS3023, AKAW5104, HI1675, UAS3022, MP3557, MP3556, WH1310, HI1673, MACS6814, NIAW4114, DBW394, NIAW4028* , DBW359* , HI1665* , NIAW3170 (C), HI1605 (C), DBW397, **HYPT (NWPZ):** PBW872(I) (C), DBW371(I) (C), DBW187 (C), , DBW370(I) (C), DBW303 (C), DBW380 **HYPT (CZ):** NIL

Parameter	Value	Genotypes
		(T. durum)
Protein	>13.0%	PZ : UAS481(d),
Sedimentation value	≥ 40ml	PZ : MACS3949(d) (C), UAS478(d)*, UAS446(d) (C), DDW61(d)
Yellow Pigment	>7.0ppm	PZ: UAS478(d)*, UAS481(d), DDW61(d)
Iron	≥ 40ppm	PZ : HI8840(d)*, NIDW1149(d) (C)
Zinc	≥ 40ppm	PZ : MACS4100(d)(I) (C), MACS3949(d) (C), HI8826(d)(I) (C), HI8841(d), UAS478(d)*, HI8840(d)*, NIDW1149(d) (C), UAS446(d) (C), UAS481(d), DDW61(d)

High Molecular Weight Glutenin subunits (HMW-GS) of *T. aestivum entries*

Seventy-four (74) 2nd year AVT and HYPT entries including checks were evaluated for HMWGS composition from various sowing conditions of different zones of the country. Subunit 5+10 was present in 52.7 % of the total entries whereas 2+12 in 47.2 % entries, indicating greater frequency of 5+10 subunits in all the zones. Subunits 1, 2* and N were present in 14.8 %, 71.6 % and 13.5 % of the total entries, respectively. The subunits 7, 7+8, 7+9, 17+18, 13+16 and 6+8 were present in 35 %, 17.5 %, 16 %, 28 %, 1% and 1 %, respectively. Subunit 7 was present in greater frequency across all zones. The percent entries having Glu-1 score 4, 5, 6, 7, 8, 9 and 10 were 1, 1, 19, 12, 40.5, 2.7 and 23, respectively. Maximum entries had score of 8 and 10.



Distribution of HMW glutenin subunits

Ensuring Nutritional Quality Through Wheat-Based Blended Products

Wheat flour is used to prepare a large number of food products for human consumption. The health benefits of wheat flour can be further enhanced by blending it with the flours of other nutritious grains. Health essentially depends upon the food we consume. Nowadays, people have become more health conscious and now look for additional health benefits besides the basic nutrition from cereal-based food products. Functional foods target improvement in the physiological functions in the body, which are linked to the presence of specific food components and these foods are consumed as a part of the daily diet. Combining cereals with legumes and nutri-cereals might accentuate the nutritive value of the products. Grain legumes are fairly rich in protein content, minerals, bioactive compounds, vitamins and fibres. Millets are dry land and climate-smart crops grown in semi-arid and tropical regions and are rich in specific mineral components such as Ca in finger millet and Fe in pearl millet. Therefore, multigrain products are a recent trend in the market which attracts consumers. Soft wheat is the primary requirement of producing good quality biscuit by the baking industry and the technology was tested as per the international protocol. The addition of finger millet flour didn't cause appreciable reduction in spread factor. The work implied that chick pea, green gram, and finger millet can be incorporated into wheat flour up to 40% level while pearl millet and sorghum can be incorporated up to 30% level without considerably reducing the spread ratio. The addition will certainly enhance the nutritional profile of the biscuits.

Wheat Grading Standards Proposed for Improving Indian Wheat Quality for Export and Domestic Trade

India is the 2nd largest producer of wheat in the world and has the potential to export large quantity of wheat. Bread wheat is used mainly for chapati, bread, biscuit, cakes and noodles while durum is used for pasta products and dicoccum for some local products. Hard

amber wheat with medium strong gluten is used for chapati; hard wheat with high protein content and strong and extensible gluten for bread and soft wheat with low protein and weak gluten for biscuit and cakes. However each class has some common features for trading and accordingly grades can be made. There is a need to have grades for different classes of wheat for both domestic and international trade as well as procurement by the Government agencies.

High quality wheat (Grade I) should fetch a premium price and the subsequent grades should fetch correspondingly lower price or MSP. Premium price for high quality wheat will boost the export demand as well as domestic production. Farmers, if produce high quality wheat based on the demand and selling at premium can earn more profit than selling the 'dara' wheat (pooled produce irrespective of quality) at the support price. This will enhance the market share of Indian wheat in the international market besides staying ahead of international competitors. Followings are the grades proposed for both aestivum and durum wheat for tarde purposes. Apeda a government agency for export of food items can use the criteria of grades mentioned below for export purposes.

Bread wheat grading

S. no.	Grading standard	Grades				
		I	II	III	IV	V
1	Hectolitre Weight (Kg/hl) (Minimum)	76	74	72	70	68
2	Moisture content (%) (Maximum)	12	13	14	15	15
3	Foreign Matter (FM) (%)(Maximum)	0.5	0.8	1.5	3	6
4	Other Food Grain (OFG) (%)(Maximum)	0.5	1	2	3	5
5	Damaged Grains (DG) (%)(Maximum)	2	4	7	10	15
6	Shrivelled/Shrunken (%)(Maximum)	3	5	8	12	20
7	Weevilled Grains (WG) (%)(Maximum)	0.0	1	3	5	10
8	Other wheat grains (Maximum)	1	3	10	10	10
9	Ergot (%)(Maximum)	0.0	0.5	0.5	0.5	0.5
10	Karnal Bunt (Maximum)	0.0	0.0	1.0	3.0	3.0

Durum wheat grading

S. No.	Grading standard	Grades				
		I	II	III	IV	V
1	Hectolitre Weight (Kg/hl) (Minimum)	78	76	74	72	68
2	Moisture content (%)(Maximum)	12	13	14	15	15
3	Foreign Matter (FM) (%)(Maximum)	0.5	0.8	1.5	3	6
4	Other Food Grain (OFG) (%)(Maximum)	1	2	3	4	5
5	Damaged Grains (DG) (%)(Maximum)	2	3	5	7	10
6	Shrivelled/Shrunken (%)(Maximum)	3	4	6	8	10
7	Insect bored Grains (IBG) (%)(Maximum)	0.0	2	4	7	10
8	Other wheat grains (%)(Maximum)	1	2	4	7	10
9	Ergot (%)(Maximum)	0.0	0.5	0.5	0.5	0.5
10	Yellow pigment (ppm) (Minimum)	7	6	5	4	4

BARLEY

Barley is an important cereal and there is renewed interest in barley as it offers many health benefits because of the presence of functional ingredients in its grain. Barley as a staple food provides a sustainable solution to many chronic diseases. Barley has commercial value also as it is used in malting industry. The area and production of barley increased during 2022-23 as compared to 2021-22. The crop growth conditions during *Rabi* season 2022-23 were very good and all experiments were in good shape throughout the season. However, due to heavy rains in the second fortnight of March in NWPZ, the experiments faced some lodging at many locations but productivity was not affected much. The third advance estimate of production for 2022-23 has indicated 1.68 million tonnes production of barley grain in the country against the target of 2.25 million tonnes. Barley was grown in a 0.617 million hectare area with a productivity of 27.33q/ha. Rajasthan state continued to be having the largest area under barley cultivation (>54.0 % of total area) and highest production (>56.0 % of total production) of the country followed by Uttar Pradesh, Madhya Pradesh, and Himachal Pradesh. There is a significant increase in the area and production of barley in Haryana, Rajasthan, and M.P. during 2022-23 over the year 2021-22.

CROP IMPROVEMENT

Release of New Barley Varieties

HBL804 (Him Palam Jau 2), derived from a cross of DWRUB 74 x HBL316, a six-row hulled dual (feed & forage) purpose barley variety developed by CSKHPKV, Palampur has been released by State Variety Release Committee of Himachal Pradesh state for timely sown rainfed and irrigated conditions of mid & low hills of Himachal Pradesh. The mean grain yield of this variety was 25.95q/ha and 50.9 q/ha, under rainfed and irrigated conditions, respectively. The notification of this variety was made vide Govt. of India's Gazette Notification No S.O. 4065(E) dated 31st October 2022.

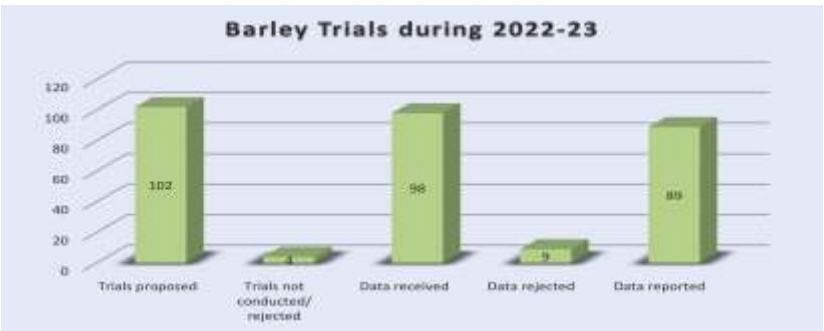
Registration of Barley Genetic Stocks:

Fifteen genetic stocks were registered with ICAR-NBPGR for their unique traits during the year 2022-23.

Genetic stocks registered with ICAR-NBPGR, New Delhi during 2022-23.

SN	Genotype	INGR No.	Parentage	Trait(s)	Developed by
1	DWRBG 7	22074	DL456/EIBON17	High bold grain proportion in six rowed hulless barley as indicated with higher 1000 g weight	ICAR-IIWBR, Karnal
2	DWRBG 8 (Tested as BCU 8028)	22075	Collection from Leh, Ladakh	Hulless barley with combination of high grain beta glucan (7%) and protein (16.6 %) content.	ICAR-IIWBR, Karnal
3	DWRB 189	22124	Selection from BH292 (BCU2336)	High anti-oxidant activity with unique black colour grains.	ICAR-IIWBR, Karnal
4	DWRBG-11 (Tested as bk 306)	22125	BK9811/DL472	Higher wort free amino nitrogen (FAN) content with higher malt diastatic power (DP).	ICAR-IIWBR, Karnal
5	DWRBG 9 (tested as HLR-20)	22126	C0118689	Hulled land race with resistance to Corn Leaf Aphid.	ICAR-IIWBR, Karnal
6	DWRBG 12 (Tested as BCU 6315)	22127	INT-15, Sterile Floret	Six rowed barley with low grain protein content and high malt diastatic power.	ICAR-IIWBR, Karnal
7	DWRBG 10 (tested as HLR-90)	22128	IC0356122	Hulless six-row land race with High ß-glucan and starch.	ICAR-IIWBR, Karnal
8	BHS 485 (BBM 839)	22129	HBL276/BHS369	Naked (hulless) barley, resistant to yellow rust and leaf rust at the adult plant stage, promising source of malt with protein and starch content.	ICAR-IARI RS, Shimla
9	BHS 486 (BBM 845)	22130	HBL276/BHS365	Possesses adult plant resistance to yellow rust and leaf rust. Resistant to all the pathotypes of brown rust at seedling stage except H4 race. Resistant to all pathotypes of yellow rust at seedling stage except for M and Q race whereby showing moderate susceptibility.	ICAR-IARI RS, Shimla
10	BHS 483 (BBM 833)	22131	BHS 352/ BHS 366	Naked (hulless) barley genotype. Resistant to yellow rust & leaf rust at the adult plant stage, moderately resistant reaction to all pathotypes of yellow rust at seedling stage (except for 24 and Q race showing MS reaction).	ICAR-IARI RS, Shimla

SN	Genotype	INGR No.	Parentage	Trait(s)	Developed by
11	DWRBG 2	21248	ICARDA 5	Barley genotype with high hectoliter weight (66.7 kg/hl) coupled with higher protein content 13.0 % (dwb) and bold grains (>2.5 mm size).	ICAR-IIWBR, Karnal
12	IC0138120	22132	Selection from IBON (1991-92) - 138-IC0138120	High test weight coupled with early maturity in two-rowed barley.	ICAR-NBPGR, New Delhi
13	DWRBG-13 (Tested as ICARDA 11)	22771	SEN/5/LEGACY/4/ TOCTE//GOB/ HUMAI10/3/ATAH 92/ALELI (PYT-15)	Higher malt beta glucanase activity (384 units/kg malt). Lower wort beta glucan content (130 ppm).	ICAR-IIWBR, Karnal
14	BHS 479 (BBM 798)	22280	BBM556/BHS169 //BHS369	Resistant to all the pathotypes of leaf rust and stripe rust at the seedling stage (except for race 24).	ICAR-IARI RS, Shimla
15	BHS 480 (BBM 803)	22279	BLG132/BHS369	Resistant to all pathotypes of leaf and stem rusts at the seedling stage (except for race 11).	ICAR-IARI RS, Shimla



- In all 89 test entries, contributed by 10 centres, were evaluated against 20 checks in the nine coordinated yield trials under rainfed (plains and hills), irrigated (plains) and saline soil conditions. The new barley entries include malt, food (hulless) feed or dual purposes types and mostly were hulled type with a few hull-less types in northern hills and plains.
- These trials were conducted at 11 main centres and 29 additional testing centres (including ICAR, SAUs and State Department of Agriculture) during *Rabi* 2022-23.
- Out of proposed 102 yield evaluation trials, 99 trials were conducted, as Gwalior centre did not conduct three trials. One trial at Berthin was rejected by the monitoring team due to a faulty layout. The data were received in time for 98 trials. After the analysis, only 89 trials (87.2% of proposed, 90.8% of received) were found good for reporting.

Promising Entries in AVT/IVTs during 2022-23

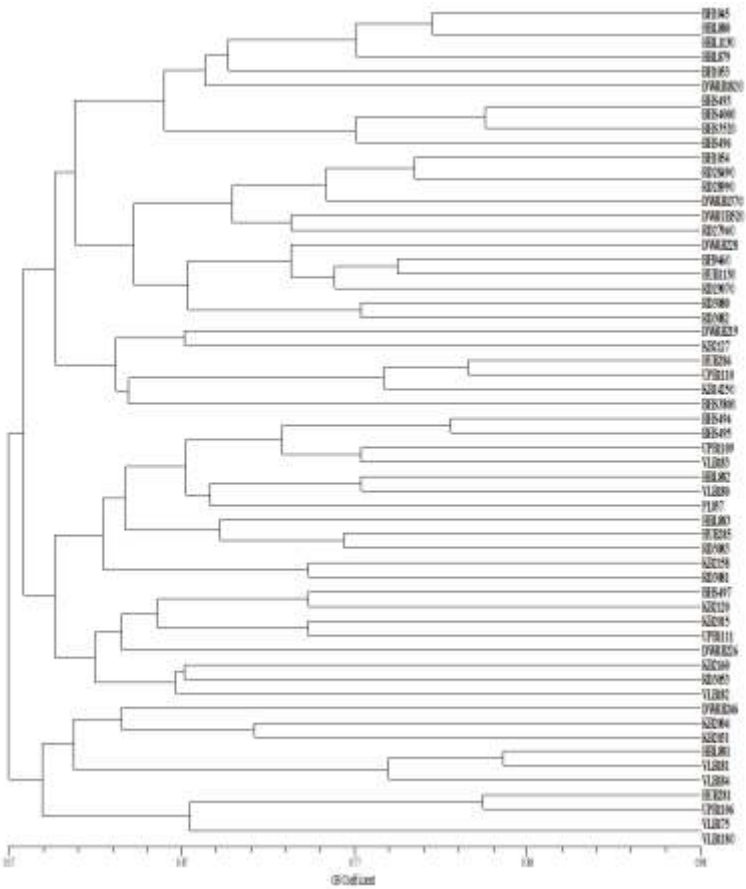
Based upon the multi-location evaluation under different trials series, 8 new entries were found promising, with significant superiority for the yield over the best check in the trials. Another 2 entries were numerically superior to the best check in different trials/ zones, however, based on the CD values these were *at par*.

Promising entries in different trials during 2022-23

SN	Trial name	Zone	Significantly superior	Superior (numerically)
1	AVT-IR-MB	NWPZ	DWRB219	-
2	IVT-IR-MB	NWPZ	DWRB235, DWRB238, RD3064	-
3	AVT-IR-TS-FB	NEPZ	UPB1106	-
4	AVT-IR-TS-NB	NWPZ	DWRB223	-
5	IVT-IRTS-NB	NWPZ	-	DWRB244
6	AVT-IR-TS-NB	CZ	DWRB223	-
7	IVT-IRTS-NB	CZ	-	DWRB244
8	AVT-SST	Plains	-	KB2031
9	IVT-SST	Plains	RD3080	KB2158
10.	IVT-RF-NHZ-NB	NHZ	BHS 497 (Forage)	BHS 497 (Grain)
11	IVT-RF-NHZ	NHZ	VLB 184 (Grain)	VL 184 (Forage)

Molecular Profiling of Barley Trials

Molecular profiles were generated to distinguish entries with their respective checks for barley AVT trials 2022-23. A set of 46 SSR/STS markers covering all the seven linkage groups of barley was screened with 58 lines including entries and checks. During UPGMA clustering, these genotypes grouped within similarity coefficient (GS) value 0.57 to 0.98 and showed sufficient genetic variability at molecular level. In dendrogram, each entry is uniquely placed at separate node and is distinct from rest of entries and check lines, respectively. The eventual intend of this effort is to develop molecular markers based amplification profiles for varietal characterization and to assess the level of genetic diversity in Indian barley.



UPGMA based clustering of entries and checks of AVT Barley Trials 2022-23

Breeder and Nucleus Seed Production

Breeder Seed Indent

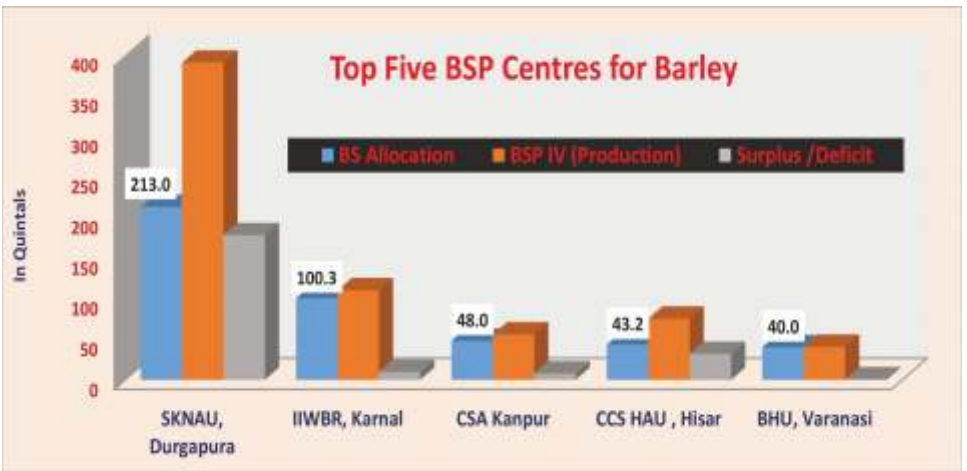
A consolidated quantity of 511.15q of breeder seed indent of 25 varieties was received from Seed Division, DA&FW, New Delhi for its production during 2022-23. Seven states *viz*., Rajasthan, Uttar Pradesh, Punjab, Haryana, Himachal Pradesh, Madhya Pradesh, and Uttarakhand, and five public sector agencies *viz*.,NSC, IFFDC, NAFED & KVSS, and National Seed Association of India (NSAI) indented breeder seed. The highest breeder seed indent was placed by Rajasthan 200q (39%) followed by UP 120q (23%), NSAI (12%) and National Seed Corporation (8%). A total of 421.80q (i.e., 82.52%) breeder seed was indented for <10years old varieties.

Breeder Seed Allocation and Production

Total of 510.85q of breeder seed of 24 varieties was allocated among 9 BSP centres. Among all 28 varieties maximum breeder seed indent was received for the variety DWRB 137 (113.30q) followed by RD 2899 (112.00q) and RDHUB 113 (40.0q).

A total of 732.63q with a surplus of 221.78q. over the total allocated quantity of breeder seed of 24 varieties was produced by 9 BSP centres during 2022-23, while maximum breeder seed was reported from RARI, Durgapura (390.99q) followed by IIWBR, Karnal (110.00qtls.). The top five breeder seed indented varieties contributed to the tune of 85.21% in total indent whereas, these varieties contributed 76.96% share in total breeder seed production during 2022-23.

A total of 46.20q. nucleus seed of 24 varieties was produced against 34.50q allocation in BNS-1 with a surplus of 11.70q seed during 2022-23.



Zonal Monitoring

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

Germplasm Evaluation &Exchange

During *Rabi* 2022-23, two international yield trials and one observation nursery were received from ICARDA which included a total of 216 genotypes for different production conditions. One set of each of these nurseries and trials was also evaluated at ICAR-IIWBR, Karnal. The rest of the sets were evaluated at different locations as per the requirements.

To give opportunity to barley breeders of NARS to select material from these nurseries as to cater their local needs, a Field Day was organized on 16th March 2023 at ICAR-IIWBR, Karnal. In addition, EIBGN (24 entries) was supplied to 12 different locations in NWPZ, NEPZ, and NHZ as a set of 48 entries including six checks repeated four times at each location. Similarly, the NBGSN comprised of a set of 15 promising genetic stocks endowed with the trait(s) of breeding value was supplied at 12 centres for utilization.

International trials and nurseries evaluated during crop season 2022-23

S.No.	Trials/Nurseries	Genotypes received	National Check	#Sets	Locations
1	2023International Barley Yield Trial for Feed Forage and Malt in Favourable Environments (IBYT-FFM-23)	48	DWRB137	4	Durgapura, Hisar,Kanpur, Karnal
2	2023 International Barley Yield Trial for Arid and Semi- Arid regions (IBYT-ASA)	48	Lakhan	4	Pantnagar, Karnal Durgapura, Kanpur,
3	2023 International Barley Observation Nursery (IBON-23)	120	DWRB137	5	Hisar, Kanpur, Karnal,Ludhiana, Durgapura

Crop Protection

Status of Barley Diseases and Insect Pests at Farmers' Field

- To know the health status of barley crop, the survey was conducted by the scientists from RARI, Durgapura on farmers' fields during Jan. 27- 28, 2023, and March 9-10, 2023 in the villages of Jaipur, Dausa,

and Tonk districts. Minor incidences of leaf rust (5S-10S) were recorded at two locations indistrict Tonk. The incidences of leaf stripe, net blotch, loose smut, covered smut, and bacterial streak were noted at few locations. However, a very severe infection (100%) of net blotch was noted at Todaraising village of district Tonk.

- In another survey, aphid infestation on the barley crop was also found to be low to moderate at the Ludhiana, Kanpur, and Karnal locations throughout the crop season. Predators including coccinellid beetles, chrysoperla, and syrphid flies were regularly observed preying on barley aphids.
- Termite damage in barley fields stayed low to moderate.

Status of Resistancein Breeding Lines and Advanced Entries

A total of 585 breeding and advanced line in different nurseries *i.e.* IBDSN (437 entries), NBDSN (118 entries) and EBDSN (30 entries) were screened for diseases, aphids, and CNN resistance at different cooperating centres. Seedling Resistance Test (SRT) for NBDSN and EBDSN entries was conducted at IIWBR, Regional station, Flowerdale, Shimla.

National Barley Disease Screening Nursery (NBDSN)

The NBDSN entries were screened for stripe rust resistance at hot spot centres that include Durgapura, Ludhiana, Hisar, Almora, Bajaura, Jammu and Karnal. Leaf rust screening was done at Ludhiana and Jammu. The leaf blight screening was done at Ayodhya, Pantnagar, Dharwad, Kanpur and Varanasi. The data of Kanpur centre were not considered due to low severity of foliar blight. CCN screening was done at Durgapura and Hisar centres.

- Based on the average score of three locations i.e. Ludhiana, Kanpur and Karnal, 12 entries *viz.*, BH 1050, BH 1051, DWRB 235,DWRB 236,DWRB 238,HUB 283,KB 2158, RD 3066, RD 3077, RD 3081, UPB 1110 and VLB 181 showed moderate (grade 3) resistance reaction to aphids.

Resistant entries in IBDSN.

Yellow rust, ACI = 0, Entries – 10	BH 1049, DWRUB 52 (C), KB 2160, PL 941, PL 942, RD 2794 (C), RD 2907 (C), RD 3065, RD 3078 and VLB 183
Yellow rust, ACI > 0 to 10, Entries – 90	BH 1045, BH 1047, BH 1048, BH 1050, BH 1051, BH 1052, BH 1053, BH 1054, BH 946 (C), BHS 352 (C), BHS 380 (C), BHS 400, BHS 493, BHS 494, BHS 496, BHS 497, BHS 945, DWRB 137 (C), DWRB 182 (C), DWRB 219, DWRB 223, DWRB 226, DWRB 228, DWRB 235, DWRB 236, DWRB 237, DWRB 238, DWRB 239, DWRB 240, DWRB 241, DWRB 242, DWRB 243, DWRB 245, HBL 113, HBL 879, HBL 880, HBL 881, HBL 882, HBL 883, HUB 113 (C), HUB 281, HUB 283, HUB 284 (C), K 2133, KB 2031, KB 2127 (C), KB 2131, KB 2145, KB 2155, KB 2158, PL 891 (C), PL 937, PL 943, PL 945, PL 946, PL 947, PL 948, PL 950, PL 951, PL 952, RD 2849 (C), RD 2899, RD 3053, RD 3064, RD 3066, RD 3067, RD 3068, RD 3070, RD 3071, RD 3076, RD 3077, RD 3079, RD 3080, RD 3081, RD 3082, RD 3083, UPB 1104, UPB 1109, UPB 1110, UPB 1113, UPB 1114, UPB 1115, UPB 1116, UPB 1117, VLB 118 (C), VLB 175, VLB 180, VLB 181, VLB 182 and VLB 184.
Leaf blight, Avg. 14-35 with HS < 57, Entries – 19	BH 1048, BHS 497, DWRB 219, DWRB 239, DWRB 240, DWRB 243, DWRB 244, HBL 113, HBL 879, KB 2120, KB 2160, PL 891(C), PL 946, PL 952, RD 3070, RD 3083, UPB 1111, VLB 118(C) and VLB 175.

Confirmed sources of resistance in EBDSN.

Yellow rust, ACI = 0, Entries – 6	BHS 488, RD 3037 (LB), RD3054, RD3055, RD3061 and DWRBG-6.
Yellow rust, Entries – 14 ACI > 0 to 10,	BH1042, BH1045, BHS491, DWRB 226, DWRB228, KB2013, RD3034, RD3050, RD3051, RD3058, RD3059, RD3063, VLB175 (LB) and HLR-324.
Leaf blight, Avg. 14-35 with HS < 57,Entries – 2	RD 3058 and RD 3059.

SRT in NBDSN and EBDSN

One hundred and eighteen NBDSN and eighteen EBDSN lines were screened against different pathotypes of three rusts of barley under precise conditions of temperature and light. Wherever needed, confirmatory and selected testing was also undertaken. These lines were evaluated against seven pathotypes of *P. striiformis* f. sp. *hordei* (57, Q, 7S0, G, 6S0, M, and 24), five pathotypes of *P. graminis tritici* (11, 21A-2, 40A, 117-6 and 122), and 5 isolates of *P. hordei* (H1, H2, H3, H4 and H5). Only one entry of NBDSN (PL946) conferred resistance to all the pathotypes of three rust pathogens while resistance to all the tested pathotypes of *P. striiformis* f. sp. *hordei*, *P. hordei* and *P. graminis* f. sp *tritici* was not observed in any of the entries of EBDSN.

NBDSN: A total 118 entries of NBDSN were evaluated against the different pathotypes of *Puccinia* spp.. Only one entry (PL 946) was resistant to all three rusts of barley. Eight lines (BHS493, RD3068,

RD3071, RD3076, RD3077, RD3078, RD3080, and RD3081) were resistant to both leaf and stripe rust pathotypes/isolates. Two entries (HBL881 and KB2120) were resistant to leaf and stem rust while DWRB182 was resistant to stripe and stem rust pathotypes. Additionally, 26 and 16 NBDSN lines were resistant only to leaf and stripe rust pathotypes, respectively. Resistance to all the pathotypes of *P. graminis* f. sp. *tritici* was observed only in PL950.

Rust resistant lines in NBDSN during 2022-23

Rust (s)	No. of lines	Lines
All	01	PL946
Leaf and stripe	08	BHS493, RD3068, RD3071, RD3076, RD3077, RD3078, RD3080, RD3081
Leaf and stem	02	HBL881, KB2120
Stripe and stem	01	DWRB182
Leaf	26	BHS380, BHS400, BHS494, BHS496, BHS945, DWRB238, DWRB240, DWRB243, DWRB244, HBL879, HBL880, HUB282, K2133, KB2159, PL943, PL945, PL948, RD3067, RD3083, VLB118, VLB175, VLB180, VLB181, VLB182, VLB183, VLB184
Stripe	16	BH1048, BH1049, DWRB137, DWRB228, DWRB241, HUB113, KB2031, KB2155, KB2160, RD2794, RD2899, RD2907, RD3053, RD3079, RD3082, UPB1115
Stem	01	PL950

EBDSN: Eighteen EBDSN lines were evaluated for resistance to three rusts by using seven pathotypes of *P. striiformis* f. sp. *hordei*, five of *P. graminis* f. sp. *tritici*, and 5 of *P. hordei*. Resistance to all three rusts was not recorded in any EBDSN line. However, four lines (BHS488, BHS491, RD3050, and RD3051) were resistant to leaf and stripe rusts. Resistance to all the pathotypes of leaf and stripe rust pathogens was observed in four (KB2013, RD3055, RD3058, and VLB175) and five (DWRB228, RD3034, RD3037, RD3054, and RD3061) entries of EBDSN, respectively.

Rust resistant lines in EBDSN during 2022-23

Rust/s	No. of lines	Lines
All	None	
Leaf and stripe	04	BHS488, BHS491, RD3050, RD3051
Leaf	04	KB2013, RD3055, RD3058, VLB175
Stripe	05	DWRB228, RD3034, RD3037, RD3054, RD3061
Stem	None	

Chemical control of diseases and insects pests

- Among eight different fungicidal treatments, two sprays of *viz*., Tebuconazole 50% + Trifloxystrobin 25%, Picoxystrobin 7.05% + Propiconazole 11.7% and Propiconazole 25% were found most effective in management of foliar blight of barley.
- An experiment on management of aphids through foliar application of new bio-chemical molecules was conducted at three locations *viz*., Ludhiana, Kanpur and Karnal. Foliar spray of pymetrozine 50 WG @ 100 g/ha and 120 g/ha was found effective in reducing aphid population.

Resource Management

One coordinated trial was proposed and conducted at four locations (Durgapura, Hisar, Karnal and Ludhiana) and results revealed that test entry DWRB 219 recorded the highest yield (52.90 q/ha) at 120 kg N/ha which was numerically better than the best check RD 2849 (two row) and DWRB 137 (six row). The increase in nitrogen level significantly improved the grain yield on mean basis. The genotypes DWRUB 52, RD 2849 and DWRB 219 responded up to 120 kg N/ha while rest of the entries responded only upto 90 kg N/ha.

Productivity Enhancement of Barley Through Nitrogen and Zinc Scheduling: This trial was conducted with the aim of enhancing the barley productivity through nitrogen scheduling and foliar application of urea and zinc at five locations (Agra, Durgapura, Hisar, Karnal, and Ludhiana). Three-year results revealed that the maximum grain yield was recorded to be 51.42 q/ha with recommended nitrogen (half at basal + half at tillering) and foliar spray of 5% urea + 0.5% $ZnSO_4.7H_2O$ at the anthesis stage. However, similar yield (50.96 q/ha) was obtained with treatment having half recommended nitrogen applied at basal+1/4 at tillering (35-40 DAS) +5.0% urea + 0.5% $ZnSO_4.7H_2O$ spray at flag leaf (65-70DAS) and 5% urea spray at the anthesis stage (80-90DAS). These treatments registered 8.6-9.5% increase in grain yield as compared to recommended N.

Enhancing Nutrient use Efficiency Through Nano Fertilizer in Barley: This trial was conducted at five locations in NWPZ, three in NEPZ, one in CZ and two in NHZ to optimise nano nitrogen dose for barley using different combinations of nano fertilizer. The grain yield increased with increase in nitrogen level. The maximum productivity (52.08 q/ha) of barley was recorded with recommended N level. The foliar application of different combination of nano urea with recommended N did not produce any significant effect on grain yield. The productivity at 75% RDF + nano fertilizer and RDF were at par in CZ and NHZ.

Sowing Method and Seed Rate on Barley Productivity: This trial was conducted at five locations in NWPZ (Agra, Hisar, Ludhiana, Karnal and Durgapura) in split plot design. The results revealed that barley productivity was similar with normal sowing and paired row method. The grain yield with 100 kg seed/ha and 87.5 kg seed rate/ha were *at par* but superior to 75 kg seed rate/ha, thereby suggesting a savings of 12.5 kg seed/ha.

Quality Evaluation

Malt Barley Trials

The Barley Improvement Unit conducted a comprehensive malting quality evaluation of grain samples from the Initial Varietal Trial (IVT) and Advanced Varietal Trial (AVT). These grain samples, each weighing 500 g, were collected from eight different locations (Hisar, Bathinda, Durgapura, Karnal, Ludhiana, Pantnagar, Modipuram, and Ajmer) for AVT and seven locations (Hisar, Bathinda, Durgapura, Karnal, Ludhiana, Pantnagar, and Modipuram) for IVT, respectively. In total, 215 coded samples were received and analyzed at the central facility. The mean values were taken for the identification of promising limes based on minimum standards determined by the NCGMBD for malt barley in the country. These standards are revised from time to time and latest revision was on 22.06.2020. Several genotypes were observed as good source of individual and malt quality traits, though they may not have good values for other traits.

Promising entries for individual malting quality traits.

Trait	Promising entries
Hectoliter weight	BH1051, DWRB237,
Bold Grains	BH1050, BH1051, BH1052, DWRB235, DWRB236, DWRB237, DWRB238, DWRB239, DWRB240, KB2145, PL941, PL942, PL943, PL945, RD3064, RD3066, RD3067, UPB1116, UPB1117, DWRB137 ©*
**Husk Content	BH1050, BH1051, DWRB236, DWRB237, DWRB239, RD3064, RD3065, RD2849 ©
**Grain Beta Glucan	RD3066, DWRB182 ©
Malt Friability	DWRB235, DWRB240, KB2131, KB2145, PL945, RD3064, RD3065, RD3066, DWRUB52 ©, DWRB182 ©, RD2849 ©
Hot water extract	BH1051, BH1052, DWRB238, DWRB240, KB2131, DWRB137 ©*
Filtration Rate	BH1050, BH1051, DWRB237, DWRB240, KB2131, KB2145, PL943, PL945, RD3065, RD3066, RD3067, DWRB182 ©
Diastatic Power	BH1050, BH1051, BH1052, DWRB236, DWRB238, DWRB240, KB2131, KB2145, PL941, PL942, PL943, PL945, RD3066, RD3067, UPB1116, UPB1117, DWRB137 ©*, DWRB182 ©, RD2849 ©
FAN Content	BH1052, DWRB235, DWRB236, DWRB237, DWRB238, DWRB239, DWRB240, KB2131, KB2145, PL942, PL943, PL945, RD3064, RD3065, RD3066, UPB1116, DWRUB52 ©, DWRB182 ©, RD2849 ©
Wort β- glucan	BH1051, BH1052, DWRB235, DWRB236, DWRB237, DWRB240, KB2131, KB2145, PL943, PL945, RD3065, RD3066, UPB1116, UPB1117, DWRB182 ©, RD2849 ©
**Over all Malt Quality (weighted performance compared to best check)	BH1051, BH1052, DWRB238, DWRB240, KB2145, PL943, RD3066, DWRB182 ©

**Six row; ** Compared to the best check.*

Barley Quality Screening Nursery (BQSN):

The BQSN is conducted to find out the source of better quality traits for hulless and malt barley. The nursery was conducted at six locations i.e. Karnal, Hisar, Pantnagar, Durgapur, Ludhiana, and Kanpur. The nursery was sent under four categories i.e. protein content barley, naked/hulless barley, evaluation of beta-glucan content and higher anti-oxidant activities in entries contributed by malt barley and molecular breeding programme. The identified promising entries analyzed in the nursery are given below.

Promising entries from BQSN for different traits

Traits	Promising entries
Protein Content	BCU6369, BCU6315, BCU 6316, BCU 5924, DWRB137 ©
Starch Content	BCU 5957, BCU 6040, BCU 6306, BCU 6315, BCU 6316, DWRUB 52 ©
Higher Friability	BCU6369, BCU6315, DWRB137 ©
Higher Hot Water Extract	BCU6315, BCU6369, DWRB137 ©
Higher Diastatic Power	BCU6315, DWRB137 ©
Higher Free Amino Nitrogen	BCU6315, BCU6369, DWRB137 ©
Low beta glucan	BCU6369, BCU6315, DWRB137 © DWRUB64 ©

Feed and Food Barley Quality Evaluation

The feed and food grain samples from various trials grown at different locations were analyzed for physical parameters and protein content. The quality data has been presented trial wise. The entries having highest thousand grain weight, protein content and hectoliter weight have been listed below.

Entries with 1000-grain weight, protein content and hectoliter weight in different trials

Trial	Zone	1000- grain weight	Protein content	Hectoliter weight
IVT-IR-TS-FB	NWPZ	KB 2145	HUB 284	PL 947
	NEPZ	KB 2145	DWRB 242	DWRB 243
	CZ	RD 3068	DWRB 242	KB 2145
AVT-IR-TS-FB	NWPZ	DWRB 137 ©	DWRB 226	DWRB 137 ©
	NEPZ	KB 2004	UPB 1106	KB 2004
	CZ	RD 2899 ©	RD 3053	RD 3053
IVT-RF-TS-FB	NEPZ	PL 952	PL 952	HUB 282
	NHZ	VLB 183	VLB 182	HBL 113 ©
AVT-SST-FB	NWPZ/NEPZ	KB 2120	DWRB 246	KB 2120
IVT/AVT-IR-TS-NB	NWPZ/NEPZ/CZ	DWRB 245	DWRB 244	DWRB 244

Technology Outreach Programme

Barley Frontline Demonstrations (2022-2023)

To disseminate a new technology among farmers, it is necessary that the technology is demonstrated at farmers' field. During the *rabi* crop season 2022-23, 140 hectares Barley Front line Demonstrations (BFLDs) were allotted to 37 cooperating centres in eight states/UT namely, Himachal Pradesh, Uttar Pradesh, Bihar, Jammu & Kashmir, Punjab, Haryana, Rajasthan and Madhya Pradesh. Out of these, 134.4ha BFLDs were conducted by 36 centres, covering 141.72 hectares area of 382 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 (35.6 ha), followed by MP (24.0 ha), Rajasthan (22.8 ha), Punjab (19.2 ha), Haryana (14.8 ha), Bihar (8.0 ha), HP (6.0 ha) and J&K (4.0 ha). The highest gain in barley yield was recorded in Eastern UP (59.56%) followed by MP (47.63%), All UP (43.25%), HP (39.92%), UT of J&K (37.67%), Central UP (34.84%) and Rajasthan NWPZ (19.69%). The lowest gain in yield was reported in Haryana (9.26%). Centre-wise yield gain was highest at Rewa (142.40%) in CZ and lowest at Muktsar (05.02%) in NWPZ.

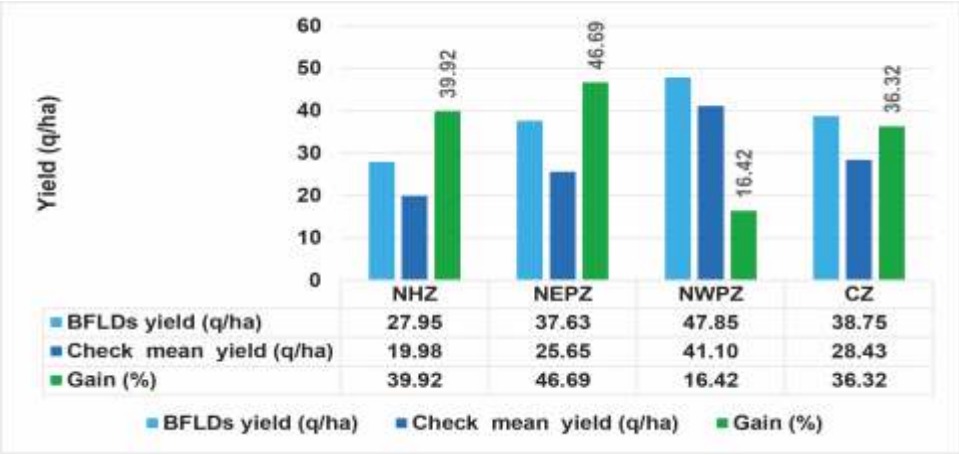
State wise performance of the Improved barley varieties during *rabi* 2022-23

State/UT	BFLDs yield (q/ha)	Check yield (q/ha)	Gain (%)
HP	27.95	19.98	39.92***
Eastern UP	35.90	22.50	59.56***
Central UP	33.58	24.90	34.84***
Western UP	58.43	52.10	12.14***
All UP	37.68	26.30	43.25***
Bihar	42.18	36.40	15.87*
UT of J&K	30.70	22.30	37.67***
Punjab	47.58	40.38	17.83***
Haryana	42.20	38.63	09.26*
Rajasthan (NWPZ)	60.03	50.15	19.69***
Rajasthan (CZ)	42.20	36.10	16.90***
All Rajasthan	53.13	44.70	18.85***
MP	39.75	26.93	47.63***

**** Significant at 1 per cent level, ** Significant at 5 per cent level , * Significant at 10 per cent level*

The highest average yielding varieties were HBL 804 (29.18 q/ha) at Bajaura centre in NHZ; DWRB 137 (56.33 q/ha) at Barh Patna in NEPZ, RD 2907 (63.75 q/ha) at Durgapura Jaipur in NWPZ and DWRB 137 (47.58 q/ha) at Rajgarh in CZ. It is evident that recent varieties outperformed old/check varieties at all locations. The yield gain due to varietal intervention ranged from 4.18 % at Bhiwani centre in Haryana to 142.40% at Rewa centre in MP. The variety-wise yield data revealed that HBL 713 (35.00 q/ha), DWRB 137 (58.50 q/ha), DWRB 137 (69.50 q/ha) and DWRB 137(51.00 q/ha) performed better than other varieties at Bajaura Kullu, Barh Patna, Karauli and Rajgarh centres in the NHZ, NEPZ, NWPZ and CZ, respectively.

The yield gain due to improved varieties over check was highest in NEPZ (46.69%) followed by NHZ(39.92%), CZ (36.32%), and NWPZ (16.42%).



Zone-wise productivity of improved barley varieties over check during *rabi* 2022-23

The overall analysis of constraints in different zones clearly indicated that untimely rain, lodging, high cost of inputs, decline in the water table, *Phalaris minor*, low price of barley grains, small land holding, non-availability of labour, poor participation in exposure visits arranged by various departments and poor information delivery 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 for intervention to ensure the supply of quality inputs to the farmers. Farmers need to be updated on the 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 barley.

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 Durgapura-Jaipur, Chomu-Jaipur, Alwar, Jalandhar, Kapurthala, and Bathinda centres during the *rabi* crop season 2022-23.

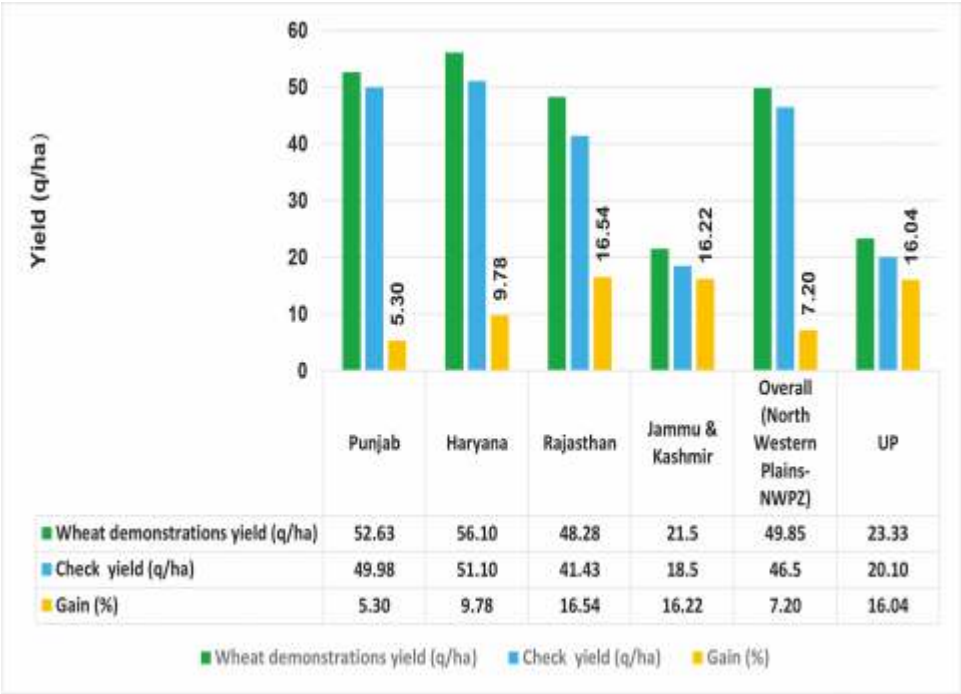
Wheat Demonstrations Conducted Under SCSP Programme During rabi 2022-23

Under SCSP Programme, 510 varietal demonstrations of wheat varieties DBW 187, DBW 222, DBW 327, DBW 332, and HI 1605 were organized during 2022-23 *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); and RLBCAU Jhansi (10) benefitting 539 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 (Sriganganagar and Hanumangarh), 1 aspirational district of UT of Jammu & Kashmir (Samba), and 1 aspirational district of UP (Jhansi) covering a total of 510 acres area and 539 farmers of Scheduled Castes (SC) category.

In Punjab, the demonstrations were conducted in 360 acres area benefitting 360 SC farmers; in Haryana, the demonstrations were conducted in 80 acres area benefitting 80 SC farmers; in Rajasthan, the

demonstrations were conducted in 40 acres area benefitting 40 SC farmers; in J&K (UT), the demonstrations were conducted in 20 acres area benefitting 49 SC farmers; and in UP, the demonstrations were conducted in 10 acres area benefitting 10 SC farmers. In each aspirational district, 20 demonstrations were conducted, except Jhansi in which 10 demonstrations were conducted. At all the locations, the yields of demonstrated varieties were more than the check varieties. Improved wheat varieties DBW 187, DBW 222, DBW 327, DBW 332, and HI 1605 with the complete package of practices (irrigation management, nutrient management, weed control, seed treatment, etc.) were demonstrated.

The yield gain due to improved variety was highest in Sriganganagar (24.04%) district in Rajasthan state followed by Samba (16.22%) district in Jammu and Kashmir (UT), Jhansi (16.04%) in UP state, Fatehabad (12.94%) district in Haryana state and Kapurthala (12.13%) district in Punjab state. The lowest yield gain was in Fatehgarh Sahib (3.47%) district in Punjab state.



State-wise productivity of improved Wheat varieties over check during *rabi* 2022-23

Under SCSP wheat demonstrations, the state-wise yield gain was highest *i.e.*16.54% in Rajasthan. The lowest yield gain was 5.30 % in Punjab state. The zonal (NWPZ) yield gain was 7.20%. The demonstrated varieties outperformed the existing varieties.

In Punjab state, the significant yield gain due to improved wheat variety DBW 222 over check mean yield was highest at Kapurthala (14.23%). In Haryana state, the highest significant yield gain due to improved wheat variety DBW 327 was at Yamunanagar (14.15%). In Rajasthan state, the highest significant yield gain due to improved wheat variety DBW 187 was at Sriganganagar (24.23%). In J&K (UT), the highest significant yield gain due to improved wheat variety DBW187 was at Samba (20.90%). In UP, the highest significant yield gain due to improved wheat variety DBW 187 was at Jhansi (22.28%).

In Punjab, the highest yield of variety DBW 327 was 70.00 q/ha in Sangrur district. In Haryana, the highest yield of variety DBW 222 was 63.75 q/ha in Fatehabad district. In Rajasthan, the highest yield of variety DBW 327 was 60.00 q/ha in Hanumangarh district. In UT of Jammu & Kashmir, the highest yield of variety DBW 222 was 30.00q/ha in Samba district. In UP, the highest yield of variety DBW 187 was 27.50 q/ha in Jhansi district.

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

Wheat

Analysis of data indicated that on average, demonstration of improved wheat varieties at the farmers' field under the SCSP program gave ₹3.96 per rupee of investment in comparison to the farmers' practice (₹3.73). A significant difference in returns per rupee of investment was noticed between the demonstrated and check plots at the farmer's field. The profit per hectare in the demonstrated plot was highest in Haryana (₹107409), followed by Punjab (₹103858). The difference in profit levels between demonstration and check plots was highest in

the case of Haryana. Further, ₹711 has to be spent to produce a quintal of wheat through a new variety against ₹763 (farmers' choice of variety in the check plots).

Barley

The economic analysis of barley FLDs indicated that on average, improved barley varieties demonstrated at the farmers' field under the FLD program gave around ₹65305 profit per hectare. A significant difference in returns per rupee of investment was noticed between the demonstration and check plots across states and zones. Uttar Pradesh registered the highest returns per rupee of investment (₹4.50) through demonstrations, followed by Bihar (₹4.40) and Punjab (₹3.58). The profit per hectare in FLDs was highest in Rajasthan (₹62654), followed by UP (₹62269) and UT of J&K (₹62370). The difference in profit between FLD and check plots ranged from ₹22541 in Uttar Pradesh to ₹3136 in Haryana. The returns per rupee of investment across barley growing zones were highest in the NEPZ (₹4.50), followed by NWPZ (₹2.89) and CZ (₹2.30). Estimates of the cost of production indicated that the cost incurred in producing a unit quantity of barley output was the least (₹445 per quintal) in Uttar Pradesh 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/participating in Foundation Day, World Soil Day, Mahila Kisan Diwas, Agricultural Education Day, Kisan Diwas, Kisan Mela, Sanitation Drive, International Women's Day, World Water Day; National Girl Child Day, DD Kisan Vichar-Vimarsh Programme, Agricultural Awareness/Training Programmes under 'Mera Gaon Mera Gaurav' scheme, SCSP, TSP, and NEH programs. Apart from these, the Social Sciences unit delivered lectures benefitting students, farmers, and the scientific community during their visit; attended the meetings and participated in seminars/symposia/conferences/workshops and

coordinated 98 visits of farmers, students, and agricultural officers at ICAR-IIWBR, Karnal. The advisory services were also provided to the farmers through letters, phone calls, and emails. The unit conducted 18 training/ awareness programs 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.

ICAR-IIWBR RS Dalang Maidan, Lahaul & Spiti (H.P.)

The ICAR - IIWBR Regional Station located at Dalang Maidan, in Lahaul valley of Himachal Pradesh serves as a national off-season crop facility for wheat and barley researchers of the country.

Generation Advancement of Wheat And Barley

In the summer nursery 2022 more than 25000 breeding lines of wheat and ~1600 breeding lines of barley 39 teams were planted at Dalang Maidan. These breeding lines of wheat and barley from several research institutes and State Agricultural Universities (SAUs) were advanced for speeding the breeding work. The facility was utilized by breeders, and plant pathologists from all five zones of the country.
The maximum materials were from NWPZ followed by NHZ, CZ, NEPZ and PZ. Apart from ICAR-IIWBR Karnal, ICAR-IARI New Delhi, CCS HAU Hisar, NABI Mohali, VPKAS- Almora and CSHPKV Palampur were major co-operators for utilizing the off season facility. The sowing of all the seed materials was done during 19-21 May, 2022, harvested in the second fortnight of September 2022 and supplied to the respective researchers well in time.

Corrective Hybridization

The summer nursery 2022 was also utilized for corrective crossing and backcrossing for gene introgression, mapping of the traits for genetic study and various breeding programmes of wheat and barley. More

than 350 corrective crosses, back crosses/three way crosses were attempted.

Disease Screening and Monitoring

The season was favourable for the screening for yellow rust and powdery mildew and more than 18,000 lines were screened. In collaboration with breeders and pathologists of IIWBR RS Shimla, CSKHPKVV, Palampur and NBPGR New Delhi a set of 4575 germplasm lines of wheat was screened for yellow rust and powdery mildew resistance against natural pathogen flora of the valley. The yellow rust incidence was first observed during first week of August and the disease severity was highest during first week of September 2022. Powdery mildew disease also appeared during the last week of September. Wheat disease monitoring nursery (WDMN) was planted at this station and the samples of yellow rust were collected for pathotype analysis at Regional Station Flowerdale, Shimla. The pathotypes analysis at rust laboratory Shimla identified yellow rust *Pst* 238S119 as the most common pathotype followed by 110S119, 46S119 and 79S68. There was occurrence of insect-pest infestation on summer nursery wheat crop such as stem borers during the month of July which was timely controlled through chemical spray. The weather during the month of June 2022 was unusually warm.

Natural Repository for Wheat and Barley Germplasm

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

Annexure I

Action taken report on the major recommendations of the 61st All India Wheat & Barley Research Workers' meet held at Gwalior during August 29-31, 2022

S. N.	Recommendations	Action Taken
Crop Improvement		
1.	Newly released varieties will be taken up in seed chain for cultivation. Also, new genetic stocks will be shared with co-operators.	Wheat varieties notified for cultivation through CVRC were included in the breeder seed indent allocation. Thus seed produced is shared with stake holders. Similarly genetic stocks registered at NBPGR were shared with co-operators through NGSN.
2.	The newly identified varietal proposals will now be put up to CVRC for release and notification as soon as possible.	The proposals of identified varieties were put up to CVRC and these have been notified for release.
3.	Work plan 2022-23 in respect of breeding trials and nurseries will be executed as per set norms.	Work plan as whole in respect of breeding trials, Physiological trials and nurseries was executed during 2022-23.
4.	High fertility early sown trial now will be constituted as NIVT 6 only and conducted in NWPZ and CZ. This trial will be of 36 genotypes including checks for this year only. Similarly, special HYPT trial will also be conducted in NWPZ and CZ only.	The NIVT 6 trial was successfully constituted and conducted in NWPZ and CZ with 36 genotypes including checks. HYPT was also conducted in these two zones during 2022-23 and results have been presented in the Crop Improvement Progress Report.
5.	In NHZ a common trial IVT and AVT will be conducted under both rainfed and irrigated conditions.	A common trial with entries of IVT and AVT was conducted under rainfed and irrigated conditions.
6.	From 2022-23 onwards Gwalior centre will conduct trials sets of CZ and Durgapura centre will conduct trials of NWPZ.	The Gwalior and Durgapura centres have been included back to CZ and NWPZ respectively during 2022-23.
7.	Special trial and nursery for addressing heat and drought tolerance in wheat will be initiated from 2022-23 season.	Heat and Drought Tolerance Screening Trial (HDTST) was conducted to identify the temperature and drought stress tolerant lines among AVT final year genotypes
8.	The QCBWSN will be discontinued and pipelines material from centres will be assessed for quality parameters to provide additional data on grain quality.	The QCBWSN was discontinued and pipe line material from IPPSN has been evaluated this season for quality traits.
9.	For strengthening wheat breeding program on grain quality, set of IPPSN entries (grown under protected condition) will also be evaluated for basic quality parameters.	It has been done as mentioned at S N 8 above.
10.	Wheat blast data will be used as a promotion criterion for promotion/retention of entries in NEPZ trials. From 2022-23 season onwards, duly treated seed from centres in West Bengal and Assam will be included in IPPSN for testing.	The treated seed from cooperating centres of West Bengal and Assam have been included in the testing.
11.	Entries contributed as MABB will be evaluated in the respective AVTs of the zone. The background recovery for such lines should be > 90%.	MABB entries were evaluated as per prescribed norms in respective AVTs.

S. N.	Recommendations	Action Taken
12.	For evaluating genotypes of private companies and other institutions outside NARS, a testing fee of Rs 1.0 lakh +GST per entry will be charged separately for each program, i.e. Breeding, Agronomy, Pathology, Quality, Physiology etc..	The rates of testing were fixed by a committee and the rates are Rs 60000/ per entry each for IPPSN, NIVTs etc. However the rates for quality testing are based on the specific traits.
13.	Under HRD, One Orientation Course on AICRP activities for new incumbents will be conducted during the Crop Season.	Short Course on Agri-preneurship Development in Seed Sector for Sustainability of Agriculture & Rural Economy was organized for Scientist/Assistant Professor of SAUs during 1-10th Feb., 2023.
14.	As an initiative to strengthen research for wheat improvement, trait/problem specific programs have been proposed at major centres.	The programs with specific traits to the centres was formulated and executed during the season. The traits included related to biotic and abiotic stresses and quality.
Resource Management		
1.	Sea weed extract as seed treatment @ 3 ml/kg followed by two foliar sprays @ 1.6 litres in 400 litres of water per hectare at tillering and jointing stage is recommended for improving the wheat productivity across the zones.	Communicated to all cooperating centres for implementation
2.	Foliar application of Cycocel (CCC) @ 600 ml in 400 litres of water per hectare at 50 DAS is recommended to reduce lodging and improve productivity of dicoccum wheat in PZ.	Communicated to all cooperating centers in PZ for implementation
Crop Protection		
1.	The plant pathological nursery EPPSN and MDSN has to be merged and should be one nursery as EMDSN to keep elite germplasm and will be screened against multiple diseases.	As per the suggestion, two plant pathological nurseries, EPPSN and MDSN were merged into one nursery, EMDSN.
2.	It is recommended to grow the highly yellow rust resistant newly released varieties like DBW 296, DBW 327, DBW 332, DBW303, DBW187, JKW 261, WH1270, DBW 222, PBW 771, HD 3226, PBW 752, HD 3237, HI 1620, DBW 173, WB 02, HD 3096, DBW 90, WH 1124, WH 1080, WH 1142 etc. in view of current pathotype prevalence in Haryana, Punjab, Himachal Pradesh and Jammu.	The farmers of yellow rust prone areas like Punjab, Haryana, Himachal Pradesh and Jammu were made aware to grow newly released disease resistant wheat varieties through field visits, seminars, workshops, trainings, monthly online advisories, digital social means suchas Whatsapp group, SMS services, Kisan gosthies and TV talks.
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, grow wheat blast resistant varieties identified for the NEPZ with seed treatment etc. in disease prone areas.	A strict vigil was kept on the incidence of wheat blast disease in NEPZ. Surveys were conducted in West Bengal near Indo-Bangladesh border by team of Scientists from UBKV, Coochbehar, and BCKV, Kalyani. The farmers were made aware about the symptoms of the disease and its management through the seed treatment. Farmers were also advised to cultivate newly released improved wheat varieties.

S. N.	Recommendations	Action Taken
4.	It is recommended to apply Azoxystrobin 18.2% w/w + Difenoconazole 11.4% w/w SC @ 0.1% to management of powdery mildew and may be repeated after 15 days as per need.	Through series of comprehensive initiatives such as trainings, workshops, and KisanMelas, awareness was made among farmers, KVK officials and other stakeholders about this recommendation for tackling powdery mildew disease.
5.	Soil application of Fipronil 0.6% GR @ 7.5 kg/ha is recommended for the management of lepidoterous pest pink stem borer in wheat.	Farmers and state agriculture officials were made aware of this recommendation for the effective management of pink stem borer in wheat through trainings, workshops, seminars and Kisan Mela etc.
6.	Training to scientists recently associated with crop protection programme for diseases and insect pest scoring, recording and reporting to further improving effectiveness of the programme.	A three- day National training on "Precise and Uniform Data Recording and Reporting in Wheat and Barley Crop Protection Trials" was organized by Crop Protection Section, IIWBR, Karnal from February 22-24, 2023. Scientists were given hand-on training to record observation on incidence of diseases and insect-pests of wheat and barley crops.
Quality Improvement		
1.	It is recommended that grading standard of wheat should be developed and notified with APEDA and accordingly recent varieties should be graded along with their product profile for domestic and export purposes.	Grading standard of wheat have been developed and submitted to APEDA for notification. Grading standards are based on physical impurities, grain size and weight, disease infestation and any external matter. Grading parameters are influenced by environmental conditions including severity of disease and weed infestation etc. Recent wheat varieties have been analysed for quality traits. A bulletin has been published giving details of quality traits including product quality across the zones. Product profile of each variety will be revised after every three years.
2.	As genetics of most of the quality traits is known and microlevel tests are available associated with industrial quality traits, the information should be utilized in breeding for developing product specific varieties.	All the AICRP centres have been requested to utilize information in their breeding programme. Some of the centres including ICAR-IIWBR, Karnal PAU, Ludhiana; ICAR-IARI, New Delhi and UAS Dharwad have started using some of the information.
3.	Emphasis should be put on understanding molecular basis of nutritional quality traits and concerted efforts be made for improving nutritional quality for enhancing antioxidants including anthocyanins, resistant starch, dietary fibre and reducing antinutritional factors such as phytic acid.	Emphasis has been put on understanding molecular basis of nutritional quality traits. Molecular study under CRP Biofortification revealed the upregulation of genes related to transport and accumulation of Fe and Zn. We have developed mutant and RIL populations for deciphering the molecular basis of micronutrient absorption and accumulation. Concerted efforts are being made for improving nutritional quality for enhancing antioxidants including anthocyanins, resistant starch, dietary fibre and reducing antinutritional factors such as phytic acid. We have identified QTL for low phytic acid in mutant population which explains around 3% variability. We have evaluated wheat varietes for antioxidant levels and work is going on anthocyanin and resistant starch and dietary fibre content. Coloured wheats have been used in making crosses and materials were at F_4 stages during 2022-23.

S. N.	Recommendations	Action Taken
4.	It is recommended that along with yield and disease resistance, quality will be used as criteria for identification/promotion of varieties and weightage will be given to entries having exceptionally good quality irrespective of yield	The recommendation has been implemented. The criteria of giving weightage of quality traits along with yield and disease resistance for identification and promotion of varieties is given to entries having exceptionally good quality and are *at par* in yield with respect to best check.
Barley Improvement		
1.	Decreasing trend of breeder seed indents in barley is a serious issue and it should be improved by all concerned states.	We have been trying to educate people about health benefit of barley by organizing meetings, publishing in News Papers and folders etc.
2.	New centre at Banda (CZ) and BISA Samastipur (NEPZ) are proposed, while Samdari (Central Zone), Kalyani (NEPZ), Katrain, Kangra, Rajauri (all in NHZ) have been discontinued.	Banda and BISA Samastipur have been included as test sites and also for demonstrations of Barley crop.
3.	Under the current situation Kumarganj centre (the centre lost all the breeding material, crossing block as well as seed of station as well as coordinated trials) will continue under AICRP only as testing centre for 2022-23 season. The centre should make sincere efforts to get status as breeding centre as soon as possible.	The promising breeding materials have been shared with Kumarganj centre and now they have contributed new entries in IVTs of Feed Barley, SST/ALK and rainfed trials.

Annexure II

Financial Highlights for the Year 2022-23

A. Budget Utilization

(₹ in Lakhs)

Name of Scheme	Total BE 2022-23	Total R.E. 2022-23	Total Remittance Received 2022-23	TOTAL EXP.	% of EXP. Against RE
IIWBR, KARNAL	3609.00	3552.20	3539.34	3539.34	100 %
AICRP on Wheat & Barley	1900.00	1889.64	1889.57	1889.57	100 %

Expenditure Statement for the year 2022-23 in respect of ICAR-IIWBR, Karnal

(₹ in Lakhs)

Name of Scheme	HEAD	BE 2022-23	RE 2022-23	Other than NEH & TSP	EXPENDITURE TSP	NEH	SCSP	TOTAL EXP.	% of EXP. Against Net RE
	Grants in Aid - Capital	150.00	150.00	137.14	0.0	0.0	0.0	137.14	91.43%
	Grants in Aid - Salaries	2380.00	2257.89	2257.89	0.0	0.0	0.0	2257.89	100%
IIWBR,	Grants in Aid	- General :							
KARNAL	(1) Pension	350.00	410.67	410.67	0.0	0.0	0.0	410.67	100%
	(2) Others	729.00	718.64	700.00	0.00	5.00	13.64	718.64	100%
	(3) Non-Scheme	0.00	15.00	15.00	0.00	0.00	0.00	15.00	100%
	TOTAL	**3609.00**	**3552.20**	**3520.70**	**0.00**	**5.00**	**13.64**	**3539.34**	**100 %**

(₹ in Lakhs)

Name of Scheme	HEAD	BE 2022-23	RE 2022-23	Other than NEH & TSP	EXPENDITURE TSP	NEH	SCSP	TOTAL EXP.	% of EXP. Against Net RE
	Grants in Aid - Capital	0.00	0.00	0.00	0.0	0.0	0.0	0.00	0 %
AICRP	Grants in Aid	1518.18	1644.82	1594.82	0	50.00	0	1644.82	100 %
(Wheat	- Salaries								
& Barley)	Grants in Aid - General :								
	(1) Pension	0	0	0	0	0	0	0	0 %
	(2) Others	198.00	187.64	162.00	2.00	10.00	13.57	187.57	100 %
	TOTAL	**1900.00**	**1889.64**	**1833.92**	**32.08**	**10.00**	**13.57**	**1889.57**	**100%**

B. Revenue Generation for the year 2022-23

(₹ in Lakhs)

Year	Target	Revenue Generated as per Schedule 8, 10 & 12 of Balance Sheet 2022-23	Total Revenue Receipts during 2022-23
2022-23	269.40	46.16	392.23

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

S. N.	Year	Number of outstanding Paras	Remarks
1	2017-20	07	Facts will be verified w.e.t. original record during next audit of CAG, Chandigarh vide letter No. P.D.A/C.E./waiting/2022-23/180 dated 26-10-2022.

D. Status of ICAR Inspection Report as on 31.07.2023

S. N.	Year	Number of outstanding Paras	Remarks
1	2018-19	Nil	

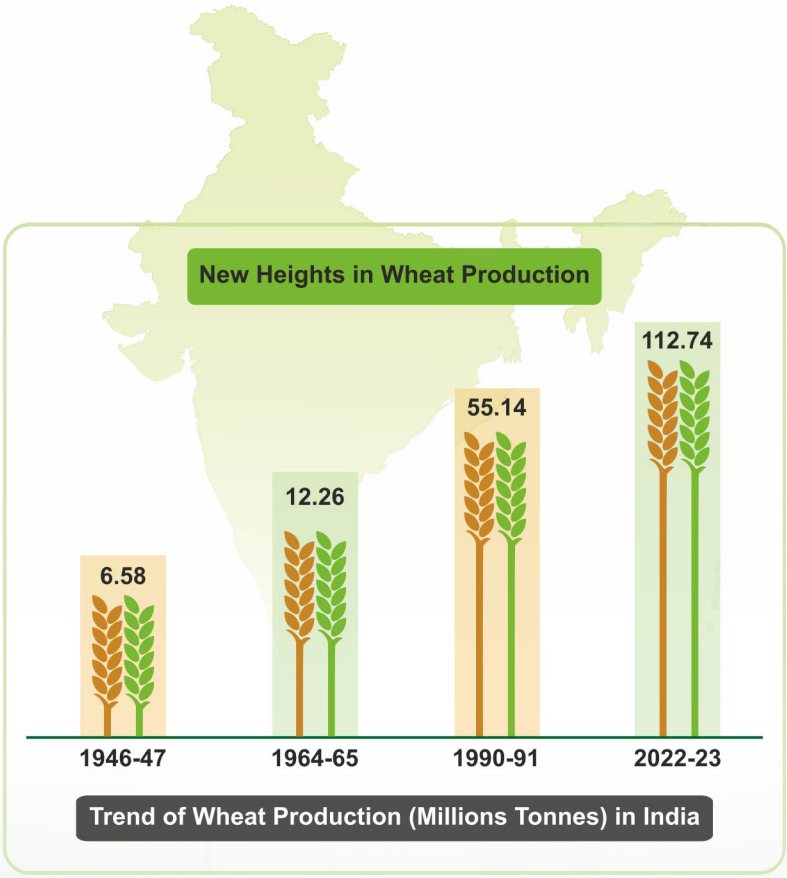
STATEMENT SHOWING NET GRANT RELEASED TO AICRP ON WHEAT & BARLEY CENTRES DURING THE YEAR 2022-23

(Amount in ₹)

S.N.	Name of Centre	GIA-Salary	GIA General	Capital	Grand Total(₹)
1	Bajaura	1290074	310933		1601007
2	Bilaspur	5330655	152832		5483487
3	Coochbehar	1888649	360000		2248649
4	Dharwad	8625000	629828		9254828
5	Durgapura	10703288	1052618		11755906
6	Faizabad	7990397	723000		8713397
7	Gwalior	5014709	356250		5370959
8	Hisar	10350000	941250		11291250
9	Jabalpur	1526971	558846		2085817
10	Jammu	3999189	380250		4379439
11	Junagadh	4630202	180285		4810487
12	Kalyani	2811464	342766		3154230
13	Kanpur	10275913	752613		11028526
14	Ludhiana	12051780	877050		12928830
15	Mahabaleshwar	1855147	253500		2108647
16	Niphad	6375000	482500		6857500
17	Palampur	7523604	594978		8118582
18	Pantnagar	13608750	681502		14290252
19	Powarkheda	4841930	653457		5495387
20	Ranchi	2091539	260861		2352400
21	Sabour	2723802	139678		2863480
22	Sagar	1515384	236276		1751660
23	Srinagar	1667578	255000		1922578
24	Udaipur	5866635	531908		6398543
25	Vijapur	2211472	658615		2870087
26	Pune (100%)	8349024	1012828		9361852
27	Varanasi (100%)	3242379	504498		3746877
	Voluntary Centres	0	1179371		1179371
	TSP Grant	0	665338		665338
	Total	**148360535**	**13884122**		**164089366**
NEH					
1	Shillongani	1004347	19565		1023912
2	Imphal(100%) NEH	0	37908		37908
	Total	**1004347**	**57463**		**1061820**
	G. Total	**149364882**	**13941585**		**165151186**

STATUS OF AUC/UC FOR THE YEAR 2022-23 IN R/O CENTRES UNDER WHEAT AND BARLEY

S. N.	Name of Center	Name of University	Position of AUC/UC
1	BAJAURA	CSKHPKVV PALAMPUR	Only AUC Received
2	BILASPUR	IGKVV RAIPUR	Only UC Received
3	COOCHBEHAR	UBKV COOCHBEHAR	Only UC Received
4	DHARWAD	UAS DHARWAD	Only AUC Received
5	DURGAPURA	RAU BIKANER	Only AUC Received
6	FAIZABAD	NDUA&T FAIZABAD	Only AUC Received
7	GWALIOR	RVSKVV GWALIOR	Only UC Received
8	HISAR	CSHAU HISAR	Only UC Received
9	JABALPUR	JNKVV JABALPUR	Only UC Received
10	JAMMU	SKUAST JAMMU	Only UC Received
11	JUNAGADH	JAU JUNAGADH	Only UC Received
12	KALYANI	BCKVV NADIA	Only AUC Received
13	KANPUR	CSAUA&T KANPUR	Only AUC Received
14	LUDHIANA	PAU LUDHIANA	Only UC Received
15	MAHABALESHWAR	MPKVV RAHURI.	Only AUC Received
16	NIPHAD	MPKVV RAHURI	Only AUC Received
17	PALAMPUR	CSKHPKVV PALAMPUR	Only AUC Received
18	PANTNAGAR	GBPUA & T PANTNAGAR	Only AUC Received
19	POWARKHEDA	JNKVV, JABALPUR	Only AUC Received
20	RANCHI	BAU RANCHI	Only UC Received
21	SABOUR	RAU SAMASTIPUR	Only AUC Received
22	SAGAR	JNKVV JABALPUR	Only UC Received
23	SRINAGAR	SKUAST SRINAGAR	Only AUC Received
24	UDAIPUR	MPUAT, UDAIPUR	Only AUC Received
25	VIJAPUR	SDAU, SARDARKRUSHI NAGAR	Only UC 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



62वीं अखिल भारतीय गेहूँ एवं जौ अनुसंधान कार्यकर्ता गोष्ठी

महाराणा प्रताप कृषि एवं प्रौद्योगिकी विश्वविद्यालय, उदयपुर, राजस्थान

(अगस्त 28-30, 2023)

62nd All India Wheat and Barley Research Worker's Meet-2023

Maharana Pratap University of Agriculture and Technology (MPUAT),Udaipur, Rajasthan

(August 28-30, 2023)